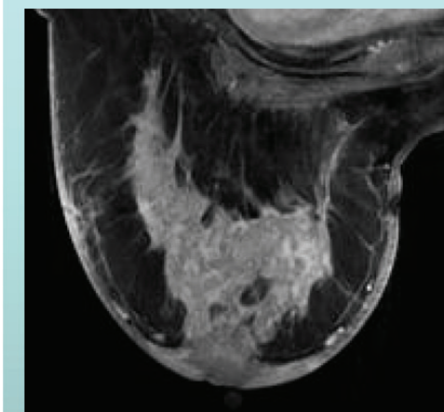
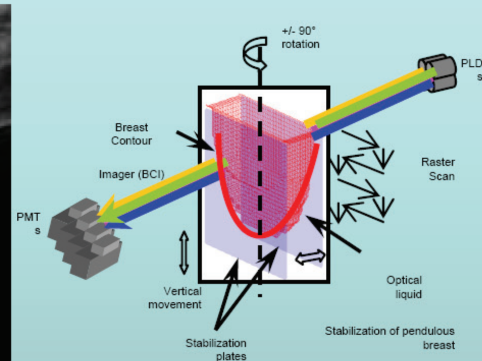
InterACTIONS

CANADIAN MEDICAL PHYSICS NEWSLETTER
Le BULLETIN CANADIEN de PHYSIQUE MÉDICALE

Optical imaging of neo-adjuvant chemotherapeutic response





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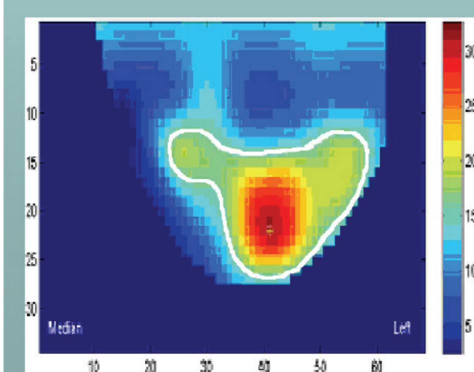

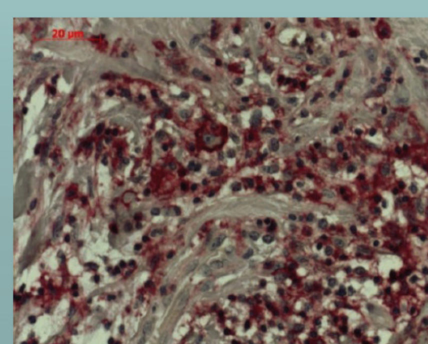

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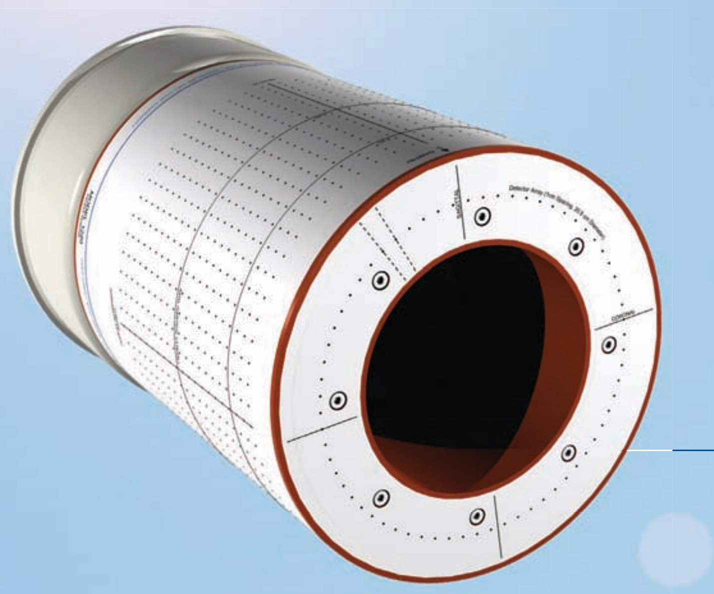

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InterACTIONS

Volume 55, Number 2– janvier/January 2009

Cover Image

Breast cancer is a leading cause of death in Canadian women. Although the clinical utility of breast imaging in the detection, diagnosis, and treatment monitoring of breast cancer is well established, the limitations of x-ray mammography, ultrasound imaging and other breast imaging modalities are well described in the medical literature. Near infrared diffuse optical spectroscopy (DOS) and diffuse optical tomography (DOT) are non-invasive techniques that quantitatively measure near-infrared absorption and scattering spectra across tissue. Although the technique has relatively low resolution compared to conventional imaging modalities, diffuse light contains *functional* information that is unavailable from structural imaging. Specifically, DOS / DOT provides information regarding the concentration and molecular status of intrinsic tissue absorbers such as oxyhemoglobin, deoxyhemoglobin, water and lipids. The cover shows a transverse image of a breast cancer patient imaged using DOT demonstrating an enhanced region of oxyhemoglobin within the tumour volume as determined by magnetic resonance imaging (MRI).

Currently, the Czarnota lab at the Sunnybrook Health Science Centre is exploring the use of DOS / DOT for use in breast cancer patients as a tool to monitor treatment efficacy. The study investigates optical tissue characteristics of breast tumours during neoadjuvant breast cancer treatment using a clinically approved DOS / DOT hybrid imaging system to determine if it is possible to distinguish responders from non-responders as assessed by MRI and clinical pathological outcome. The ultimate goal is to use optical imaging with ultrasound as an early predictor of partial or complete pathological response in women receiving treatment with neoadjuvant chemotherapy for locally advanced breast cancer.

Images provided by Dr. Hani Soliman and Dr. Gregory Czarnota, Odette Cancer Centre, Toronto ON

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Please submit stories in Publisher 98, Word 6.0, Word 97, or ASCII text format. Hardcopy submissions will be scanned to generate an electronic document for inclusion in the Newsletter. Images in Tiff format at 300 dpi resolution are preferred.

Message from the COMP Chair:

I would like to take this opportunity to welcome **Jean-Pierre Bissonnette** who has recently accepted the volunteer position of Chair of the Radiation Safety and Technical Standards Advisory Committee. Jean-Pierre is replacing **Robert Corns**. Special thanks to Robert for all the hard work he has put into chairing this committee.

We are now in the process of preparing for the 2009 Annual Scientific Meeting that will take place from July 21-24 in Victoria, BC. The Local Arrangements Committee (LAC) has been hard at work organizing the event and it promises to be an excellent conference. Now that abstract submissions are open (closing date May 1st) I hope that you will share your hard work with us by presenting your research in Victoria. I look forward to seeing you there.

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An important document for the Diagnostic Imaging community has recently been released by Health Canada: ***Safety Code 35: Safety Procedures for the Installation, Use and Control of X-ray Equipment in Large Medical Radiological Facilities.*** This is an excellent document and stresses the role of medical physics in quality assurance and safe practice in radiological facilities. Please take the opportunity to read the review article submitted by **John Aldrich** later on in this newsletter.

Here is a brief update on a few of our strategic plan items that are nearing completion:

Identify Potential Membership Categories

A new category will be introduced that will recognize those who have had a significant contribution to the field of Medical Physics and to COMP. The proposed category and criteria will be emailed to the membership prior to the 2009 ASM for voting.

Revise Professional Materials for the Medical Physicist Profession

A document detailing the role of a Medical Physicist and the educational and training opportunities available in Canada is nearly complete and will be available in time for the ASM in Victoria. This is an important document that will hopefully be used to promote our specialty and garner interest in those who may be considering a career in medical physics.

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Develop Guideline for the Development, Approval, and Use of Consensus Statements

Work is now underway regarding the review of pre-existing COMP documents with the goal of updating the terminology used within these documents. Specifically, this is to bring them in line with our current policy on evidence-based guidelines and consensus statements. This is being done so that those both inside and outside of our profession understand the degree to which these documents should be applied in practice.

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Mr. Jason Schella
COMP President

I wish to thank all those who take the time to volunteer on the various committees as well as those who are volunteering in other ways (reviewing abstract submissions, LAC, etc…). COMP would not be able to function without their help.

As always, if you wish to volunteer with COMP in some way, feel free to contact me at jason.schella@cdha.nshealth.ca or Nancy Barrett at nancy@medphys.ca. There is always room for you.

If you have an article that you would like to share with other COMP members, publishing through *InterACTIONS* is a great way to do it.

Wishing you all the best.

Message from the CCPM President:

This editorial is in response to questions posed by a colleague.

"Is or will COMP become a scientific society composed solely of clinical radiation therapy physicists?"

"Are medical physicists becoming narrow minded concentrating on their professional area and neglecting their roots in physics and other sciences?"

"Is the move in the US towards establishing a Doctor of Medical Physics degree an affirmative answer for both these questions?"

"Is or will COMP become a scientific society composed solely of clinical radiation therapy physicists?"

My response to these questions is not in my capacity as president of the CCPM, but in my day time job as a hospital based imaging medical physicist and an academic researcher at the University of Western Ontario.

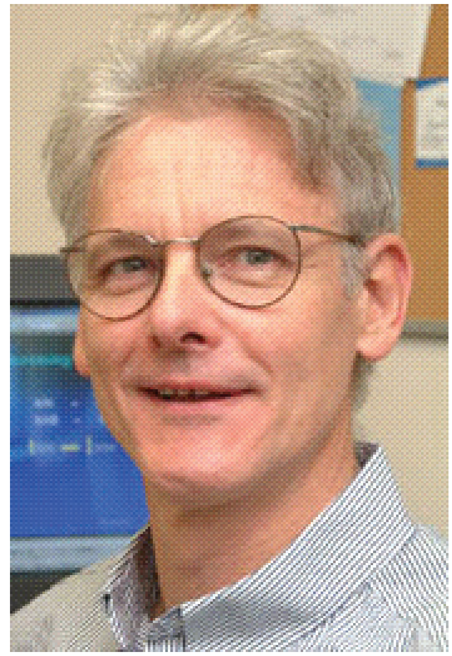
The answer to the first question is no. COMP's current membership and the mix of scientific presentations at the annual scientific meeting do not suggest that COMP is becoming a society for radiation therapists only.

"Are medical physicists becoming narrow minded concentrating on their professional area and neglecting their roots in physics and other sciences?"

The second question and how it relates to the third question is more complex. Both newer medical physics technology and changes in research funding with more emphasis on multi discipline research projects are pushing medical physicists away from a "narrow minded concentration on their professional area". For example, with many radiation therapy improvements requiring imaging, I have seen closer ties developing between the radiation therapy community and the imaging community. In London I've noticed much more interaction between the two disciplines in the past few years. This interaction includes both research grants and co-supervision of graduate students. Approximately 50% of the graduate student projects in radiation therapy involve imaging. In addition, many medical physicists interact with other colleagues from other medical disciplines outside of cancer therapy including psychiatry, cardiology, pediatrics, etc as well as the basic science departments including physics, biology and engineering. As far as I am aware, most if not all academic medical physics centers in Canada have a similar broad outlook and philosophy. So certainly in the medical physics academic centers the move is towards more multi discipline training and research as opposed to a parochial approach.

"Is the move in the US towards establishing a Doctor of Medical Physics degree an affirmative answer for both these questions?"

The corollary to the above is that with broader training there is less concentration on basic physics. Our training environment reflects this in that often graduate training in medical physics is centered outside the university physics department, for example the medical biophysics department. Yes, this does weaken the physics training of medical physicists. As a result, sometimes a new medical physics development, for example Magnetic Resonance Imaging, originates from physicists outside of medical physics and new medical physicists must be recruited from physics, chemistry and/or engineering programs to provide the knowledge and expertise in the new medical physics area. I don't see this as a negative; what would be a negative is if medical physicists were not willing to accept ideas from outside their own perceived discipline.



Dr. Dick Drost,
CCPM President

The move towards a Doctor of Medical Physics (DMP) degree program followed by board certification is controversial (Point/Counterpoint in Med. Phys. 35 (6) pg 2201-2203, 2008). The benefits are better trained medical physicists for patient care, but at the cost of a narrower scientific content with no research component in the training program. Both the current shortage of qualified medical physicists and the attempt at gaining state licensure in the US will push the development of a DMP training program. What would be the predicted effect if a DMP degree became a common medical physics training route in Canada? Based on similar models of training in other medical professions such as radiology and their scientific societies, I don't see it affecting COMP's membership composition or scientific work. However the radiology model does predict that medical physics would divide into two subgroups: the majority with a DMP that is primarily involved in patient care and a minority that is primarily in academic research and would have had additional research training. Therefore, the DMP would likely create (more of) a divide between research medical physicists and clinical medical physicists, but it will not make medical physics, as a whole, a field with a

Message from the Executive Director of COMP/CCPM:

Celebrating Volunteers

The month of April is not only an opportunity to celebrate that Spring is on the horizon but it is also the month in Canada where we celebrate the contribution of volunteers (April 19 – 25 is National Volunteer Week). Here are some of the activities COMP volunteers are involved in:

- Serving on the COMP Executive to set future direction, provide leadership and ensure the financial health of the organization
- Planning events – The ASM, the CCPM Symposium, the soon-to-be launched Winter School
- Coordinating the abstract submission process for the ASM and reviewing abstracts
- Serving on committees – Professional Affairs, Communications, Science and Education, RSTSAC, Awards, Gold Medal
- Keeping the website fresh and up to date
- Editing and coordinating the publication of the COMP newsletter
- Writing articles for the newsletter
- Reviewing CAPCA guidelines
- Judging award submissions
- Representing the medical physics community to other organizations

COMP is very fortunate to have so many dedicated volunteers and on behalf of the medical physics community in Canada, I would like to take this opportunity to say thank you!

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Join us in Victoria!

The Victoria Local Arrangements Committee and the Conference Committee have been working hard to create an event that will be top-notch both in terms of scientific content and networking. If you haven't already done so, register today! Please visit http://members.shaw.ca/COMP2009/

The Victoria Local Arrangements Committee and the Conference Committee have been working hard to create an event that will be top-notch both in terms of scientific content and networking.

Strategic Plan Update

As I mentioned in my last submission, we are making progress in a number of areas that were identified in our strategic plan. Here is an update:

- The newly-formed Science and Education Committee has hit the ground running. I encourage you to learn more about their activities by reading the SEC's article in this issue of the newsletter.

- One area that we focusing on is membership expansion. This is a significant undertaking and the first step is to get a handle on what the potential membership is. We have already extended an invitation to Physics Assistants to join COMP as Associate members. This was an initiative of the Professional Affairs committee and will provide this smaller group of professionals an opportunity to connect with each other under the COMP umbrella

- In an effort to reach out to our members working in an academic or research environment, we will be hosting a special session at the Victoria meeting. The session will provide an opportunity for members in this important group to provide us with insight and suggestions to better serve their needs.

In an effort to reach out to our members working in an academic or research environment, we will be hosting a special session at the Victoria meeting.

Ms. Nancy Barrett,
COMP/CCPM Executive Director

- We are also making an effort to reach out to adjacent communities. We have extended formal invitations to the leaders of CAMRT, CAR, AAPM, CARO, SNM, CRPA, ISMRM and ASTRO to attend our Victoria meeting. The Professional Affairs Committee is working to clarify and streamline our relationships with other organizations so that we are in a better position to advance the medical physics profession.

We are also making an effort to reach out to adjacent communities. We have extended formal invitations to the leaders of CAMRT, CAR, AAPM, CARO, SNM, CRPA, ISMRM and ASTRO to attend our Victoria meeting.

As always, please feel free to contact me at nancy@medphys.ca or Gisele Kite at admin@medphys.ca at any time with your feedback and suggestions.

CNSC Feedback Forum

Demystifying the CNSC Class II Facilities Licensing Process

Submitted by: Sonia Lala
CNSC, Ottawa ON

If you perused the CNSC Feedback Forum in the January issue of Interactions, you are probably now comfortable with reading a Class II licence and understanding its general scope and significance. Armed with this knowledge, it would only be natural that other questions would have popped up in your mind: Are there different types of licenses? How do they relate to one another? Can you hold more than one at a time? How does the whole process flow together? If you aren't one of the lucky few responsible for applying for a Class II license, hopefully this article will serve as a primer for how it all works!

At a Glance

From soup to nuts, the lifespan of a new Class II facility involves construction, commissioning, routine operation, and decommissioning. Each of these stages requires a separate CNSC licence, with conditions that are specific to the activity being conducted. Additionally, separate licences must be issued for each use type (eg. accelerator, teletherapy, brachytherapy remote afterloader). Fig 1 depicts the sequence, along with the estimated norms within which the Class II group aims to issue each type of licence <u>once they have a complete submission to assess</u>.

The requirements to apply for a new facility licence, as well to amend or renew an existing licence, are detailed in the regulatory guide entitled *Radiation Therapy – Licence Application Form and Guide*, fondly known as *C-120*.

A Closer Look

Certain information is consistently required in applications for all types of licences. Descriptions of use types and associated nuclear substances, proposed activities and their locations, and details of the radiation safety program, policies and procedures are just a few examples. Additional information is requested that is more specific to each type of application.

1. **License to Construct:**

An application for a construction licence consists largely of the proposed plans and elevation drawings to which the facility will be built. This information is reviewed for, among other things, the adequacy of shielding based on the specifications and intended operation of the prescribed equipment (equipment), as well as the purpose and occupancy levels of adjacent areas. Descriptions and wiring schematics for a number of safety systems and interlocks are also assessed at this time. Construction may begin upon the issuance of a licence to construct, and must be done according to the information provided in the application.

2. **Licence to Operate (Commissioning):**

The completion of construction is followed by commissioning, which refers to the necessary adjustments, tests and inspections that ensure the facility is in full working order according to specified structural and functional requirements before it is put to use. The process begins with testing of the functioning of all safety systems and a radiation survey – performed under worst case operating parameters – to ensure the integrity of the shielding, while under restricted facility access. Only once this has been done can operational acceptance tests be performed on the equipment

(Continued on page 45)

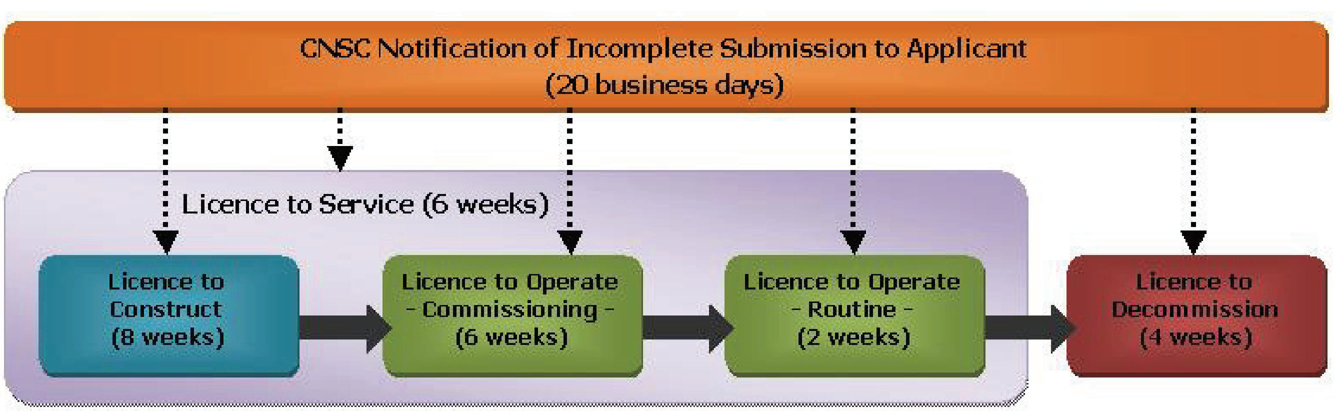

Fig 1: CNSC Class II Facility Licensing Sequence

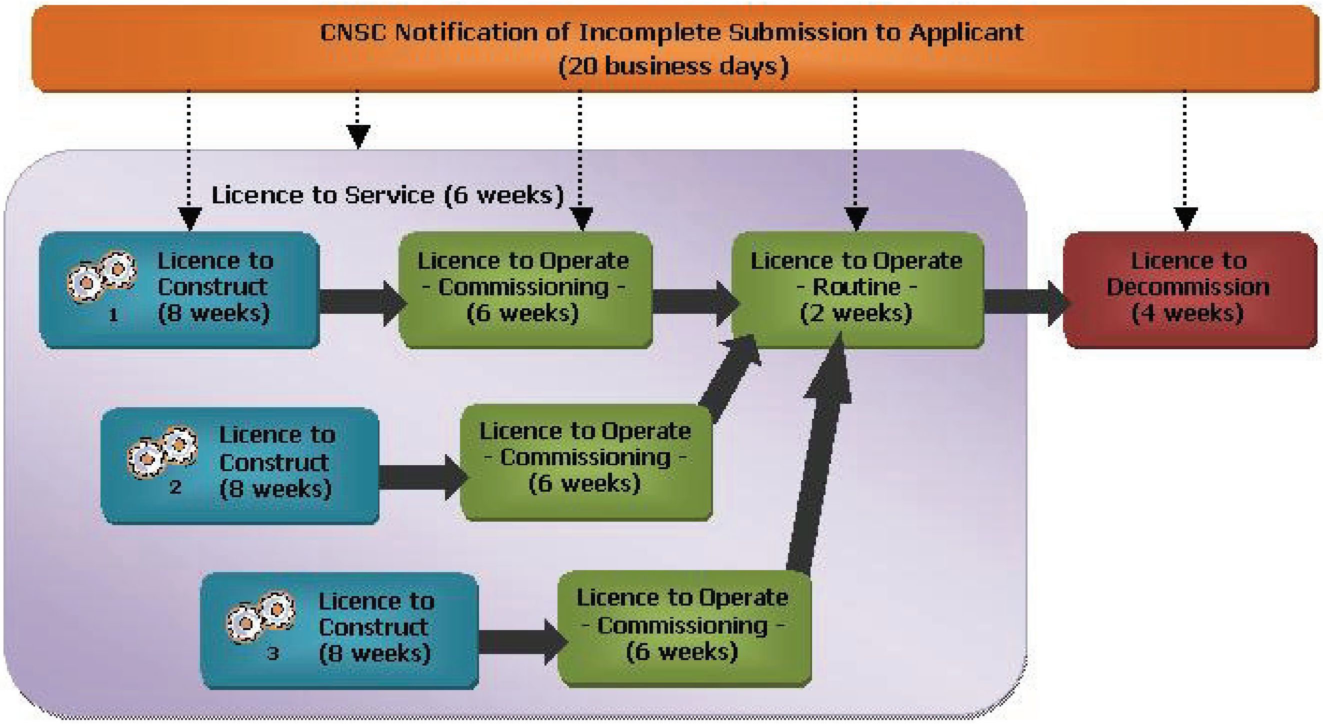

Fig 2: Amendment to Existing Routine Operating Licence

(Continued from page 44)

(e.g. beam commissioning).

The application for a commissioning licence requires confirmation that the facility was built according to the specifications in the licence to construct. Additionally, descriptions of the safety system tests, survey protocols and all associated safety precautions are necessary.

3. Licence to Operate (Routine): Incredibly important to note - during no time up to this point can patients be treated at the facility! How, then, does a facility “go clinical”? The plans for safety system testing and room surveys are put into action, and the results and any necessary corrective actions taken are sent to the CNSC. Along with these, operating procedures for equipment and instructions for specific groups of staff should also be submitted. Once all of this has been reviewed, a routine operating licence is issued. Here’s a mildly interesting fact – when a facility already holding a routine operating licence wishes to add new equipment of the same use type, the transition from the commissioning to patient treatment phase is treated as an amendment to the existing licence. This process is illustrated in Fig 2.

And now, you’re good to go! The facility has been built, the equipment and surrounding structures have been tested, and at long last, the doors can be thrown open to patients. So is that all there is to know? Not quite. CNSC licences are issued on the basis of the information submitted. Any changes made to this information need to be communicated to the CNSC, who then decides if a licence **amendment** should be made based on safety considerations. There is also the issue of licence expiry – licences are typically valid for 5 years, after which they must be renewed. At the time of **renewal**, relevant updates are made to any of the information used in licensing applications, or to the information contained in the Annual Compliance Report (ACR) submitted by the facility to the CNSC.

4. Licence to Service: The sharper-eyed among you will have noticed a slightly nebulous piece in the schematic shown in Figs 1 and 2, the servicing licence. These can be issued to the holder of the facility operating licence itself, the equipment manufacturer, or an independent service provider. If the licensed facility wishes to service in-house, this licence can be obtained as early as pre-construction up to the point where any initial manufacturer warranties or purchased service contracts expire. The application form and guide for servicing can be found in a separate draft regulatory document known as *C-207.*

5. Licence to Decommission: Now we have reached the final stage in the

(Continued on page 46)

CNSC Feedback Forum… continued

(CNSC...Continued from page 45)

lifespan of the facility. Decommissioning is a process by which the facility is retired once it is no longer needed. Radioactive and hazardous materials, equipment or structures are cleaned, dismantled, secured or disposed of so that the facility does not pose any safety risks to humans or the environment from that point onwards. The application for a decommissioning licence must demonstrate a clearly defined plan to do just this.

Before you break into a cold sweat at the vision of a growing mound of licences as the years go by and the facility expands and evolves, take heart. There is a method to the madness. For a given machine (and associated facility location), a particular type of licence is revoked once the next one in the sequence shown in Fig 1 is issued. Typically, a written request to revoke a current licence is sent by the licensee at the same time as the application for the next one.

It is worth pointing out that various types of licences (commissioning, routine operation etc) can be held simultaneously for different machines. Additionally, in the same way that a routine operating licence is amended each time a newly commissioned machine is added, it needs to be amended each time a machine on it is decommissioned. In fact, once a decommissioning licence is revoked, that particular machine should be removed from any other licences (e.g. servicing) that refer to it.

A Few Words of Advice

By now you're thinking, that's a lot of time and paperwork! And you would be right. If ever you find yourself charged with the task of applying for these licences, here are a few thoughts to keep in mind that could possibly smooth out and speed up the process.

- There is a decent amount of overlap in the information required from one licence application to the next. Don't resubmit all of this – simply refer back to the previous licence where relevant. To expedite the process, be as specific with your references as possible, using CNSC document reference numbers where known and applicable.

- If your licence is up for renewal but you have submitted an ACR within the last 6 months containing the same information required in the renewal application, refer to the report instead of resubmitting.

- You do not need a construction licence to prepare the site for the proposed facility. Soil and water level testing, clearing, excavation and pouring the foundation are all fair game.

- It is not necessary to have a commissioning licence before bringing in the equipment – it can be purchased and even installed during the construction phase. **Any production of radiation, however, is strictly forbidden in this phase!**

- Most of the application for a commissioning licence can be completed in advance, and sent to the CNSC at the same time as the application for the construction licence. Once construction is complete, simply submitting verification that it was done according to licence specifications significantly reduces the amount of paperwork to be reviewed by the CNSC at that time in order to issue a commissioning licence.

- The same can be said for the transition from commissioning to routine operating. Licensees are often in a big hurry to start treating patients, so it would be wise to complete and submit as much of the paperwork as possible ahead of time, and finish up with the safety system testing and room survey results.

- Housekeeping is always a good idea - keep licences "clean" by revoking any you no longer need. This frees you of associated obligations, such as ACRs.

- Let the CNSC know your anticipated timelines, (eg. when you would like to begin patient treatment, when you expect to shut down your machine for decommissioning). This helps your friendly Class II team prioritize their licence assessment load to help you meet your targets.

It's likely that you will require multiple licences for multiple use types. To significantly reduce the documentation required for licensing, you are permitted to consolidate all operating and servicing licences. Choosing this type of licence has the added benefit of expiry after 10 years, as opposed to 5. This is explained in more detail in the October 2007 issue of Interactions.

So this is the licensing sequence in all its glory. As you undoubtedly keep back issues of Interactions at your fingertips for quick reference, you may wish to reach for the October 2008 issue. It is here that you can learn about the legal basis for Class II licences, as well as the answers to more specific questions frequently asked by licensees about the process. If you would like copies of any of the regulatory guides mentioned in this article, please don't hesitate to contact your Class II physics specialist or project officer.

Happy reading!

COMP Member Joins the Canadian Medical Hall of Fame

Dr. Sylvia Fedoruk, FCCPM and Emeritus member of the Canadian Organization of Medical Physicists has been inducted into the Canadian Medical Hall of Fame. Dr. Sylvia Fedoruk was professor of oncology and associate member in physics at the University of Saskatchewan, as well as chief medical physicist at the Saskatchewan Cancer Clinic and director of physics services at the Saskatchewan Cancer Clinic.

She was involved in developing the world's first cobalt 60 unit and one of the first nuclear medicine scanners. From 1986 to 1989, she was chancellor of the University of Saskatchewan and was subsequently lieutenant-governor of the province. She is also a member of the Canadian Curling Hall of Fame*.

** Adapted from an announcement published in the December 5, 2008*

Introducing the COMP Science and Education Committee

Submitted by: Marco Carlone on behalf of the SEC committee
Princess Margaret Hospital, Toronto ON

COMP has recently initiated a new committee, the Science and Education Committee (SEC). The mandate of this new committee is to promote and support the science of medical physics; to facilitate good practice in all aspects of education, training and professional development for those within the profession, and to organize educational programs of high quality. The SEC began formal operation last fall when the first members of the committee were assembled. The committee membership is made of seven individuals including: the Chair, the COMP Chair-elect, a representative from the CCPM, the Chair of the COMP Student Council (see the article in this issue of IntreACTIONS from the Student Council co-Chairs) and three members at large.

As the name implies, this committee will preoccupy itself with matters of Science and Education relevant to COMP members. There are many areas in the Medical Physics community for COMP members to turn for guidance in scientific issues and to seek out continuing education and professional development. Why does COMP need a new committee to address this? As the voice of Medical Physics in Canada, COMP has many responsibilities to its members. Our practice is in many ways similar to that of Medical Physicists worldwide. However, Medical Physics in Canada poses some unique challenges: The manner in which our health care system is funded, our proximity to the United States, the great distances between major Canadian cities, the relative small number of practicing Medical Physicists in Canada and the relatively large size of the average Radiation Oncology facility in Canada make our scientific, education and professional development needs distinct from other Medical Physicists elsewhere in the world.

Starting a new committee such as this one, with its ambitious mandate, is an overwhelming task. There are many areas that need attention and championing, however there are few resources available to promote these. The decision by COMP has been to begin to address these by developing a new continuing education opportunity for Medical Physics in Canada. Hopefully, January 24, 2010 will see the first offering the COMP Winter School of Medical Physics in Banff, Alberta. The purpose of this school will be to provide practicing Medical Physicists an opportunity to learn from world experts in areas that are of current importance to the practice of Medical Physics in Canada. Many details of the school have yet to be worked out, however the intention is to run this school yearly in two alternating locations, one in the east, and one in the west.

Some may ask the question, why does COMP need a continuing education “School”? Doesn’t the AAPM already offer this through its very successful Summer School? The purpose of the Winter School will not be to compete with the AAPM’s Summer School, but rather to complement it. The format of the school will consist of lecture time, free time to discuss and interact with other attendees, and organized discussion sessions with world leaders in Medical Physics in an intimate setting. The particular subjects of the school will be thematic and may continue for several successive years rather than change from year to year. In my brief time in the field of Radiation Oncology Physics, I have already witnessed several watershed moments where this practice changed significantly over a matter of a few years. The introduction of CT into radiotherapy, the transformation of planning systems, the automation of treatment delivery, and the addition of sophisticated image guidance systems were

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2009 Recipient of the COMP Gold Medal

The Gold Medal is the highest award given by the Canadian Organization of Medical Physicists and is given to currently active or retired individuals to recognize a medical physicist who has worked mainly in Canada and who has made an outstanding contribution to the field of medical physics in Canada. An outstanding contribution is defined as one or more of the following:

1. A body of work which has added to the knowledge base of medical physics in such a way as to fundamentally alter the practice of medical physics

2. Leadership positions in medical physics organizations which have led to improvements in the status and public image of medical physicists in Canada

3. Significant influence on the professional development of the careers of medical physicists in Canada through educational activities or mentorship

This year, the 2009 Gold Medal is awarded to:
Mrs. Margaret E. J. Young
Congratulations!

2009 COMP Gold Medal

Introduction Speech provided by Cheryl Duzenli
Vancouver Cancer Centre, Vancouver BC

Margaret Young was a pioneer in clinical radiation oncology physics in British Columbia. She was born Margaret Elizabeth Jane Carr in Ealing, London in 1922. Following elementary school, she was educated at Haberdasher's Aske's School which was evacuated to Dorchester during the war. She took a first in Physics at Royal Hollaway College, London University, completing her BSc in 1943, followed by an MSc in 1949.

In 1943 at the age of 20, while working as a demonstrator in physics at the Royal Free Hospital for Women, Margaret was invited to become the youngest founding member of the Hospital Physics Association in the UK. She continued to work as a lecturer in physics at the Royal Free Hospital from 1943 to 1949 and as a physicist at the MRC Radiobiological Research Unit at the Atomic Energy Research Establishment in Harwell from 1949 to 1951. Mrs. Young's first publication in the field of Medical Physics appeared in Nature: M.E. J. Carr, A simplified chemical method radiation dosimetry, 167, 363, 1951. In 1951 she married Dr. Lawrence Young and accompanied him to Ottawa. The Youngs spent 1951 to 1952 in Ottawa, Mrs Young working as a physicist at the Ottawa Civic Hospital. After returning to London from 1952 to 1955 where Mrs. Young worked at the Charing Cross Hospital, Dr. and Mrs. Young returned to Canada in 1955, taking up residence in Vancouver.

In 1956 Mrs. Young was hired as a medical physicist by Dr. Harold Batho at the British Columbia Cancer Institute (BCCI, successively known as the Cancer Control Agency of British Columbia, CCABC and now as the B. C. Cancer Agency, BCCA). At this time, the first Cobalt unit had just arrived at the BCCI and Margaret's first task was to construct wedge filters and measure isodose curves for this unit. Wedge filters were made by the physicist, sticking together sheets of lead of different width, finding out by trial and error and many dose measurements the required thicknesses to produce the desired dose distribution. Margaret was a close colleague of Dr. Batho until he retired in 1973, co-authoring at least nine papers primarily related to linear radium sources. Mrs. Young and other members of the medical physics group at the BCCI were highly dedicated to establishing the validity of the Batho correction which appeared as an empirical correction in Dr. Batho's 1964 paper (H.F. Batho, Journal of the Canadian Association of Radiology, 15, 79, 1964). Mrs. Young wanted to ensure that if the method was challenged it was at least challenged on the basis of good science and a correct understanding of the physics involved. This is witnessed by Mrs Young and Dr. Kornelsen's letter to the editor (Med Phys 5 (1) p68-69, 1978) in response to a paper by McDonald et al (MedPhys 3 p 210 1976).

Margaret did extensive teaching for nurses (who have now been replaced by therapists for treatment delivery) radiographers and physics students. Her textbook titled 'Radiological Physics' is still in use at the BCCA today. The first, second and third editions of this book were published by H.K. Lewis & Co. LTD in London in 1957 and 1967 and 1983 respectively.

In addition to the textbook, perhaps her best known contribution to medical physics was the work Mrs. Young did on Radium tables. Primarily, she performed calculations for converting the in-air dosimetric data to tissue dosimetric data. To accomplish this work, she used a fairly primitive computer, an ALWAC 3E at the University of British Columbia The first paper published in an international journal by the medical physics group at the

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2009 COMP Gold Medal Speech… continued

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BCCI was: M.E.J. Young and H.F. Batho, The use of electronic computers to calculate data for isodose curves, British Journal of Radiology (Instrumental and Technical Notes), Vol XXXII, no 381, 629, September 1959. Mrs. Young was also involved in treatments using ^{32}P for intra-peritoneal treatment for ovarian carcinoma and had some involvement with the negative pi meson medical facility at TRIUMF. Some of the more intriguing titles of internal BCCI reports authored by Mrs. Young include: "Measurements with Lithium fluoride and aluminum rods in p-therapy beams", and "Precautions required to prevent radioactive contamination of operating room during abdominal operations on patients who have had an intra-peritoneal therapeutic dose of radioactive phosphorus ^{32}P.

Mrs. Young was involved and committed to various professional organizations. She was a founding member of the Canadian College of Physicists in Medicine (CCPM). The founding of the CCPM took place in 1978, at the annual general meeting of the Canadian Association of Physicists (Division of Medical and Biological Physics) in London Ontario. She was also the Secretary Treasurer of the Division of Medical and Biological Physics of the Canadian Association of Physicists from 1975 to 1978. In addition, Mrs. Young was a member of the Institute of Physics and Physical Society, the Society of Nuclear Medicine an a associate member of the Royal Society of Medicine. Margaret also served a three year term on the Editorial Board of the journal Physics in Medicine and Biology as the Canadian representative.

True to her determined and rigorous work ethic, Mrs. Young retired from the BCCA in 1985 only after a protracted argument with the pension authorities about their method of calculating pensions for part-timers. Eventually, Mrs. Young 's argument succeeded and employees at the BCCA today continue to benefit from her efforts in this regard. The Youngs have remained in Vancouver, having settled in the Southlands area known for its' horse back riding facilities. Mrs. Young and her husband were very involved in horse riding as a lifelong hobby and have spent some time in Montana pursuing this.

It was a great pleasure and honour to have met Mrs. Young in April 2007 when she visited the BCCA and toured our new machine shop facility and our newest image guided, stereotactic radiosurgery / IMRT equipped linear accelerator. Mrs. Young made use of the opportunity to remind us of the importance of the role of the physicist in checking the accuracy of dose calculations for our patients. On this occasion, Mrs. Young donated her personal copy of the 3rd edition of her book 'Radiological Physics' to the department of Medical Physics at the BCCA.

A fitting summary of Margaret Young's qualities as an individual and as a medical physicist is provided in her biographical sketch found in the 'History of the Hospital Physicists Association 1943-1983' (HPA, Newcastle upon Tyne, 1983). To quote from page 138, "…she is a country lover and when not walking or gardening, she may well be show jumping. She is (known) for her warmth of personality and as a first rate physicist, methodical and reliable in all she (does), an idea colleague."

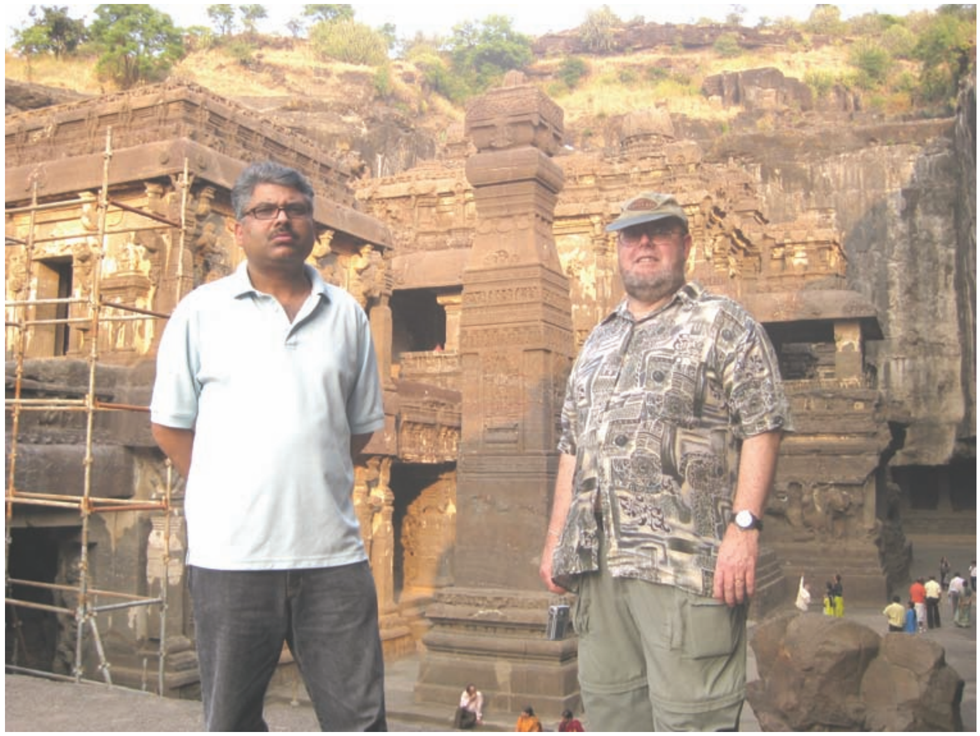
Vancouver BC, February 2009

This contribution was complied by Dr. Cheryl Duzenli with assistance from Dr's Ken Yuen, Lawrence Young, Doug Cormack and R. Kornelsen (departmental files), Larry Watts and Greg Kennelly

International Conference on Medical Physics (ICMP08) at BARC, Mumbai, India

Submitted by: L. John Schreiner and Chandra P. Joshi
Kingston General Hospital

Last year we were invited by the organizers to attend the International Conference on Medical Physics-2008 (ICMP-2008) and 29th Annual Meeting of the Association of Medical Physicists of India (AMPI). The conference was organized by Bhabha Atomic Research Centre (BARC), Mumbai, India in collaboration with AMPI, and there was a joint session on the Friday with the Association of Radiation Oncologists of India (AROI).



Chandra Joshi (left) and John Schriener (right) at the carved Hindu temple at Ellora Caves, near Aurangabad.

With local hospitality provided by the organizing committee and with travel support from Best Theratronics and the CCSEO we were able to attend the meeting between November 26 and 29 in Mumbai. The meeting attracted about 650 medical physicists and researchers, including ~120 postgraduate radiological/ medical physics students. About 300 radiation oncologists joined the AMPI/ AROI session on Friday, although ~800 had been expected. Events in Mumbai at the time had changed many people's plans, as we will also report below. About 24 equipment vendors and suppliers attended the meeting including Canadian representatives from Modus Medical in London, although sadly, after Wednesday some booths were vacant.

We arrived in India a week before the meeting, since we had some business at the University of Pune in Pune, a city of 5 million about one hundred and fifty kilometers inland from Mumbai. This provided time for us to acclimatize ourselves before the meeting, and gave us a chance to do a bit of travelling to further sites near Aurangabad (240 km further inland still) over the first weekend. India is an amazing country of contrasts with areas of incredible affluence with access to the highest technology and in immediate contact with desperate poverty where barely the basic necessities are available. This was an eye opener to John the Westerner.

When we returned to Mumbai we joined many of the other invited speakers at a pleasant hotel, the Jewel of Chembur in Chembur, a suburb of Mumbai. We had a day and half to sightsee around Mumbai, an amazing city of about 19 million (in an area smaller than the city of Ottawa). We went to the Gateway of India where we took a picture of John with the Taj Mahal Hotel in the background and walked to the CST (Victoria Terminus) train station to take a train back to the suburbs – which we never did since John found the crowds too overwhelming and asked that we leave.

We had the opportunity to visit the radiation oncology department of the Tata Memorial Hospital, a six hundred bed hospital devoted only to cancer care that is one of the major cancer centres in India. The department runs from about eight o'clock in the morning to seven at night and typically treats about four hundred patients daily on four cobalt machines, three linear accelerators and an HDR suite. About 260 patients are treated with cobalt (70 of these on a single T780c from Canada), 140 on the linacs and 10-12 on HDR. Between 40-50% of the patients have a computerized treatment plan generated.

We had an opportunity to see perhaps the smallest cobalt room in the world where the machine could not even rotate through a full ninety degrees. Yet they were doing IMRT in that same centre and were installing a tomotherapy unit (there is one already in service at a satellite clinic across town). This illustrates the innovation of the 8 medical physicists, and the radiation therapists and oncologists, as they use a broad range of tools to provide care. It was quite remarkable to observe how they work. One of us (John) had never been to a cancer centre where patients were lined up in the hall to come to their treatment sessions. The medical physics department also provides training for physics graduate students, diploma in radiation physics students and radiation oncology residents for the University of Mumbai. Research topics range from basic science to clinical practice including topics in dosimetry for IMRT and treatment planning evaluation and development. The department also runs workshops for CME of medical physicists and radiation oncologists from across India and neighboring countries (under the auspices of the IAEA and WHO).

The conference began on the Wednesday morning at the excellent facilities in a training centre at BARC. The conference

ICMP08… continued

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was very formal and the first morning had numerous welcoming talks by officials and dignitaries from various scientific organizations and the Atomic Energy Commission of India. The formality was maintained throughout the conference and at the end of every session speakers were thanked by one or two senior scientists or officials and presented with a plaque that they could keep as a memento. Because of the formal protocol followed sessions ended late and the days ended typically one to one and half hours later than planned. Another interesting point was that the whole meeting was recorded on video so that every session was actually captured for posterity. These sessions are going to be available in the near future.

The sessions were very consistently well attended and the science was much like that we would see at the annual COMP/ CCPM meeting. There were a number of plenary talks that had content similar to talks we would have at a CCPM symposium, some of these were given by international invited speakers (three of these by us). Bhudatt Paliwal, (University of Wisconsin, Madison), Lei Xing (Stanford University), C. Kirisits (Medical University of Vienna), and Habib Zaidi, (Geneva University Hospital) gave excellent talks on developments in modern radiation therapy, image guided radiation therapy, imaging in brachytherapy and molecular imaging, respectively. Bhagwat Ahluwalia (University of Oklahoma Health Centre), Lisa Karam (NIST), Satish Jayawant (New Jersey but an old friend from Princess Margaret), Surendra Rustgi (D3 Radiation Planning), Natalie Fournier-Bidoz (Institut Curie, Paris), Venkat Narra (New Jersey Medical School), Baldev Patyal (Loma Linda University), and Daryl Nazareth (Roswell Park, Buffalo) not only gave interesting reports on technical developments and advances in the clinic and in dosimetry but also became good friends over the course of events in the city, as we were all in the same hotel.

The proffered talks were much like those at a COMP meeting, although unfortunately there were two parallel sessions so we were not able to attend all the sessions. We say unfortunately since the sessions were on the whole very good and it was quite impressive to hear a number of students and researchers present very

John Schriener speaking at the conference.

nice pieces of work in a clear and very professional manner. There were excellent sessions on IMRT, image guidance, tomotherapy, molecular imaging and similar topics. There were also a number of talks on the challenges of doing medical physics in India, including some reports on the challenges of establishing cancer centres in rural communities where access to technology and funding is limited. One talk we enjoyed was on the indigenous Indian cobalt unit under development: the Bhabhatron II. Many of the candidates presented as clearly and articulately as anyone we would see at COMP. In particular, the talks by the young attendees were, for the most part, very good and the professors and supervisors in the room could be very proud of their students and how well they represented their respective institutions.

Some of our encounters were different from what we would usually experience at a meeting in Canada. Although there were announcements at the start of every session that cell phones should be silenced, there was a pretty constant cacophony of cell phones sounding ringtones throughout the meetings. At one point in the joint meeting with the radiation oncologists we observed to each other that the room sounded like a games arcade. Cell phones are much more widely used and tolerated in India than we are used to in Canada.

The other unusual occurrence was of course the horrible events associated with the terrorist attacks at the Oberoi Trident and Taj Mahal hotels, and the CST train station during the Wednesday evening and Thursday morning. Fortunately for us and many of the invited speakers, we were at the Jewel of Chembur about eight kilometers away. However, the conference did not go untouched and as most of you are likely aware that there were a number of attendees at the conference who were affected by the attacks. In particular, five representatives from Tomotherapy and from Kirloskar Medical (the Indian agents for Tomotherapy as well as Best Theratronics) were at the Oberoi Trident Hotel when it was attacked.

The incidents at the hotel and downtown did have a major effect on the meeting right at the outset. Quite a few of the exhibitor booths were vacated and many of the oncologists expected at the AROI meeting did not travel to Mumbai. Some of the social events, such as a dinner cruise near Gateway of India, had to be quickly relocated. A number of speakers on the Thursday, the second day of the meeting, did not show up at their ap-

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Safety Code 35 and Canadian Medical Physics

Submitted by: John Aldrich
Vancouver Coastal Health Region, Vancouver BC

Introduction

Health Canada Safety Code 35 (SC 35) - ***Radiation Protection in Radiology – Large Facilities*** is easily the most important document for diagnostic x-ray systems that has been published in the last 25 years – it may also be a seminal one for Canadian medical physicists.

First, a bit of history. Safety Code 20A ***X-ray Equipment in Medical Diagnosis: Recommended Safety Procedures for Installation and Use*** has guided the use of x-ray systems in Canada since around 1976 (although there was a minor revision in 1999 to include the new Radiation Emitting Devices Act). It included mandatory and recommended practices for ensuring radiation safety in medical radiological facilities. It addressed the responsibilities of personnel, building and installation requirements, radiation protection surveys, equipment specifications, procedures to minimize radiation exposures to personnel, patients and the public. The Code was written primarily for the instruction and guidance of persons employed in federal public service departments and agencies, as well as those under the jurisdiction of the Canada Labour Code. However, it became widely used in provincial radiological facilities such as hospitals and clinics, in teaching institutions as well as by provincial government departments and agencies responsible for radiation safety. Many provinces now reference Safety Code 20A in their regulations for radiation safety in medical facilities. It is referenced in provincial regulations and forms part of the curriculum of trainee technologists and physicists.

In 2005 the first draft of the new Code, then called XX was circulated for comment by Health Canada. Most of those who saw this document were impressed by its almost audacious scope, but were rather critical of the complexity of the document. Another draft in 2006 and further comments has led to this current published version, which is a far better document, and of which Health Canada can be justly proud. Now, as well as being a member of COMP, I am a member of the AAPM and IPEM, so I see a lot of patient dose and quality control standards come across my desk. Health Canada has carved a very neat line between over- and under-prescription of QC procedures and has managed to address the issue of patient dose. Apart from a few minor mistakes, it is a very useful document.

Everyone involved in medicine will know that diagnostic radiology has dramatically changed since 1976. Even since 2000! Safety Code 35 aims to address this changed environment, specifically:

The introduction of digital detectors in almost every imaging modality
New standards from the International Electro-technical Commission (IEC)
Newer x-ray shielding design methods based on empirical data

Not surprisingly, SC 35 is dramatically different from SC 20A. Firstly, it combines SC 20A and SC 31 ***Radiation Protection in CT Installations***, so covers all x-ray modalities (except DEXA and mammography). Another large change is the amount of QC in SC 35. SC 20A covered only film processor QC: SC 35 devotes over a quarter of the document to QC.

The Code can be divided into the following sections:

A1.0 Responsibilities of owners and users
A2.0 Procedures for minimizing staff dose
A3.0 Procedures for minimizing patient dose
B1.0 Facility shielding
B2.0-B6.0 Equipment performance (RED Act) and protection surveys
C1.0-C3.0 Quality Control
Appendices

Sections A1.0 and A 2.0 are largely similar to SC 20A, but rewritten with better clarity. They form a good outline for the radiation safety program of any radiology department or radiation oncology department where x-rays are used for diagnosis or planning.

Patient Dose

Section A3.0 covers the general principles for dose reduction, and those like myself interested in optimizing patient dose, were pleased to see that it includes Diagnostic Reference Levels (DRLs). Unfortunately part of this important section can be misinterpreted. For those of you unfamiliar with patient dose, DRLs are guideline values of *dose indicators* which can be easily measured and are related to patient dose. Examples would be dose-area product or surface dose for radiography and radioscopy and dose-linear product for CT. It turns out that it is very difficult to find the minimum dose *acceptable* for a certain diagnostic accuracy. It is however fairly easy to find those doses which are ***unacceptable*** by measurement of typical doses in a country or region. Those doses which are in the top 25% are said to be unacceptable, and the DRL is set to the 75% value of the dose indicator distribution.

SC 35 appears to recommend that individual departments measure their own DRL values using phantoms. As phantoms are rarely truly anthropomorphic, this may produce unusual results (for example even the simple PA chest x-ray). Most published DRLs have been obtained from actual patient studies. It is also necessary to measure many clinics or departments, as in the same department the protocols are likely similar and possibly incorrect. In the absence of local DRLs, the EU or ACR DRLs should be used as a starting point for comparison of your own measured dose indicators.

Shielding

Section B outlines the shielding methods of NCRP 147(2004), which is largely based upon empirical measurements of scatter, and takes into account attenuation by the patient and detector. However, Appendix III gives detailed information on how to calculate shielding based upon NCRP 49 (presumably due to copy-

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Safety Code 35… continued

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right considerations), which tends to err on the conservative side, and had little information on CT! It is much better to purchase NCRP 147 or the parallel document from the British Institute of Radiology – *Radiation Shielding for Diagnostic X-rays*(2000).

Quality Control

Section C is all concerned with Quality Control – far too detailed to go into in a review! So I am only going to touch on two areas. Firstly, QC which is common to most x-ray systems, and secondly, QC for computed tomography. These sections will apply to all diagnostic radiology departments and most radiation oncology departments.

The next few tables show the common QC procedures SC 35 recommends for all systems.

Quality Control Procedures	Film	All Systems
Daily Quality Control Tests		
Equipment Warm-up (D1)	According to manufacturers instructions Can include auto calibration(D1)	
Meters Operation (D2)	*Meter, visible and audible indicators should function*	
Equipment Conditions (D3)	*Visual inspection for loose or broken components, ease of movements*	
Darkroom Cleanliness (D5)	(M DAP)	
Film Processor Function (D6)	(M DAP)	
Overall Visual Assessment of Electronic Display Devices (D7)		Display SMPTE or QC pattern for general image quality of all Radiologists' workstations

The indication for required or recommended tests is the same in all the tables.

Normal Font – Required Tests *Italics – Recommended*

Letters and numbers refer to the detailed paragraphs in the Code.

Quality Control Procedures	All Systems
Weekly Quality Control Tests	
Viewbox condition (W2)	Visual inspection for cleanliness, colour, illumination
Laser Film Printer Operation (W3)	Print pattern such as SMPTE or PQC Check for 0/5% and 95/100% patch visibility OD of 10% to 90% patches No artifacts or geometrical distortion
Monthly Quality Control Tests	
Darkroom Temperature and Humidity (M2)	Temp: 18-23C; Humidity 40-60%
Darkroom Light Conditions (M3)	Visual check for light tightness
Film Processor Operation (M4)	Temp ± 0.5C; Developer and fixer correct (M DAP)
Electronic Display Device Performance (M6)	Display pattern such as SMPTE or QC on all image display stations
Laser Film Printer Operation (M7)	As W3 plus measurement of optical density of the 10% to 90% grey scale

Quality Control Procedures	All Systems
Quarterly Quality Control Tests	
Interlocks (Q2)	These are not usually used on diagnostic doors
Annual Quality Control Tests	
Safelight Test (Y1)	Expose film for 2 min
Viewboxes (Y26)	Check luminance, uniformity, homogeneity, ambient light
Electronic Display Device Performance (Y27)	All clinical workstations must be calibrated for luminance, distortion, resolution and noise
Integrity of Protective Equipment (Y28)	Lead aprons, glasses, integral shields
General Preventive Maintenance (Y29)	As per manufacturer

Comments in the last column are partly from the Code and partly mine.

In the common quality control procedures required, the QC of digital display and printing systems is greatly emphasized, and is certainly more frequent than most of us have been performing.

QC of Computed Tomography

Many of these tests were performed on an annual basis by some departments, and certainly at acceptance. Again SC 35 requires many of these tests to be performed more frequently. Most CT service contracts perform some of these tests (but no radiation measurements), but usually only on an annual basis.

Quality Control Procedures	CT Systems
Weekly QC Tests	
CT Number Accuracy	Check CT number water 0 ± 4 HU (W4)
CT Noise	Image noise in center of water phantom ± 10% from baseline value (W5)
CT Uniformity	Check CT number in center and 4 quadrants ± 10% from baseline value (W6)
Monthly QC Tests	
Electronic Display Devices Performance	All device used to display digital images – use pattern SMPTE
CT Tomographic Section Thickness	Slice thickness should be ± 0.5 mm from baseline value (M8)
Calibration of CT Number	Check CT number water 0 ± 4 HU and air 1000 ± 10 HU (M9)
CT Number Linearity	*Check CT number over CT range -1000 to +1000 (M10)*

Quality Control Procedures	CT System
Quarterly QC Tests	
Interlocks (Q2)	Interlocks are seldom used on CT scanner doors in diagnostic radiology departments
CT Patient Support Movement	Check table movement corresponds to digital display ±1 mm (Q8)
CT Spatial Resolution	Measure MTF or line pair phantom (Q9)
CT Low Contrast Detectability	Q10
Semi-annual QC Tests	
CT Laser Light Accuracy	Check laser light vs X-ray beam with phantom(SY1)
CT Accuracy of Automatic Positioning of Tomographic Plane (using the scanned projection radiograph)	Check localization scan corresponds to digital display ±2 mm (SY2)
CT Accuracy of Gantry Tilt	*SY3*
CT Patient Dose	Check CTDI ± 20% from baseline values (SY4)

Quality Control Procedures	CT System
Annual QC Tests	
CT Number Dependence on Phantom Position	Check CT number water 0 ± 5 HU for possible patient positions in the gantry(Y23)
CT Radiation Dose Profile	*Y24*
CT Radiation Dose—Scout Localisation Image	Radiation Dose for Localisation Image within 20% of baseline value (Y25)
General Preventive Maintenance	PMs must be performed (Y29)

What does this all mean for Medical Physics?

Safety Code 35 is one of the few regulatory documents in Canada in which Medical Physicists are mentioned by name:

The medical physicist /radiation safety officer must:
1. possess qualifications required by any applicable federal, provincial, or territorial regulations or statutes and be certified according to a recognized standard, such as
i) for medical physicists, the Canadian College of Physicists in Medicine;

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ESTRO 2008 IGRT Teaching Course
Report of the 2008 Harold E. Johns Travel Award Visit

Submitted by: Russell Ruo
McGill University Hospital, Montreal, QC

I would like to thank the CCPM awards committee for granting me the Harold E. Johns Travel Award this past summer. The award was of significant assistance and helped give me an opportunity to attend the ESTRO 2008 IGRT teaching course. The following is a summary of the course and site visits I made during my trip.

The course was held at the University of Brussels the week of December 6th through the 11th and was well attended with 158 participants from 28 countries. Participants were roughly divided equally among the 3 professional disciplines in our field of work with 58 medical physicists, 50 radiation oncologists, 44 radiotherapy technologists, and 9 others (medical oncologists, IT support and dosimetrists).

The teaching staff was exceptional with representation from all 3 professional disciplines. The medical physics staff consisted of course director Dirk Verellen (VUB, Brussels), Marcel van Herk (NKI, Netherlands), Stine Sofia Korreman (Rigshospitalet, Denmark), Christian Kirisits (Medical Univ. of Vienna, Austria) and Uwe Oelfke (DKFZ, Germany).

The first day began with introductory seminars giving perspectives on IGRT from the physicist, physician and technologist points of view. A key component of the course were the site visits in the afternoon to several centers in or near Brussels. Participants had a choice of visiting 4 centers representing the different vendor IGRT solutions. I chose to stay in Brussels to see the BrainLAB stereoscopic KV X-ray and Tomotherapy MV-CT solutions. Each site visit included an introductory presentation from the physicists and physicians on the vendor solution available at their center and how they have utilized IGRT in their clinic. This was followed by rotations through several demonstrations illustrating the workflow process adopted by the site. In Brussels we rotated through the treatment planning, BrainLAB Novalis and Tomotherapy rooms. The day ended with a presentation of the clinical results achieved by the center followed by an open question and discussion session with the participants.

The following 2 days consisted of lectures focusing on the technical considerations for using IGRT including: errors, margins, advanced imaging technology, considerations for the 4th dimension of time, correction strategies and image registration. Each day ended with workshops discussing each of the major vendor solutions available on the market. The workshops started with videos made at each of the centers from the site visits illustrating the workflow process adopted by the center. The video sessions were then followed by open discussion periods. Several vendor or IGRT technologies were presented: KV-CBCT from Varian, and Elekta, stereoscopic KV imaging from BrainLAB and Cyberknife, MV-CT from Tomotherapy, Ultrasound from various vendors and various IGBT solutions.

The last 2 days consisted of more clinically focused lectures discussing IGRT for different patient sites, the role of patient positioning, frameless radiosurgery and the role of IMRT in combination with IGRT.

Despite the large European concentration of experience presented, I'm happy to report that Canadian content was well represented. The work of Dr. Jaffray and the PMH group in Toronto was cited numerous times. Also, the 3D ultrasound system developed by Resonant Medical in Montreal was well endorsed by one of the teaching faculty during his presentation on US guidance technology.

In addition to the course lectures, two social events were planned. On one evening, participants were invited to a friendly bowling competition at the university complemented by Belgian beer. The social dinner and dance was held at the Hotel Metropole. This site is of interest to physicists because it is the location of the Solvay conferences, the most famous being the 5th conference in 1927 where notable physicists such as Einstein, Bohr, and Marie-Curie discussed and debated over the newly formulated quantum theory at that time.

In summary, the course faculty gave a comprehensive review of IGRT and the solutions currently available. The lectures were well presented and the course was well received by all the participants. The course was useful in showing how imaging tools (2D,3D, 4D) are now finally being integrated into the delivery systems such that clinicians are better equipped to verify target positioning. However, despite better target positioning, a major dilemma is the uncertainties in delineation of the target, which now is becoming the primary source of error in target margins.

In addition to the ESTRO course, I had the opportunity to visit two other centers while in Europe: Gustave Roussy (Paris) and Royal Marsden Hospital (London-Fullham site). Both centers were in the early stages of implementing IGRT technology. Gustave Roussy was just beginning to use clinically the KV-CBCT technology while at the RMH the KV-CBCT and stereoscopic-KV imaging were being used clinically for less than a year. More interesting was the opportunity to compare and contrast the responsibilities and techniques used by our European colleagues.

Finally, I would like to thank the CCPM again for the opportunity provided through the H.E. Johns award in allowing me to attend the course. Without it, the trip certainly would not be possible. Also, I would like to mention a note of appreciation to my supervisor Dr. Ervin Podgorsak for his support of the trip and the contact information in Paris. As well, I must thank my clinical colleagues at the Montreal General Hospital for covering my duties while I was away.

2008 Citation Award

Submitted by: Michael Patterson
Juravinski Cancer Centre and McMaster University, Hamilton ON

A few years ago I wrote an article for *Interactions* (Vol. 50, pp. 29-32) in which I suggested that the ground rules for the Sylvia Fedoruk Award should be changed. I argued that it is laborious and inevitably subjective to try to identify the "best" paper published in our field each year. I proposed a simple, objective solution that would recognize the paper published in a given year that was cited most often over the next ten years. For the past four years I have announced an annual winner in *Interactions*. The rules (invented by the author) are simple and similar to those established for the Sylvia Fedoruk Award: the work must have been performed mainly at a Canadian institution, only papers in peer-reviewed journals are considered, review or popular articles are not eligible, and the paper must be "medical physics" – for example, articles dealing with clinical application of a mature imaging technology are not included, even if medical physicists are co-authors. The winner is determined from data in the Web of Science maintained by the Institute of Scientific Information (ISI). This year ISI changed their default count to include citations in their conference data base, and I have complied with this convention except as noted in the table below.

For 2008 we have a dead heat, with both papers cited 121 times since their publication in 1998:

J. H. Siewerdsen, L. E. Antonuk, Y. El-Mohri, J. Yorkston, W. Huang and I. A. Cunningham, Signal, noise power spectrum, and detective quantum efficiency of indirect-detection flat-panel imagers for diagnostic radiology, Medical Physics 25: 614 – 628.

Abstract: The performance of an indirect-detection, active matrix flat-panel imager (FPI) at diagnostic energies is reported in terms of measured and theoretical signal size, noise power spectrum (NPS), and detective quantum efficiency (DQE). Based upon a 1536 x 1920 pixel, 127 mu m pitch array of a-Si:H thin-film transistors and photodiodes, the FPI was developed as a prototype for examination of the potential of flat-panel technology in diagnostic x-ray imaging. The signal size per unit exposure (x-ray sensitivity) was measured for the FPI incorporating five commercially available Gd2O2S:Tb converting screens at energies 70-120 kVp. One-dimensional and two-dimensional NPS and DQE were measured for the FPI incorporating three such converters and as a function of the incident exposure. The measurements support the hypothesis that FPIs have significant potential for application in diagnostic radiology. A cascaded systems model that has shown good agreement with measured individual pixel signal and noise properties is employed to describe the performance of various FPI designs and configurations under a variety of diagnostic imaging conditions. Theoretical x-ray sensitivity; NPS, and DQE are compared to empirical results, and good agreement is observed in each case. The model is used to describe the potential performance of FPIs incorporating a recently developed, enhanced array that is commercially available and has been proposed for testing and application in diagnostic radiography and fluoroscopy. Under conditions corresponding to chest radiography, the analysis suggests that such systems can potentially meet or even exceed the DQE performance of existing technology, such as screen-film and storage phosphor systems; however, under conditions corresponding to general fluoroscopy, the typical exposure per frame is such that the DQE is limited by the total system gain and additive electronic noise. The cascaded systems analysis provides a valuable means of identifying the limiting stages of the imaging system, a tool for system optimization, and a guide for developing strategies of FPI design for various imaging applications.

A. Kienle, M. S. Patterson, N. Dognitz, R. Bays, G. Wagnieres and H. van den Bergh, Noninvasive determination of the optical properties of two-layered turbid media, Applied Optics 37: 779 – 791.

Abstract: Light propagation in two-layered turbid media having an infinitely thick second layer is investigated in the steady-state, frequency, and time domains. A solution of the diffusion approximation to the transport equation is derived by employing the extrapolated boundary condition. We compare the reflectance calculated from this solution with that computed with Monte Carlo simulations and show good agreement. To investigate if it is possible to determine the optical coefficients of the two layers and the thickness of the first layer, the solution of the diffusion equation is fitted to reflectance data obtained from both the diffusion equation and the Monte Carlo simulations. Although it is found that it is, in principle, possible to derive the optical coefficients of the two layers and the thickness of the first layer, we concentrate on the determination of the optical coefficients, knowing the thickness of the first layer. In the frequency domain, for example, it is shown that it is sufficient to make relative measurements of the the phase and the steady-state reflectance at three distances from the illumination point to obtain useful estimates of the optical coefficients. Measurements of the absolute steady-state spatially resolved reflectance performed on two-layered solid phantoms confirm the theoretical results.

For the record, previous years winners are given on page 56)

First steps of the COMP Students Council

Submitted by: Alejandra Rangel and Nadia Octave
University of Calgary, Calgary AB and Laval University, Quebec, QC

As some of you may already know, COMP starts this year with the participation of a Student Council.

The main objectives will be: to advise the COMP Board through the Science and Education Committee on matters of importance to COMP student members, to assist the organization in attracting and retaining student members and to help develop high quality education courses and other training activities that will promote good practice within the field.

As a first step, our student council will have a space within COMP's website that will be used to keep our members in communication and updated with the council's activities as well as to provide information of general interest to students.

We invite all Student members of COMP to participate in this first step by providing us with your suggestions, comments or any information of student interest (our e-mails: alejrang@cancerboard.ab.ca
and nadia.octave.1@ulaval.ca).

Alejandra Rangal (left) and Nadia Octave (right)

We would like to thank COMP for the opportunity to start this council in which the Student members of COMP can raise and debate issues of our interest. But the most important is that this council is firstly yours and we hope to work as the voice of all medical physics students.

2008 Citation Award (Continued from page 55)

* Does not include citations in conference proceedings.

Year of publication	Winner	Citations in 10 years	Current total
1994	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.	129*	190
1995	D. W. O. Rogers, B. A. Faddegon, G. X. Ding, C.-M. Ma and J. Wei, BEAM: A Monte Carlo code to simulate radiotherapy treatment units, Medical Physics 22: 503-524.	310*	532
1996	A. Kienle, L. Lilge, M. S. Patterson, R. Hibst, R. Steiner and B. C. Wilson, Spatially resolved absolute diffuse reflectance measurements for noninvasive determination of the optical scattering and absorption coefficients of biological tissue, Applied Optics 35: 2304-2314.	125*	212
1997	J. S. Gati, R. S. Menon, K. Ugurbil and B. K. Rutt, Experimental determination of the BOLD field strength dependence in vessels and tissue, Magnetic Resonance in Medicine 38: 296 – 302.	196*	224

Advanced Practice of Radiation Therapy in Europe
Report of the 2007 Harold E. Johns Travel Award Visit

Submitted by: Rao Khan
Tom Baker Cancer Centre, Calgary, AB

Towards the end of 2008, the author visited three leading cancer institutes in Europe, supported by Harold E. Johns Travel award for 2007. These included:

- *The Finsen Center, Rigshospitalet, Copenhagen, Denmark,*
- *The German Cancer Research Center (Deutsches Krebsforschungszentrum DKFZ), Heidelberg, Germany, and*
- *The Netherland Cancer Institute (Nederlands Kanker Instituut, NKI), Antoni van Leeuwenhoek Hospital, Amsterdam, Holland*

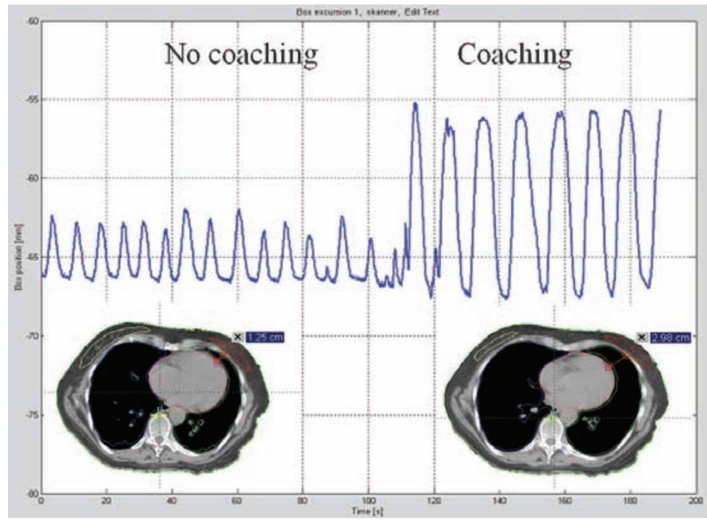
The visit was made successful by hosts Dr. Markia Enmark in Copenhangen, Prof. Uwe Oelfke in Heidelberg, and Dr. Roel deBoer in Amsterdam. Just a coincidence that these centres had expertise in using different types of radiotherapy equipments: Finsen Center - Varian, DKFZ - Siemens, and NKI – Elekta. This communication presents the personal accounts of the interactions of the author with the scientific and clinical staff at the aforementioned centres.

The Finsen Centre, Copenhagen:

The Finsen Centre is probably one of the largest radiotherapy clinics in Europe having 14 radiotherapy linear accelerators treating 4700-5000 new patients each year. The medical physics staff at the centre is classified either as clinical or research. The clinical group has developed gated radiotherapy treatments for left-sided breasts involving ipsilateral internal mammary lymph node chains (IMC) since 2003. The selected patient group has had left-side breast lumpectomies with stage II disease, left sided breast mastectomy or a history of cardio- and/or pulmonary disease (regardless of disease stage or side). The patient undergoes breathing training with a Physicist with a Varian RPM™ box (Varian medical systems, CA) placed on the thorax near the breast for an hour prior to the CT simulation. During the training and simulation, the amplitude of breathing is enhanced, and a gated-CT scan is acquired. The width of the gate is such that it allows only 4 to 5 mm of breast motion within it. This corresponds to a duty cycle of 20-25% on a treatment unit. Planning generally uses open fields and avoids the use of wedges. The treatment set up is verified by comparing the gated DRRs with the gated portal images. To verify the baseline and amplitude of breathing, portal images are acquired during the treatment (via continuous image acquisition).

The Finsen centre was part of the first clinical implementation of RapidArc™ (Varian Medical Systems, CA) in Europe. Prostate was chosen as the site for treatment. Three gold seeds are implanted in the prostate prior to the MR and CT scans. The patient is planned on the ARiA Eclipse™ 8.5 treatment planning system (Varian Medical Systems, CA). In the RapidArc™ optimization the treatment table and rails data are added to the patient CT data. Typical plans include a gantry movement from 210^{o} - 150^{o}, 18MV, 200cGy/fr., and 39 fractions for prostate and seminal vesicles (Kjaer-Kristoffersen, 2008). My interaction with the planner revealed that one can use the same objectives as for IMRT; therefore the learning curve is not steep for clinics already using IMRT. From their experience in planning and subsequent pretreatment dosimetry, the staff at the centre recommends limiting the number of MU to 500 by using the available hard con-

Fig. 1 Enhanced coached breathing can result in larger separation between organ at risk (heart) and target (breast) during inspiration. (Courtesy of Mirjana Josipovik, Finsen Centre, Denmark)



straint MU option during the optimization. A typical RapidArc™ optimization takes 20-25 minutes and the volumetric dose calculation with AAA™ (Anisotropic Analytical Algorithm) requires approximately 15 minutes. At the Finsen centre typically 5-7 RapidArc™ plans per patient are created with slightly varying objectives from each other.

For pretreatment verification, the treatment plans are recalculated for a commercial cylindrical QC phantom called Delta4® (ScandiDos, Uppsala). There are typically 177 control points in a plan. With the help of the treatment room lasers and beam cross-hairs, the Delta4® phantom is isocentrically setup on a treatment couch. The device consists of two p-Si diode matrices perpendicular to each other, a connection to the timing circuit of the linac for beam pulsing and an independent gantry angle measurement device – the inclinometer. A plan is delivered to the Delta4® phantom and the dose per control point and total dose is made available for comparison with the calculations. Keeping in view the pretreatment verification results of 5 to 7 RapidArc™ plans and planning objectives, a *best plan* is chosen. The *best plan* is delivered to the phantom three times to establish the reproducibility of delivery and finally, after a conference with the radiation oncologist the plan is approved for patient treatment. In the Finsen Centre, the trend is that each treatment plan is discussed with the oncologist and physicist prior to delivery. This interaction enhances close working relationships between the oncologists and the physicists, which is scant in most of the centres in Canada.

For the RapidArc™ treatment delivery, the patient is set up on the treatment couch with the help of ExacTrac® (BrainLab, Germany) x-ray imaging of the prostate markers; a CBCT (Varian

(Continued on page 58)

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Medical systems, Palo Alto, CA) is also acquired. After the delivery of treatment (which takes 1-2 minutes), another set of images with ExacTrac® and CBCT is acquired. The acquisition of multiple sets of images is performed as part of a study for patient position verification with various imaging systems. During the RapidArc™ delivery, the dose rate, MLC's and gantry speed vary continuously. The hard constraints are: maximum gantry speed of 65 s/rotation, maximum leaf speed 2.25 cm/s, and maximum dose rate up to 600 MU/min.

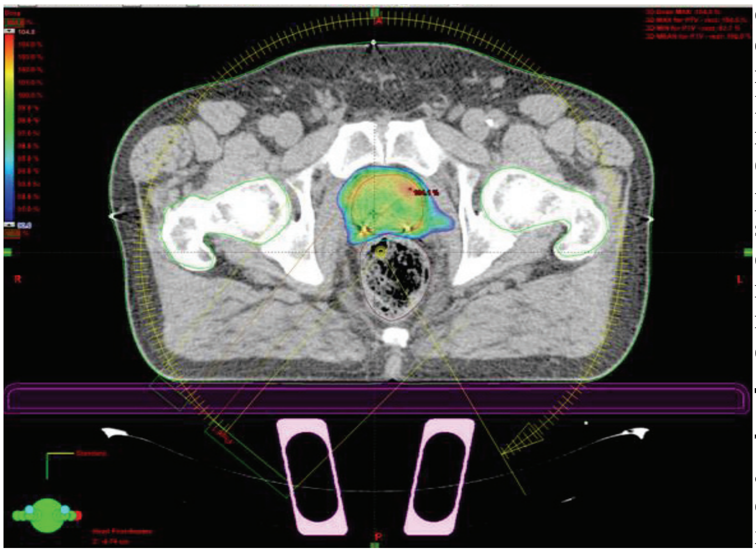

Fig.2 A RapidArc™ plan for prostates, dose cloud (> 95% doses) completely surrounds the target (Courtesy of Fleming Kjaer-Kristoffersen, Finsen Centre, Denmark)

The Finsen center has an extensive stereotactic radiosurgery/therapy program, available on three Novalis™ therapy units (Varian Medical Systems, CA). The program is currently operational on one stereotactic unit, while the other two are being replaced with new Novalis Tx™ accelerators. The new linacs will be equipped with a 2.5 mm wide leaves in central 10×10 cm^2 while the maximum available field size is 22×40 cm^2. I participated in simulation, planning and delivery of an AVM patient. An MRI was acquired a day prior to the treatment. A simulation CT was obtained with 1.2mm slice thickness and an angiography was done on the treatment day. Conformal arcs, typically 5 to 7, were used to deliver a dose of 27.5Gy in a single fraction at 800MU/min. The treatment planner briefed me about the features of the new IPlan net™ (BrainLab, Germany), such as volumetric dose calculation via Monte Carlo, and the option of using stereotactic cones, etc.

The dose rate, except for the IMRT cases (where it is limited to 300MU/min), is 600MU/min on the Varian linear accelerators. Independent IMRT dose calculation to a single point is performed with a pencil beam dose calculator called EqualDose™ (EqualEstro, France) software. Only for IMRT plans, to be delivered with a stereotactic unit, does the pre-treatment QC involve dose measurement with an array of 729 ion chambers Seven29™ (PTW Freiburg, Germany). IMRT for head and neck patients is delivered with 6 fractions per week. This means that some of the staff, including at least one medical physicist, has to work on weekends and holidays.

The basic educational requirement to enter in the medical physics profession is a university degree. Medical Physics education and training in Denmark involves on-job-training for a minimum of three years. The Danish association of Medical Physics provides approval of training programs. The license is provided by a government body after successful completion of training – the passing candidate is called a *hospital physicist* in the field of radiation oncology, nuclear medicine or diagnostic radiology. A register of qualified medical physicist is maintained by the educational committee of the Danish Society of Medical Physics, DSMF. The DSMF also holds a register for continuous professional development (CPD) according to the EFOMP (European Federation of Organisations for Medical Physics) policies. A qualified medical physicist (called hospital physicist in Denmark) after 5 years of sufficient professional development can achieve the level of an expert in the field of medical physics. Radiation therapists on the radiotherapy units are nurses by profession but with a year of radiotherapy training. A *dosimetrist* in North America has its equivalent called *radiographer* in Denmark.

The DKFZ, Heidelberg:

The DKFZ, during my visit, was celebrating the astronomical achievement of their chairman Dr. Harald zür Hausen. He received the 2008 Nobel Prize for *physiology or medicine* and sharing the prize money with two other investigators. He hypothesized that cervical cancer was caused by the human papiloma virus (HPV). Initial investigations were frustratingly contrary to the hypothesis; however, later on his hypothesis was confirmed. Now we know that almost 70% of all cervical cancers are caused by HPV16 and HPV18.

Gernot Echner from the division of medical engineering enlightened me on the development of micromultileaves at the DKFZ. The work commenced in 1980 with the design of manually operated 1mm thick leaves using 95% tungsten sintered material called densimet-18. I was also introduced to a prototype iris collimator. The concept is very simple: it is comprised of a variable aperture cone sliding over a two dimensional saddle to scan the irradiated area. The variable aperture cone consists of two (each 6 cm long) cylindrical sections one on top of the other. Each cylinder has 6 individual pieces of tungsten which can slide in and out to form small or large hexagonal apertures. The aperture of the upper cylinder, proximal to the x-ray source, is smaller than the aperture of the lower cylinder facing the patient to allow for x-ray beam divergence. This cylindrical apparatus then sits towards the inside of a two dimensional saddle and, with the help of a few motors, it can be used to scan the beam and produce arbitrary field shapes. The design was adopted in Cyberknife™ (Accuray , CA) in its new accelerators.

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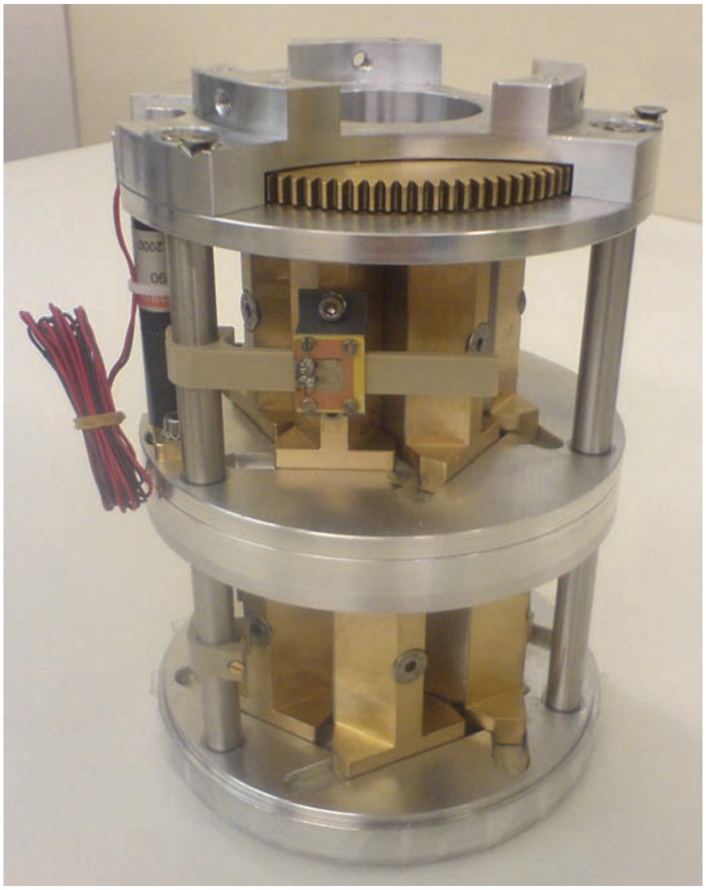

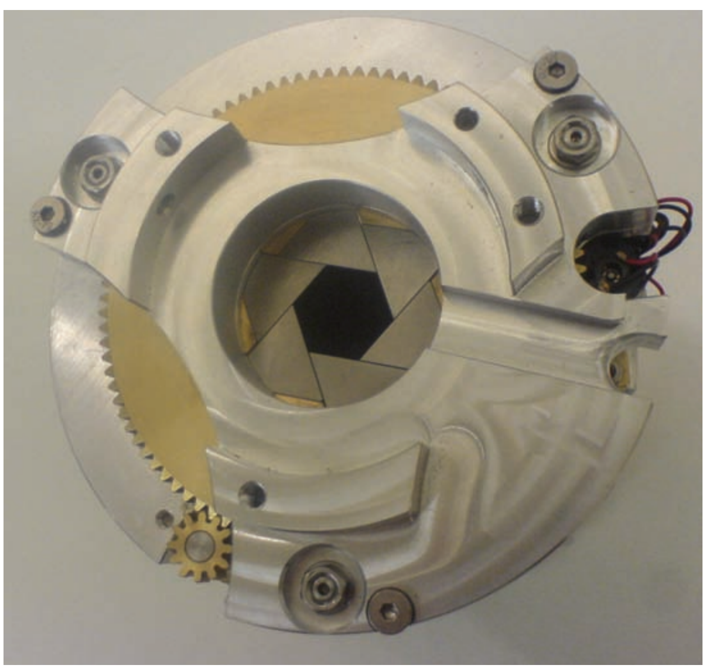

Fig. 3 Prototype Iris collimator (Courtesy of Gernot Echner, DKFZ, Germany)

The development of a respiratory phantom containing lung, heart, tumor, and skin materials, is a work in progress in the medical physics workshop. The tumor can move in and out mimicking physiological aspects of breathing for various organs, while skin is simultaneously inflated with air to model the breathing as seen from outside.

Prof. Oelfke's group is also involved in 4D planning, mobile targeting and C-12 based RBE dose optimization. Dr. Emily Heath is the leading researcher in 4D planning. 4D planning is desirable since despite 4D simulations (by acquiring a 4DCT) there is no assurance that the amplitude and the baseline of the moving tumor would not change during treatment. Traditionally, a potential change in the target volume is taken care of by increasing the margins around the tumor. However in 4D planning, it is accounted for with an objective function by using the variance information (obtained from the deformable image reconstruction of voxels of the 4DCT). This also involves a 4D dose calculation with a Monte Carlo code, EGS4 by deforming the voxels of the calculation grid. To help with Monte Carlo modeling Dr. Ivan Kawarakov – a leading expert on Voxel Monte Carlo from NRCC was visiting the Institute. Uwe's group previously designed a kV prototype imager for Siemens accelerators. In that design a kV source was mounted just behind the MV EPID, and a kV flat panel was positioned in the accessory mount. This arrangement could provide an inline kV imaging as well as the kV Cone beam CT. However, unlike their competitors, Siemens choose to proceed along the MV imaging path. Amorphous Si flat panels in the prototype have also been used to verify the entrance and exit fluence for IMRT patients in past.

Prof. Oelfke's laboratory has unique access to a dedicated Siemens Artiste™ (Siemens Medical, PA) linear accelerator for research. Several new projects involve the use of this facility. Mobile tumor targeting with the help of an MLC was an excellent demonstration of how Master/Ph.D. level research projects can find their way in to the clinic. My discussions with Ms. Silke Ulrich were very useful. Working under the supervision of Prof. Oelfke she developed the Arc Modulated Cone Beam Therapy, which used a *tabu* search and direct aperture optimization approach (Ulrich 2007). They discovered that the dose distribution was not inferior to IMRT; the major improvement was faster delivery with cone beam therapy.

Dr. Peter Häring takes care of the clinical aspects of medical physics with the two available linear accelerators at the DKFZ. One of the treatment rooms has an arrangement of a Siemens linac and a single slice CT-on-rail. A linac in one of the treatment rooms was installed on the first floor; radiation protection was accomplished by leaving the basement room empty during treatment hours, while the upper floor was not constructed. I participated in a discussion lead by Dr. Häring in which he presented the feasibility of using the EPID for daily QC of a linac. One of the students involved in target positioning demonstrated the operation and calibration of a Calypso® 4D localization system (Calypso Medical Technologies, WA) which utilizes embedded transponder coils and receiving coils built into a ~ 45×68 cm^2 detection plate. In research mode, one can obtain the individual coordinates of the sending (embedded) coils. Since the detection panel remains in the beam all the time its attenuation was measured to be ~1 % but it can vary by up to 3%. Flat portal imaging panels could be affected by the electromagnetic field from the detector plate.

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IMRT planning at the DKFZ is done by a physician. For example a recipe of 9 beams is used for IMRT of the head and neck involving lymph nodes and 7 beams for prostates. The optimization and dose calculation are done by a homemade convolution superposition algorithm – voxelPlan. VoxelPlan represents the untiring efforts of many scientists and researchers at the DKFZ over more than two decades. It is still under construction to incorporate the option of dose calculation with a Monte Carlo engine. Out of my inquisitiveness, I spent some time with the clinical physicists, Andea and Peter, during their IMRT plan check and pretreatment QC. The dose coverage around the target and avoidance of the organs at risk was verified. The number of step-and-shoot segments ~90 for a 9 beam IMRT are common, however up to 150 segments can be tolerated.

For pretreatment verification, the plan was exported to a 30×30 cylindrical solid water phantom which contained an embedded ion chamber array Seven29™. The tradition at the DKFZ is to QC all of the IMRT plans. After calculations the plan is delivered to the phantom. During delivery, not only the dose in the phantom is measured but also the exit fluence is recorded with the help of an EPID. Using the VeriSoft® environment (PTW Freiburg, Germany) the calculations and the measurements are compared to evaluate the fitness of the plan. The effect of different gantry angles on the response of the Seven29™ detector was also accounted for outside the analysis software.

I also witnessed IMRT delivery to a head and neck patient on a Siemens Artiste™. The patient was immobilized in a fixation device and a vacuum bag, the in-room CT moved on the rails and provided the positioning data which was matched with the planning CT. A radiation oncologist verified and approved the position of patient and gave the green light to treat.

The basic educational requirement to enter medical physics in Germany is a technical degree in physics or engineering. The training program is accredited by the national organization for medical physics, Deutsche Gesellschaft für Medizinische Physik, DGMP. To qualify for professional certification, one must have completed 360 h of theory and 3 years of formal clinical practice. In the case of Germany, 3-4 years of working experience can also culminate in the same certification. The evaluation is done through an oral examination. The certification by the DGMP is not mandatory to practice as a clinical medical physicist in Deutschland except for in Berlin (Eudaldo 2008).

The NKI, Amsterdam:

During the last leg of my European visit, I arrived in Amsterdam in November of 2008. Elekta (Elekta, Sweden) radiotherapy equipment powers the RT- department of the NKI centre. The NKI is a medium sized hospital, treating 4500-4700 patients receiving radiotherapy each year. The NKI houses 9 treatment units out of which 5 can perform CBCT. Elekta linacs, unlike Siemens or Varian, use a slalom magnet for bending the beam and it can provide a unique combination of 3 photon energies (6, 10 and 18MV).

Dr. Roel de Boer, my host from clinical physics, took me for a visit of the treatment and imaging facilities. All of the treatment bunkers at the NKI have been doorless for the last 20 years with shielding accomplished by a long entrance maze. The Elekta linacs use 1 cm wide MLC leaves replacing the upper jaw. A back up jaw is added to reduce leakage. The leaf position is automatically verified from reflective tape attached to the leaf end, captured by a frame grabber during leaf positioning. In newer models, 4 mm wide MLC leaves are available for small field sizes. The delivery of step-and-shoot IMRT is performed at 600 MU/min at the NKI; sliding window delivery is not available on Elekta linacs. The NKI along with the Princess Margret Hospital in Toronto and the William Beaumont hospital in Detroit developed the first prototype of Elekta CBCT in 2003. Unlike Varian's solution, the kV imaging panel is 40×40 cm^2 which can cover up to 25 cm in the SI direction in CBCT and it does not include any antiscatter grid. Elekta's CBCT, does not allow scaling of intensity in HU which is available with Varian (within ±40HU). Elekta linacs were the first to offer limited angle CBCT with a scan of 200 degrees. I was informed that VMAT calculations will be available with a newer version of Pinnacle® (Philips Medical system, MD), and Elekta linacs have the capability to deliver it.

For internal organ motion management in lung cancer patients, the patient's breathing information is acquired using a custom designed temperature sensing apparatus. The nasal apparatus senses the temperature difference between the inflow and outflow, and generates a signal. The raw signal is processed using several sinusoidal functions and it is then fed to the CT scanner for placement of phase tags on the breathing trace. The patients are not trained and the breathing is free. Siemens CT scanners can accept any external signal for gating or tagging a 4DCT. Previous studies by the group at the NKI involved testing various external surrogates for breathing motion. They previously experimented with using a pneumatic belt around the patient's abdomen; however the surrogate signal was of low amplitude in some older subjects. Further amplification of the signal resulted in noisy data. The use of pneumatic belt was abandoned in favor of the nasal temperature sensor.

The 4D simulation process involves acquiring the breathing trace with a naso-buccal mask, sorting oversampled CT data into bins, determining the position of the mid-ventilation phase from the time weighted mean of the 4DCT datasets, generating a mid-ventilation CT and determining the extent of tumor motion.

All lung plans are calculated on the mid-ventilation CT. The treatment margins are custom designed based on the displacement of the tumor in the AP, RL and SI directions using van Herk's recipe. The conventional ITV approach results in larger margins. For stereotactic lungs, a dose of 54 – 60Gy is delivered in 3 fractions with 2 fractions per week. IMRT optimization is done on Pinnacle® 8.1 for 22 beams with a total of 22 segments. Effectively, it is aperture shape and beam weight optimization. On the treatment unit the patient is set up using a 4DCBCT scan if the organ motion is more than 5 mm, otherwise a standard CBCT scan is acquired. First, a bony anatomy match is performed and this is followed by a soft tissue match. The matching

(Continued on page 82)

Feature Article
Optical Imaging of neo-adjuvant chemotherapy

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Introduction

Breast cancer is the most common malignancy for females in North America with approximately 22,300 new cases diagnosed each year in Canada. Approximately 5-15% of the estimated 200,000 new cases diagnosed each year will present with locally advanced breast cancer (LABC)[1,2]. Standard treatment for these patients is usually neoadjuvant systemic chemotherapy followed by surgery and radiotherapy[3]. While complete pathological response to neoadjuvant chemotherapy has been shown to strongly correlate with patient survival[4], conventional clinical surrogates based on anatomical information such as on-going physical assessment, mammography and ultrasound suffer from an inability to objectively assess treatment response early during the course of treatment[5]. The necessity for a non-invasive and inexpensive imaging modality to both diagnose and monitor treatment response has lead to renewed interest in the potential of near-infrared (NIR) optical imaging.

Diffuse optical spectroscopy (DOS) and diffuse optical tomography (DOT) are non-invasive, non-ionizing techniques that employ NIR light to rapidly provide quantitative spectral information (i.e. tens of second) regarding the optical absorption and scattering properties of tissue[6,7]. Typically, DOS employs a large spectral bandwidth with a sparse number of spatial measurements while DOT offers three-dimensional optical property maps with lower spectral bandwidth. This relationship is similar to that of magnetic resonance spectroscopy and MRI. The optical properties can be converted to parameters related to tissue microstructure and biochemical composition and structural parameters. Such functional information is not readily available through conventional structural imaging techniques. Since the optical contrast comes from intrinsic tissue components, the technique does *not* require exogenous contrast agents making it ideal for frequent, repeat monitoring. Furthermore, the DOS technology is portable and relatively inexpensive compared to MRI. The functional information provided by DOS provides a potential complement to traditional structural imaging techniques.

In this article, we provide preliminary results demonstrating the potential of optical imaging for monitoring of patients with LABC undergoing neoadjuvant chemotherapy. The acquisition platform (ART, SoftScan®) used in the study is a time-resolved, optical imaging device that measures photon migration through the breast in the NIR. The acquired data is reconstructed using light diffusion models that account for the highly scattering nature of light in tissue to

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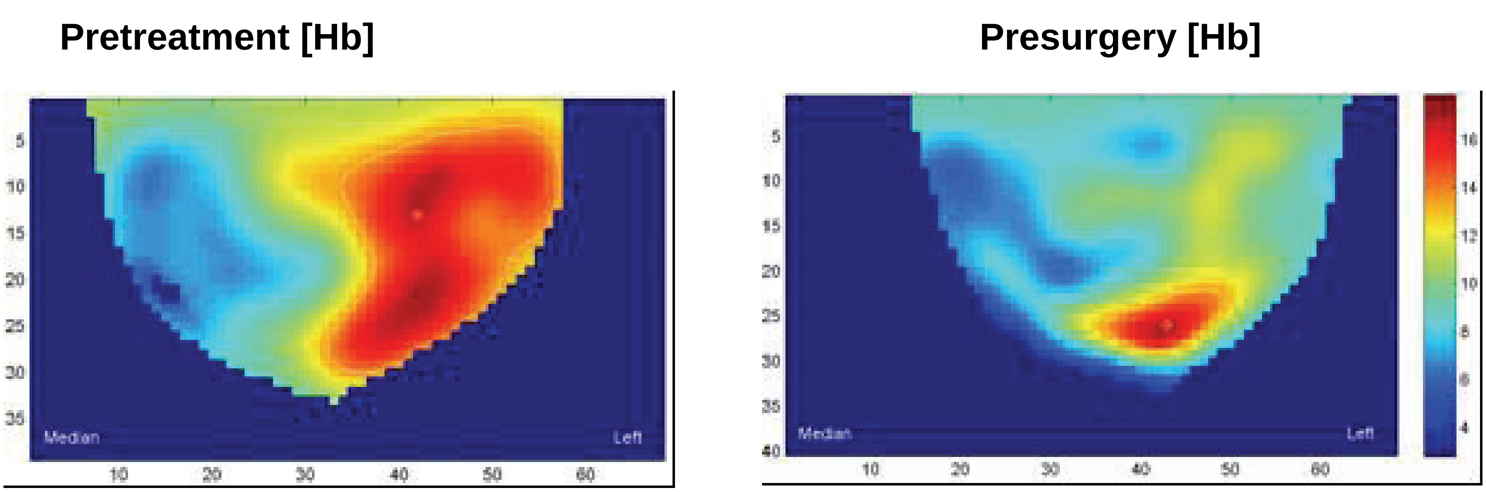

Figure 1: Responder patient showing significant changes in *Hb* (hemoglobin) during and following neoadjuvant chemotherapy. Response was observed as early as within 7 days. Pretreatment and pre-surgery transverse DOS images of deoxyhemoglobin are shown.

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MARCH 2009

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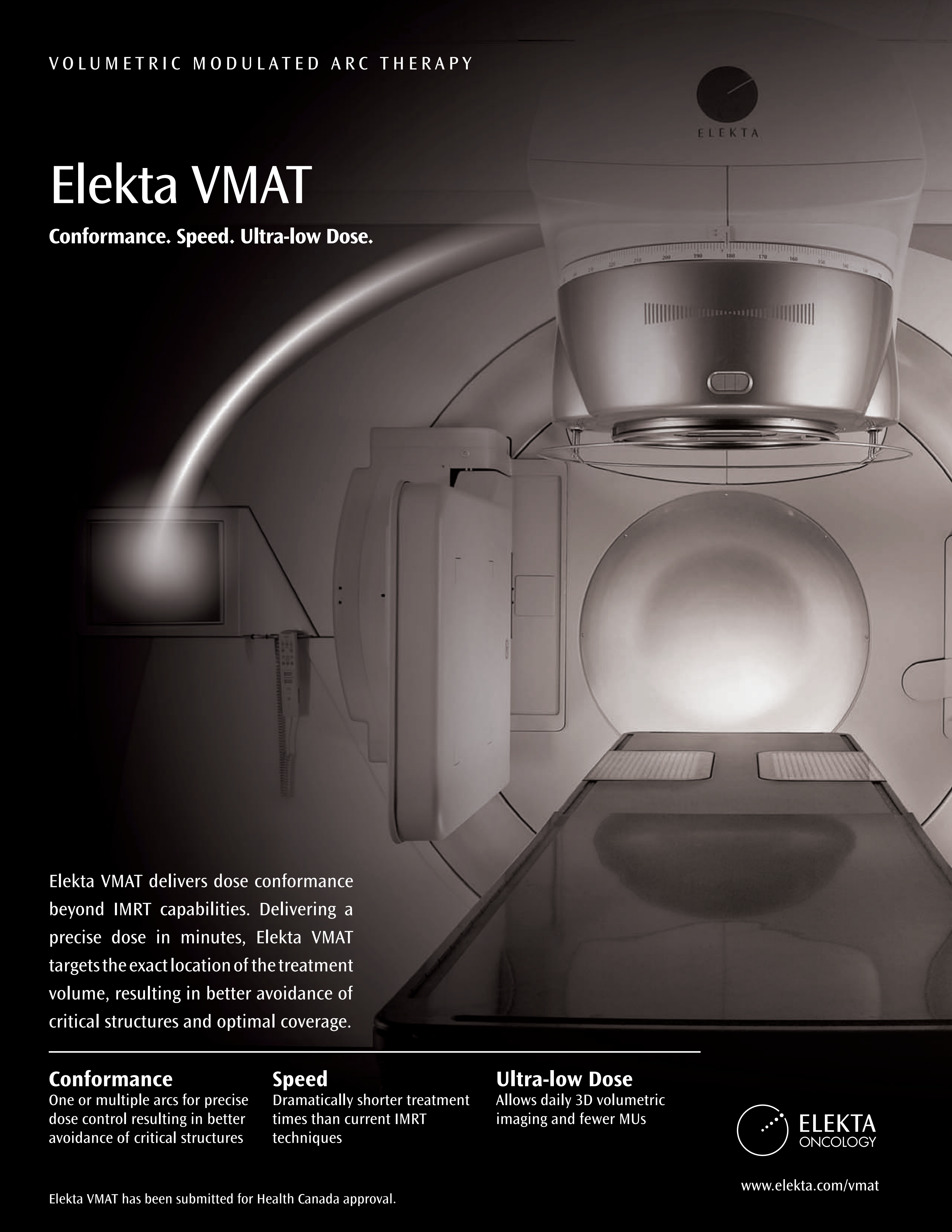

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obtain three-dimensional maps of optical absorption and scattering properties at different wavelengths. The optical properties are then converted to functional indices of hemoglobin concentration ([HbT] = HbO_2 + Hb), relative oxygen saturation of hemoglobin, $StO_2 = HbO_2/HbT$, water concentration,[HO_2] , and lipid concentration, [Li].

Tumor position in the optical images was spatially co-registered using MRI scans and physical palpation (see cover image). The measure of tumour response was defined using response evaluation criteria in solid tumours (RECIST) and further quantified through MRI studies at predetermined time-points. Based on preliminary patient results, a marked contrast in optical parameters was observed with tumor tissue demonstrating a ~ 1.6 X, 1.7 X, and 3.5 X in mean oxyhemoglobin, deoxyhemoglobin and water concentration respectively compared to background normal breast tissue. This additional functional information could potentially allow for the differentiation of benign and cancerous breast lesions during clinical examination when standard structural information is insufficient.

Optical imaging also demonstrated the potential for assessing patient response to chemotherapy. Figure 1 shows a transverse image showing the changes in optical parameters resulting from neoadjuvant treatment in a representative responding patient. From the optical image shown a distinct contrast in mean concentration of hemoglobin, between the tumour volume (as defined by MRI) and surrounding normal tissue is observed. Furthermore, oxyhemoglobin, de-oxyhemoglobin and water concentration dropped significantly in response to chemotherapy within the first week of treatment and continued to decrease up to 4 weeks. These values remained relatively stable up to the time of mastectomy. In contrast, non-responders showed a smaller decrease in optical parameters during the course of treatment eventually increasing after ~ 1 month (data not shown). Overall, the mean oxy-hemoglobin, deoxyhemoglobin and water at 4 weeks were found to be 25.6%, 26.1% and 47.7% with responders compared to 78.1%, 81.7%, 78.9% for non-responders. Based on initial patient data (to be verified over ~ 40 patients), both the deoxyhemoglobin and oxyhemoglobin parameters currently show promise as statically significant parameters in differentiating the two patient groups.

Summary

In summary, we have tracked the spatio-temporal changes in optical surrogates of treatment response during neoadjuvant chemotherapy of breast cancer and correlated these parameters with MRI and histopathological results measured post-treatment. Preliminary results indicate that functional optical parameters such a oxyhemoglobin, deoxyhemoglobin and water identify areas that corresponded to the tumour seen on MRI and clinical exam. Optical parameters associated with tumour tissue were significantly different from background breast tissue. We have also found that the optical imaging has the potential to separate non-responding and responding chemotherapy patients – potentially as early as 4 weeks into treatment. We are currently accruing additional patients to confirm these preliminary results.

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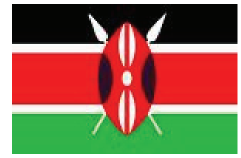
Radiation Therapy in Kenya



Submitted by: Marija Popovic
Juravinski Cancer Centre, Hamilton ON

As a recipient of the COMP resident travel award, I visited Kenyatta National Hospital (KNH) in Nairobi, Kenya. I was aware that cancer care was not the top priority in Sub-Saharan African countries even before my trip. The reality of the situation, however, was more grim than I could have imagined. Patients are many, cases are difficult and often terminal, and I will not soon forget the challenges that the oncology staff face to meet the needs of those living with cancer with nowhere else to turn for care. The devotion of the staff and level of care in spite of very limited resources is inspiring. This report contains a summary of my first-hand experiences, along with insights of many health care workers that I have met in Nairobi. It presents an overview of the current cancer situation in Kenya and my attempt to provide my explanation for the rather difficult state of affairs in Kenyan cancer care.

1. Kenya and its Health Care

The Republic of Kenya is one of five partner countries in the East African Community. The country is divided into eight provinces, which are further divided into 112 districts. Major cities are: Nairobi (pop: 2143,254), Mombasa (pop: 665,018), Kisumu (pop: 322,734) and Nakuru (pop: 231,262). Kenya has a population of approximately 38 million people and the population growth rate of 2.8%. It was estimated that in 2005/2006, 16.7 million of 35.5 million people lived below poverty line and 84% of the population lived in rural areas[1]. The adult literacy rate is reported to be 73.6%. The gross national income per capita is 1,170 dollars, but more than half the country's population lives on less than $1 per day[2]. In 2007, Kenya's position on the UNDP human development index was 148 of 177 countries[3]. The poverty declined from 52.3% in 1997 to 46.1% in 2005/2006[1]. While these numbers may be worrisome, they reflect the country's considerable economic growth over the past two decades. In January 2008, political conflicts resulted in more than 1,000 deaths and 600,000 internally displaced persons. It is feared that they will have a profound long-term effect on the country's fragile economy[4]. Table 1 provides some representative statistical measures for Kenya and Canada.

Since Kenya's independence in 1963, the Ministry of Health has been ensuring the accessibility of health services to all citizens of Kenya. Some functions of the Ministry of Health are: devising health policies, planning, organizing and administrating central health services, training health care practitioners, coordinating activities with other government departments and non-governmental agencies, and complying with international health regulations[6]. Regrettably, the government's health policy does not include national cancer policy.

The country's health care system is under extreme strain due to high incidence of HIV/AIDS and other communicable diseases.

The country's health care system is under extreme strain due to high incidence of HIV/AIDS and other communicable diseases. Malaria and infectious respiratory diseases account for a majority of illnesses and deaths, and an overwhelming

Table 1. Country statistics for Kenya and Canada. Source: CIA World Factbook[5]

	Canada	Kenya
Population	33,212,696	37,953,838
Population Growth Rate (%)	0.93	2.758
Birth rate (/1000)	10.29	37.89
Death rate (/1000)	7.61	10.3
Infant mortality rate (/1000)	5.08	56.01
Life expectancy at birth	81.16	56.64
HIV/AIDS-adult prevalence rate (% of adults aged 15-49)	0.3	6.7
HIV/AIDS-people living with HIV/AIDS	56,000	1,200,000
HIV/AIDS-deaths	1,500	150,000
Population below poverty line (%)	10.8	50.0
GDP per capita ($)	38,200	1,600
Unemployment rate (%)	5.9	40

Table 2. Causes of death, all ages (2002). Adapted from WHO Country Health System Fact Sheet, 2006[7].

Causes	**Deaths (x 1000)**	**Causes**	**Deaths (x 1000)**
All causes	376 (100%)		
HIV/AIDS	144 (38%)	Cerebrovascular disease	14 (4%)
Lower respiratory infections	37 (10%)	Ischaemic heart disease	13 (4%)
Diarrhoeal diseases	24 (7%)	Perinatal conditions	13 (4%)
Tuberculosis	19 (5%)	Road traffic accidents	7 (2%)
Malaria	18 (5%)	Chronic obstructive pulmonary disease	6 (2%)

share of financial resources is directed towards their treatment and prevention. To understand why cancer is not a priority on the government's budgetary allocation list, it is important to realize that, unlike cancer, many communicable diseases can be prevented or cured; many strike young children and affect whole schools or communities. The country is also battling childhood malnutrition (over 20% of children were considered moderately or severely underweight in 2005), the lack of clean water and sanitation. The WHO records from 2002 indicate that cancer is not one of top ten causes of death for all ages (Table 2). I suspect that these numbers are misleading due to lack of proper diagnosis and formal national cancer registry.

The health care system in Kenya has a stepwise structure. The process of diagnosis and treatment usually starts at a dispensary operated by registered nurses. Patients that cannot be managed at dispensaries are referred to health centres or sub-district hospitals. Patients that require more specialized attention are further referred to one of eight provincial hospitals. Chemotherapy is offered in district and provincial hospitals where it is delivered by general practitioners with limited oncology training. Cancer patients eligible for radiation treatment are finally referred to Kenyatta National Hospital, the only public hospital that offers radiation therapy. Few patients are able to afford private health care services offered at numerous private hospitals. The Nairobi Hospital is the only private center that offers radiation therapy on a single cobalt unit.

Kenyatta National Hospital (KNH) is Kenya's tertiary referral hospital. It is the country's chief referral, teaching and research institution. It has a capacity of 1,800 beds and cares for over 80,000 in-patients and 500,000 out-patients annually. The hospital attends to 2,000 patients daily. As a result of poor public awareness and stepwise organization within Kenyan referral system, a large percentage of cancer patients are first seen by oncologists when the disease has developed to advanced stages. The KNH offers radiotherapy, medical oncology, haematology, surgical oncology, pathology and palliative care for cancer patients[8]. Incidentally, there are approximately 6,000 physicians in Kenya; only about 1,000 of whom serve in public institutions, and 420 of whom are employed at KNH. There are only four radiation oncologists, three medical oncologists, two surgical oncologists, and two gynaecologic oncologists for the whole Kenyan population. All Kenyan oncologists practice in Nairobi[9].

Cancer patients eligible for radiation treatment are finally referred to Kenyatta National Hospital, the only public hospital that offers radiation therapy.

In response to the initiative by the World Health Organization in 1994, the Ministry of Health began to develop a national cancer control program. Regrettably, the project was abandoned in 1997 with a change in leadership at the Ministry of Health. Most staff of radiation oncology department are hopeful that the national cancer policy will be implemented in the near future. At the present time, however, cancer care is not a national priority for the Ministry of Health. Most resources are devoted to HIV/AIDS, reproductive health, maternal and child health, malaria control, environmental health, sexually transmitted infections, TB control and an expanded program for immunization[9]. The most common cancer sites, as reported by Nairobi Cancer Registry at the Kenya Medical Research Institute[9], are presented in Table 3. For comparison, the most common new cancer cases diagnosed in Ontario are also presented[10].

It is reported that the incidence of cancer in Kenya has been rising steadily. The studies to determine the reasons for the rise in the number of cases are not being conducted, but it is suspected that the HIV/AIDS pandemic, population growth, changes in behavioural and environmental factors contribute to the increase in cancer prevalence and incidence[9]. Furthermore, it is quite likely that the cancer incidence will increase in time, because other diseases that have traditionally reduced life expectancy of Africans are becoming more treatable.

2. Cancer Occurrence

In Kenya, it is not uncommon to encounter patients that have both cancer and HIV/AIDS. Several cancers are well recognized consequence of AIDS. Three types of cancer are now known to occur in conjunction with AIDS, namely Kaposi's sarcoma, non-Hodgkin's lymphoma and carcinoma of the uterine cervix. Individuals with HIV have at least 20,000 times greater risk for developing Kaposi's sarcoma. Kaposi's sarcoma is considered a rare disease in North America and Europe, with an onset normally between the ages of 50 and 70 years. The

(Continued on page 68)

Table 3. The most common cancers in Kenya and in Ontario.

	Men		Women	
	Kenya	**Ontario**	**Kenya**	**Ontario**
1.	Head and neck	Prostate	Breast	Breast
2.	Esophagus	Lung and bronchus	Cervix uteri	Colon and rectum
3.	Prostate	Colon and rectum	Nead and neck	Lung and bronchus
4.	Stomach	Urinary bladder	Esophagus	Corpus and uterus
5.	Kaposi's sarcoma	Non-Hodgkin's lymphoma	Stomach	Thyroid
6.	Liver	Leukemia	Ovary	Non-Hodgkin's Lymphoma
7.	Non-Hodgkin's lymphoma	Melanoma of the skin	Skin	Ovary
8.	Skin	Oral cavity and pharynx	Kaposi's sarcoma	Melanoma of the skin
9.	Colon	Kidney and renal pelvis	Non-Hodgkin's lymphoma	Leukemia
10.	Eye (retinoblastoma)	Stomach	Eye (retinoblastoma)	Kidney and renal pelvis

Table 4. Patients treated with radiation and re-attending patients at KNH in 1995, 2003 and 2005.

Year	New Patients	Re-attendants	Total
1995	659	3,890	4,549
2003	1,135	9,374	10,809
2004	1,499	9,761	11,260

(Continued from page 67)

tumour is commonly benign, and it can grow over 10-15 years before it develops additional lesions. Kaposi's sarcoma leads to the development of secondary malignancies, most often non-Hodgkin's lymphoma, in up to 33% of North Americans and Europeans. In contrast to its Western counterpart, African Kaposi's sarcoma is fairly common. It is aggressive and can often invade surrounding tissue and bone. The individuals that are affected tend to be significantly younger and the prognosis is generally very poor[11].

In the majority of cases, cancer is left undiagnosed until it becomes unmanageable. In rural regions of Kenya where financial resources are very limited, patients are often prompted to seek medical help only once tumour haemorrhages or pain becomes unbearable. In fact, up to 70% of cancer patients at KNH are treated with palliative intent. Approximately 30% of patients that come to KNH for an initial consultation with the oncologist do not seek treatment, primarily because of severe financial constraints that much of the population faces. The cases treated at KNH radiation therapy department are presented in Table 4[12]. From 1995–2004, 1,164 patients received chemotherapy and 22,819 patients received cobalt therapy[12]. It is worth noting that the reported number of new patients has doubled over a period of 10 years. Higher cancer incidence is one explanation. It is also likely that advances in diagnostic methods have led to a greater probability of tumour detection.

3. Radiation Therapy Department and Resources

The radiation therapy unit at KNH was established in 1968 in collaboration between Karolinska University in Stockholm and the Ministry of Health in Kenya. At that time, Swedish researchers secured funding to study Burkitt's lymphoma, the type of non-Hodgkin's lymphoma most commonly seen in children in equatorial Africa. As part of the agreement, Ministry of Health in Kenya required that the Karolinska University establish a permanent radiation department. A cobalt unit was purchased and installed. Subsequently, an orthovoltage machine was purchased for treatment of skin lesions. Professor Rune Walstam from Karolinska University was the first radiotherapy physicist consultant in Kenya, and he extensively worked on the Nairobi project during 1968-1975[13].

The current staff of the radiation oncology department which serves the entire population of 38 million people are:

- Four radiation oncologists;
- Two medical physicists;
- Five radiation therapists and five others awaiting formal training;
- One nuclear medicine physician;
- Two nuclear medicine technologists;
- Three oncology nurses;
- One physicist in charge of radiation safety;
- Five hematologists;
- One oncology pharmacist;

At present, the following radiation equipment is available:

- Two cobalt-60 therapy units, installed in 1983 and 1993;
- One conventional treatment simulator (recently purchased, received in November 2008, not installed at the time of my visit);
- One mobile C-arm x-ray unit;
- Two brachytherapy units, high dose rate (HDR) and low dose rate (LDR, neither unit was functional at the time of my visit);
- One treatment planning unit (PLATO TPS, functional, but not in use);
- Mould room facility, hot wire cutter, and accessories;
- One TLD reader used for monthly monitoring of occupational exposure;
- All dosimetry equipment;

An additional cobalt-60 unit (purchased in 1989) is available at the private Nairobi Hospital. It is available to patients who can afford high-cost treatment of approximately $1,700 US.

An HDR iridium-192 unit is available in Kisumu and it was used clinically from 1996 to 2004. Patients that resided near Kisumu were sent to this satellite clinic for 'boost' dose of radiation, following external beam radiotherapy treatment in Nairobi. The staff of the radiotherapy unit in Kisumu consisted of one radiation oncologist that retired from Nairobi, a medical physicist and a trained radiographer. In 2004, problems arose with the treatment planning system and electronics that controlled the source dwell positions. During the time it took to service the system, the source decayed and was not replaced again. In the mean time, the oncologist relocated and there are currently no radiation oncologists in the Kisumu area to carry workload.

In essence, all patient treatments in Kenya are done with a single C-arm x-ray unit and two cobalt-60 therapy units.

In essence, all patient treatments in Kenya are done with a single C-arm x-ray unit and two cobalt-60 therapy units. The maintenance of the cobalt units is performed by the hospital's bioengineering department. Some technicians have taken the IAEA/AFRA courses providing them with an introduction to radiation safety and equipment. In absence of a technology team dedicated to the radiotherapy department, preventative maintenance of units has become rare and challenging. Cobalt-60 sources are replaced approximately every 7 years. The two cobalt units were purchased in 1983 and in 1993. The manufacturers do not guarantee the availability of compatible replacement parts 10 years after the purchase. Improvisations are sometimes made, and less than optimal mechanical parts are installed when original parts fail. One example are treatment couches that sag, which prohibits the use of couch angles in treatment. Preventative maintenance of the two units is also restricted by an extremely high number of treatments conducted daily, as both units are used clinically between 7am and 10pm. Quality assurance tests are conducted and cobalt-60 output factors are measured monthly when a machine is taken out of clinical service for several hours.

The 250kVp orthovoltage unit was installed in 1993, but it was short lived. Problems started occurring even during acceptance testing. A lot of effort was put into making the unit functional and reducing the output variations to acceptable levels. Finally in 2000, the unit was decommissioned due to a leaky x-ray tube. The model was out of production, the product was not covered by manufacturer's warranty, and replacement parts were no longer available. While in clinical use, the unit was only used to deliver superficial 'boost' dose to breast.

The department has been functioning without a treatment simulator since 2002. When the simulator was available, it was used for nearly all treatment plans. Upon its breakdown, department physicists contacted IAEA in order to rectify the problem. Engineers were sent by the manufacturer of the simulator to evaluate the problem. Upon their investigation, the engineers submitted a report to IAEA and concluded that repairing the unit is not an economical option. Subsequently, the funding was secured for a purchase of a new treatment simulator. The simulator was received in early 2008 and the room that will house the simulator is ready for use. It was expected that the acceptance testing of the unit would be performed in December 2008, but the plans were postponed by the service provider. Additionally, department staff including radiation therapists that will be using the simulator are still awaiting formal training on the unit.

Both LDR and HDR brachytherapy units belong to the department, but neither unit is functional at this time. The Amersham afterloading cesium-131 LDR brachytherapy system was used for treatment of cervical cancer from 1986 to 1993. The system is housed in a dedicated room within the radiation department. It is conveniently located next to a surgery theatre that was used for applicator insertions. The unit had six leads, allowing for simultaneous treatment of two patients. The doses were calculated from pre-plans derived for specific applicator geometries, obviating the need for a treatment simulator. Dr. Rogo *et al*. (1992)[14] concluded that even though the method was safe and acceptable, long delivery times did not justify unit maintenance and its use in a department with such a heavy work load. Consequently, preventative maintenance on the afterloader became irregular. The structural integrity of plastic components of the afterloader became questionable under prolonged exposure to radiation, but replacement parts were not purchased and this treatment method was ultimately abandoned.

The HDR unit was delivered and installed in 2002, but the iridium-192 source has never been purchased.

The HDR unit was delivered and installed in 2002, but the iridium-192 source has never been purchased. The unit was purchased with hope that the oncologists, physicists and therapists would go outside Kenya to be trained to use HDR technology. Regretfully, that has not been on the priority list for the hospital's budgetary allocations. The unit is housed in a bunker with a cobalt therapy unit. The location of the HDR unit is not ideal. There is no clean room for applicator insertions in the vicinity of the bunker. HDR applicators would likely be inserted in the surgical theatre on the upper floor, and the patient would then be relocated to the bunker on a stretcher. The only entry point into the bunker is through a common and usually crowded waiting room. At the present time, the pressing issue is the lack of adequate training in brachytherapy. A South African clinic has provided KNH with dozens of representative HDR treatment plans. The intention was for all oncologists to study plans and possible dose distributions before the method was to be implemented at KNH. Treatment planning in real time cannot be done without a functioning simulator or a treatment planning system that is equipped to handle 2D plans. Instead, the objective would be to use plans generated in South Africa, and to use the C-arm x-ray unit to image the position of the applicator. All staff of the department are reluctant to pursue HDR treatments without adequate training by experienced clinicians elsewhere.

The department has purchased PLATO treatment planning system (Nucletron, The Netherlands). Although operational, the system has not been used to generate any patient plans. The department purchased the licence for 3D planning only, but the treatment simulator required for 3D planning has not been in use since 2002. Instead, all plans are done by hand. Breast treatments and the curative head and neck treatments are planned by medical physicists. The majority of other sites are not planned. The mould facilities exist, but they are rarely used. Custom-made shielding is also very rarely used, and it was not used on anyone during my visit.

4. Radiation Therapy: From Consultation to Treatment

The general schedule within the radiation oncology department is structured as follows:

Monday: The new-patient clinic. Patients referred by provincial hospitals are seen by the oncologists. The wait time from referral to consultation is 6-8 weeks. The records that the patients bring from their local hospitals are reviewed, and additional diagnostic tests are ordered. 40-50 new patients are seen each week.

Tuesday: Patients that have completed work-up are seen by the oncologists. The course of therapy is decided and patients that are eligible for radiation therapy are scheduled for radiotherapy planning. The wait time from 'ready-to-treat' to treatment is another 6-8 weeks.

Wednesday: About 120 patients come for follow-up each week. The status of chemotherapy patients is assessed and blood tests are ordered.

Thursday: Chemotherapy is delivered. Approximately 40 patients are on chemotherapy at any given time. The records of patients on treatment are reviewed by oncologists.

Friday: Ward rounds. The oncology department also has a ward with 32 beds for in-patients on treatment. The paediatric oncology department is a separate unit, and radiation oncologists offer regu-

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Radiation Therapy in Kenya… continued

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lar consults to haematologists in the paediatric department.

Treatment planning starts in the clinic. It is a single examination room with four examination couches separated by curtains. Up to four oncologists, nurses, medical physicist and radiation therapist are normally present in the clinic. Patient records are examined, vital tests are performed, additional tests are ordered, and radiation doses are prescribed. The oncologist discusses possible lines of action with the patient.

Patients that are eligible for radiotherapy are sent for x-ray imaging on the C-arm x-ray unit in the department. The bony anatomy visible on x-ray images is used by the oncologist to decide on field borders. Metal filaments are placed on the skin before final images are taken to localize the tumour and avoid organs at risk. A radiation therapist is present during imaging to record field borders in the patient's chart for radiation treatment. Skin tattoos are normally not used as most patients have dark skin. Instead, instructions are recorded by oncologists, giving field positions on the skin with respect to major anatomical landmarks. The institution does not have standardized protocols or doses for treatment of various sites. The oncologists were trained at different foreign schools, and each oncologist prescribes treatment at his/her own discretion.

A larger fraction of treatments are not planned, and the beam time (in minutes) is calculated monthly by radiation therapists from prescribed dose (Gy), output (Gy/min), % depth dose, and field size correction factor (normalized to 10x10 field size, equivalent square calculation). Radiation beams are not directed through accessories such as neck rest, obviating the need for accessory correction factors. Tray factors are not considered in the calculation. Compensators are not used for any treatment. The only patient specific blocks are those used for Hodgkin's lymphoma. Wet gauze is used as bolus for skin treatments.

All breast treatments and curative head and neck treatments are planned by a medical physicist. Contouring is done in the examination room by the radiation therapist and medical physicist either using a contouring board for breast or flexible curve for head and neck. Treatment plans are done by hand, from isodose curves for various field sizes and wedge angles. A correction is made for patient contour along the midline of the field in one dimension.

Treatment plans are simple, consisting of a minimal number of beams. There are several reasons to keep plans uncomplicated. First, the majority of patients present in the advanced disease stages and are treated with palliative intent. Second, the wait time measured in months implies tumor growth before treatment begins obviating the necessity for tight tumor margins. Third, there is a lack of imaging equipment at the treatment planning stage, making tumor delineation and accurate treatment set-up nearly impossible. Fourth, the number of patients treated daily (130-150 patients on two cobalt-60 units) makes it impossible to spend extended amounts of time positioning each patient. For the same reason, patient-specific shielding and casts are normally not machined. The couch on either machine cannot be angled. Moreover, the couch on the unit purchased in 1983 cannot be moved sideways, restricting gantry angles to 0, 90, 180 and 270 degrees.

Field borders are recorded in patient's charts, written out in reference to nearby bony anatomy. The radiation therapist delineates the borders with a marker on the skin along the circumference of the projected light field. Such marks are used for field matching. Radiation therapists are expected to use their own judgment concerning the coverage of visible tumours. The size of the tumour is assessed by the oncologist 6-8 weeks prior to the first treatment, and it is likely to have changed. A therapist may increase the field size to cover the visible tumour with an estimated margin before the patient is seen by the oncologist at follow-up.

The only patient specific blocks are those used for Hodgkin's lymphoma. Wet gauze is used as bolus for skin treatments.

Where appropriate, lead shields of standard thicknesses are positioned according to the shadows they cast on the skin. A beam may be angled by a few degrees to avoid irradiating the spinal cord or the oesophagus, as is the case in the treatment of superclavicular nodes in breast patients. Parallel-opposed beams with either 30-degree or 15-degree wedges are used for breast treatment. Blocks are not used to eliminate the divergence in the lung. In head and neck treatments, a lead shield is placed over the spine once the cord threshold is reached. Treatment plans are mainly based on criteria suggested by IAEA and WHO[15].

5. Radiation Therapy Unit Workload and Wait Times

130-150 patients are treated on two cobalt machines each day, and a therapist normally works alone on a cobalt unit. The workload is divided among three shifts: 7am-1pm, 1pm-5pm, and 5pm-10pm. The evening shift is normally reserved for patients from the ward. Some exceptions are made for out-patients whose jobs prevent them from coming for treatment during the day.

Due to a very high number of referrals, patients can wait up to four months to commence treatment.

Due to a very high number of referrals, patients can wait up to four months to commence treatment. This may have serious impact on the treatment outcome for many patients. Normally, there are about 90 patients at any given time waiting to start treatment.

Patient teaching is an important factor in improving a patient's quality of life. It is meant to provide knowledge that patients need to make informed decisions and manage their condition. In Canada, it is done individually for every patient and his/her family. In Kenya, oncology nurses perform patient teaching in front of large groups of patients as they wait to be seen by oncologists. Nurses also perform patient teaching periodically while patients are waiting to be treated on cobalt units. A large number of patients treated daily restricts scheduling of patients to large groups. While this means that patients may wait for hours for their radiation treatment, it also gives nurses an opportunity to perform patient teaching. Nurses address possible side-effects of

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Radiation Therapy in Kenya… continued

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radiation therapy and ways of managing them, but this method does not allow the nurses to address individual needs of patients. Oncologists review the status of patients on treatment every Thursday. Depending on the treatment progress, prescriptions may be modified.

The majority of Kenyan population lives on less than $1 per day.

6. Cancer Care: Difficulties that Patients Face

The majority of Kenyan population lives on less than $1 per day. Kenya has inadequate basic infrastructure of roads, clean water and sanitation, which makes it difficult to see a physician regularly. The country lacks in cancer prevention and screening programs. All of the oncology specialists in Kenya are located in Nairobi, inaccessible to the majority of patients. It is not uncommon for cancer patients to be misdiagnosed and mistakenly treated for other ailments. Basic radiologic services are generally available in the country, but CT and MRI are not. Molecular diagnostic facilities are rare and unavailable to the majority of patients. All these factors lead to late cancer diagnosis and, consequently, poor treatment outcome. Surgical services are widely available, but the two surgical oncologists are in Nairobi. The pathology results may take months because there are too few pathologists in the country.

Upon diagnosis, many patients will choose alternative forms of medicine. Particularly in rural communities, there is a widespread opinion that illness is caused by various metaphysical forces and much trust is put into traditional medicine, naturopathy and various forms of witchcraft. In addition, stigma seems to surround Kenyatta National Hospital itself. Given that KNH is the largest hospital offering most specialized treatment in the country, patients with most serious conditions are referred to KNH. A referral to KNH is viewed as a sign of serious illness with little chance of being cured. Hence, patients with restricted financial resources or little faith in western medicine may choose not to seek treatment at KNH.

Upon referral to KNH, patients wait 6-8 weeks to be seen by an oncologist. A large proportion of the radiation treatment cost is covered by the Ministry of Health. The patient is expected to pay $4 US per fraction, amounting to up to about $80 US for treatment. This may be contrasted with the treatment cost of $1,700 US at the Nairobi Hospital. While the cost to the patient at KNH is low by our standards, it is still beyond reach for many patients. An additional expense are the accommodations in Nairobi. The oncology ward consists of 32 beds, at an additional cost to patient of $4 per day. Commuting daily to Nairobi is usually not an option. Some patients must travel as far as 600km, and public transport outside of Nairobi is very unreliable and inconvenient. Nairobi is an expensive city, and the government provides no subsidy for stay near the hospital while on treatment.

Chemotherapy is an option, but again, it is out of reach for many. Patients are expected to pay full cost of chemotherapy drugs, and the cost ranges from $50 and $100 US per course, for up to 6 courses. Consequently, many patients will opt for inferior chemotherapy drugs or opt out altogether. Outside of Nairobi, chemotherapy is administered by physicians that are not trained in oncology. This leads to complications due to toxicities that are preventable or treatable.

The dilemmas that most patients face are extremely difficult. Receiving treatment may mean selling their property and compromising the livelihood of their families.

The dilemmas that most patients face are extremely difficult. Receiving treatment may mean selling their property and compromising the livelihood of their families. Given that the cancer diagnosis often comes at a time when palliative care is the only option, it is hardly surprising that many patients resort to alternative means of dealing with cancer, such as traditional healing using herbs, spiritual interventions and prayer. There are six hospices in Kenya that offer end-of-life care, numerous nursing homes and palliative care units in most hospitals. Many palliative patients prefer to return to their homes. The hospice in Nairobi is located in the KNH compound. It is run by registered nurses trained in palliative care. The hospice offers services to terminal cancer patients during the day time. Narcotics and analgesics are sold to patients that can afford to pay, but the drugs are also given to patients who do not have the means of paying for them.

Patients for whom the financial aspects are not a deciding factor in terms of treatment also face considerable difficulties. Late prognosis, long wait times, rare follow-up sessions with oncologists, lack of conformal treatments and means of boosting dose to superficial tissues are some of the factors that result in toxicities and morbidity that may be managed successfully in other parts of the world.

7. Cancer Care: Difficulties that Clinicans Face

The lack of resources and a great number of extremely ill patients also have an effect on all clinicians in the radiation oncology department. Four radiation oncologists manage the entire population of Kenya. The time an oncologist spends with a patient is therefore extremely limited. The appointments are conducted in a clinic with four examination couches, where all oncologists work together with nursing and radiotherapy staff. Hospital records are not computerized. The referral notes and supporting documents are hand-written and most often quite sketchy. Moreover, the staff at the public hospitals are underpaid. In addition to working full time at KNH, all radiation oncologists work in private hospitals. KNHY offers no internet access and the department has no formal library with international medical journals and textbooks.

Medical physicists encounter similar challenges. Overcrowded wait lists allow for little time to individualize patient treatment and work on implementing novel ways of treatment. Receiving funding from the hospital or the Ministry of Health for continuing education in medical physics outside of Kenya is nearly impossible. Moreover, the same is true for the oncologists, and that leads to general stagnation in terms of implementation of newer treatment methods. Unfunctional equipment and limited resources cause frustration. Western jour-

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Table 5. Equipment requested from the Ministry of Health in 2008.

Nairobi Centre	Mombasa Centre	Kisumu Centre
1 cobalt, 1 Linac	2 cobalt	2 cobalt
1HDR afterloader	1HDR afterloader	
	1 C-arm x-ray unit	1 C-arm x-ray unit
1 CT simulator	1 CT simulator	1 CT simulator
Mould Room	Mould Room	Mould Room
3D TPS	3D TPS	3D TPS
Dosimetry equipment	Dosimetry equipment	Dosimetry equipment

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nals present countless ways of improving patient outcome, yet little can be done at a hospital that only has cobalt treatment units. Moreover, while all personnel aspire to complete continuing education courses in the developed countries, they realize that the methods they learn outside Kenya will be of limited use once they return to KNH.

8. Challenges in Radiation Oncology in Kenya

Kenya faces numerous constraints which must be overcome to improve cancer control at all levels. Problems include: prevention, screening, oncology training for general practitioners to ensure early diagnosis, centralized patient databases, clear and well-documented national cancer policy and national cancer registry. The country's diagnostic capabilities must be improved for curative effects of radiation therapy to be realized. In the meantime, providing most optimal care to alleviate suffering of palliative patients may be of most benefit.

In radiation therapy, there is room for growth in all aspects of planning, education and implementation of new methods. The hospital does not have established protocols for treatment of various sites. The existing infrastructure is absolutely inadequate for a population of 38 million.

In January 2008, a programme for improvement of radiotherapy services was developed and approved by the Ministry of Health. However, the funding for various parts of the project remains to be found. It is expected that IAEA will agree to share the cost of the project under the umbrella of its PACT initiative, but the project has not been approved in IAEA's General Assembly yet. With this project, the radiotherapy centre at KNH is to be significantly expanded and two additional radiotherapy centres are to be built in Mombasa and Kisumu. The funding for a replacement cobalt unit ($1 million US) was allocated already, and it is expected that the new unit will arrive during 2009. Table 5 indicates the equipment that was requested in the proposal, and staffing needs are presented in Table 6. Furthermore, M. P. Shah private hospital in Nairobi is currently building bunkers for two linear accelerators that are going to be installed in the near future. While only the privileged few can afford treatment at a private centre, this will alleviate the wait list for treatment at KNH and will benefit all patients at least indirectly.

The country's diagnostic capabilities must be improved for curative effects of radiation therapy to be realized. In the meantime, providing most optimal care to alleviate suffering of palliative patients may be of most benefit.

9. What can we do?

Management of patients with cancer and other non-communicable diseases in Kenya requires intervention on many levels: in prevention, early diagnosis, treatment and palliative care. A national cancer registry would provide a more accurate means of assessing the country's cancer burden and incidence of cancers due to preventable causes such as viral infections and malnutrition. Improvements in radiation therapy will require considerable effort and foreign intervention, because the cost of infrastructure and treatment units is high. There is no residency program in oncology in Kenya. Oncology is covered as a rotation while pursuing residency in internal medicine or radiology. Within the undergraduate curriculum, oncology lectures are given as part of main subjects. Exposure to specialized oncology ward is purely by chance or student's personal interest.

Medical physics training programme is not offered in any of the East African countries, but that is about to change. In 2004, Dr. David Chettle (Medical Physics and Applied Radiation Sciences, McMaster University) started discussions with Dr. Michael Gatari and Mr. David Maina (The Institute of Nuclear Science and Technology, INST, Nairobi University) about potential collaborations between the two departments. The process was continued this winter when Dr. Fiona McNeill (Medical Physics and Applied Radiation Sciences, McMaster University) and I visited Nairobi. A memorandum of understanding between the two departments was signed, and Dr. McNeill accepted a position of the external examiner at INST. Links with

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Table 6. Positions for radiation centres requested from the Ministry of Health in 2008.

	Nairobi Centre (existing)	Nairobi Centre (proposed)	Mombasa Centre	Kisumu Centre
Radiation oncologist	4	4	5	5
RT technicians	5	20	12	12
Physicists	2	4	2	2
Oncology nurses	3	6	4	4
Engineers/technicians	0	2	1	1

Radiation Therapy in Kenya… continued

(Continued from page 72)

foreign universities such as this are important for the developing world, because they help with funding for graduate projects and other scientific undertakings.

Mr. Maina and Dr. Gatari have a keen interest in developing MSc programme in Medical Physics that would serve all East African countries. The mission of their institute is to propagate the application of nuclear science in the country. Their syllabus has many similarities with the syllabus for MSc degree in Medical Physics at McMaster, and all alumni that received MSc degree from INST in the past 10 years currently work in radiation protection. Our colleagues from INST are currently revising the syllabus to add several courses specific to medical physics. The course syllabus will be submitted to the post-graduate committee and the senate of Nairobi University for approval in the very near future. The support from McMaster is expected in terms of joint projects, student exchanges and external examiners.

Medical physics training programme is not offered in any of the East African countries, but that is about to change. In 2004, Dr. David Chettle (Medical Physics and Applied Radiation Sciences, McMaster University) started discussions with Dr. Michael Gatari and Mr. David Maina (The Institute of Nuclear Science and Technology, INST, Nairobi University) about potential collaborations between the two departments.

It will be difficult to incorporate a clinical component in the MSc programme in its early days, because there are only two physicists at KNH. In the foreseeable future clinical physicists, oncologists and therapists must rely on scarce funding from KNH to receive training at foreign institutions.

I would like to ask COMP to consider the possibility of bringing one of experienced medical physicists to Canada for continuing education. A HDR brachytherapy unit is already available at KNH. Some experience with the use of the HDR brachytherapy equipment at a clinic such as Juravinski Cancer Centre would benefit Kenya tremendously because no physicists in Kenya have received any hands-on training. There is also a need for training in quality assurance on linear accelerators which are expected to arrive in Kenya.

Joint studies are another way of helping cancer patients, and physicists and radiation oncologists at KNH are eager to partake in research. Collaborations and clinical trials with scientists from developed countries allow third-world countries to become more visible, to secure funding from international organizations. This benefits patients directly, but it also ensures sustainable programme with continuing education of oncology personnel.

Acknowledgements

I am grateful to the people and institutions that have supported me at various stages of the project. This trip was financed by the Canadian Organization of Medical Physics. Dr. David Chettle had encouraged me to apply for the award and had initiated contact with Dr. Michael Gatari. Dr. Michael Gatari took sole responsibility for hosting my stay in Nairobi and facilitated my visit at KNH. Mr. Francis Ngaruiya, senior physicist at KNH, generously spent over two weeks with me, familiarizing me with all aspects of the radiotherapy department. Mr. Ngaruiya allowed me to shadow him during his daily routine work, and he facilitated three brief visits to private clinics in the area. Among others, I thank Dr. Opiyo, the head of the oncology department at KNH, Dr. Mwang'ombe, College of Health Sciences, Ms. Opindi, RN, for sharing the views on the state of cancer care and health care at KNH and in Kenya. I am grateful to radiation therapists, nurses and oncologists for all their hospitality and help during my visit. I would also like to express my gratitude towards Dr. Patterson, Dr. Farrell and Dr. Ostapiak from Juravinski Cancer Centre for their support and help with the topic of dose calculation algorithms which I presented on two separate occasions during my visit.

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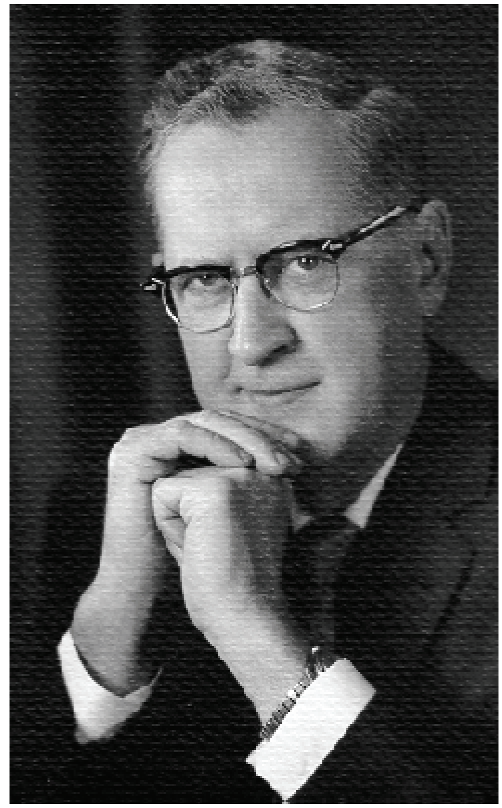
Contributions to the HE Johns Fund



CCPM wishes to recognize and thank the following members for their 2009 donation to the Harold Johns Travel Award. For many years the HE Johns Travel fund has been awarded to young medical physicists to support their travel to another center so that they may gain further experience in their specialty. For the past several years donations to the fund have been significantly less than the annual expenditure. Please consider donating to the fund this year so that we may continue this legacy of education. Further details on the award can be found on the CCPM website.

> *HE Johns—Officer of the Order of Canada, Ph.D., LL.D., D.Sc., Emeritus University Professor and Professor Emeritus in the Department of Medical Biophysics and Radiology, University of Toronto*
>
> *Dr Johns was born of missionary parents while in West China. During his scientific career, he published over 200 peer-reviewed papers, trained over 100 graduate students, many of whom hold key positions in the field of Medical Physics across Canada and around the world. He has won many prestigious awards and has published four editions of "The Physics of Radiology", the premiere textbook in the field.*
>
> *His developments in the late 1940's of the Cobalt 'bomb' led to a new career in the pioneering field of Medical Biophysics. This in turn led to international reputation among scientists. His many awards and accolades reflect the respect and admiration in which he was held by academics and scientists around the world. He was inducted into the Canadian Medical Hall of Fame in 1998. Dr Johns passed away on August 23, 1998.*

Generous Donors to the HE Johns Fund for 2009

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Medical Physicists Scope of Practice

Submitted by: Joseph E. Hayward on behalf of the Professional Affairs Committee
Juravinski Cancer Centre, Hamilton ON

The Professional Affairs Committee of COMP is pleased to provide a draft of the Scope of Practice for Canadian Certified Medical Physicists. Members are invited to provide feedback regarding this document via e-mail to joe.hayward@jcc.hhsc.ca by May 15, 2009.

A number of COMP members have provided substantial contributions to the formation of this document, in particular Curtis Caldwell, Ian Cameron, Peter McGhee, Daniel Rickey and Dave Wilkins.

SCOPE OF PRACTICE FOR CANADIAN CERTIFIED MEDICAL PHYSICISTS

A document prepared by the Professional Affairs Committee of the Canadian Organization of Medical Physicists (COMP).

Revised: February 23, 2009.

DRAFT

I. INTRODUCTION

Medical physicists are health care professionals with specialized training in the medical applications of physics. Their work involves the use of x-rays, radioactive materials, ultrasound, magnetic and electric fields, radiofrequency waves, infrared and ultraviolet light, heat and lasers in medical diagnosis and therapy. Most medical physicists in Canada work in cancer treatment facilities, hospital diagnostic imaging departments, or hospital-based research establishments. Others work in universities, government, and industry.

This document describes the scope of practice for medical physicists who are certified to work in clinical environments. Moreover, this document is based upon the certification structure as established by the Canadian College of Physicists in Medicine (CCPM). That structure recognizes four sub-specialties:

Radiation Oncology Physics
Diagnostic Radiology Physics
Nuclear Medicine Physics
Magnetic Resonance Imaging Physics

COMP does not limit recognition of competence to CCPM certification and has issued a statement on the subject of what constitutes competence for a medical physicist:

"The Canadian Organization of Medical Physicists accepts as evidence of proven competence in clinical medical physics certification by one or more of the

Canadian College of Physicists in Medicine
American Board of Radiology
American Board of Medical Physics.

Certification in one sub-specialty of Medical Physics does not imply competence in other sub-specialties. Competent Medical Physicists are expected to comply with the "COMP/CCPM Code of Ethics" (www.medphys.ca/info/reports/ethics.cfm).

II. GENERAL DESCRIPTION OF MEDICAL PHYSICISTS

A. Clinical Service

Medical physicists are primarily responsible for a variety of clinical activities. Such activities include technique development, clinical consultation, facility design, optimal equipment performance through appropriate design, specification, acceptance, commissioning, testing, calibration, and troubleshooting, as well as regulatory compliance, radiation protection, and preparation of policies and procedures.

Medical physicists, due to their unique knowledge and expertise, are also often called upon to contribute to resolving issues related to complex cases, equipment malfunction or breakdown, computer hardware or software problems and human errors. Medical physicists play an important role in the interpretation of complex technical information and subsequent translation into a form that is more accessible to others such as hospital administrators and physicians. Additionally, they are uniquely qualified to communicate technical requirements to representatives of the equipment manufacturing companies.

While many of the activities are generic to all sub-specialties, there are also responsibilities particular to each sub-specialty.

1. Radiation Oncology

Radiation oncology physicists are responsible for the accuracy of the radiotherapy treatment delivered. The roles of a medical physicist in radiotherapy include treatment planning, dosimetry, and equipment performance. Fulfillment of these roles entails detailed knowledge of information systems, mathematical algorithms, software, and a diversity of complex devices such as CT-simulators, linear accelerators, and remote afterloading brachytherapy units.

2. Diagnostic Radiology

Diagnostic radiology physicists are primarily responsible for the quality and safety of diagnostic imaging modalities such as Computed Tomography (CT), fluoroscopy, radiography, mammography and ultrasound. The roles of a medical physicist in diagnostic imaging include equipment specification, acceptance testing, quality assurance, protocol development, image optimization, and troubleshooting.

3. Nuclear Medicine

Nuclear medicine physicists are responsible for many aspects of the management and use of unsealed radioactive sources for diagnosis and therapy including: equipment selection and performance assessment; design of planar, Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET) image acquisition protocols; determination of appropriate SPECT and PET reconstruction protocols; assisting in image and data analysis; and design of dosimetric studies. In addition, physicists act as radiation safety experts, advising on the safe handling of radioactive material, including performing shielding calculations, advising on safe disposal techniques, and on contamination control measures.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) physicists work with MRI scanners and are responsible for ensuring optimal image quality, magnetic field shielding, properly functioning radiofrequency shielding, and safe practices, policies and procedures for areas near a strong magnetic field. MRI physicists also play an important role in the development of acquisition sequences and protocols as well as image post-processing software

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and procedures. The MRI physicist may also be asked to assist with the interpretation of images or spectra, especially when image artefacts are present. The responsibilities of a MRI medical physicist include equipment specification, MRI siting design, acceptance testing, quality assurance, and image artefact troubleshooting.

B. Radiation Safety

Medical physicists have expertise in radiation safety. Although subject to additional assessment, Canadian regulatory bodies do recognize medical physicists who are certified by the Canadian College of Physicists in Medicine as particularly suited to being Radiation Safety Officers for medical facilities employing radiation-emitting devices and radioactive materials.

C. Research and Development

In general, medical physicists play a central role in the design, construction, characterization, and optimization of imaging systems and radiotherapy treatment equipment. Research areas engaged by oncology physicists include the theory of radiation absorption and dose calculation, measurement of radiation dose, the use of heat and lasers in cancer treatment, and radiobiology. Imaging physics research includes the theory of image formation, detector development and characterization, development of techniques for image quality assessment, and investigating the safety aspects of imaging.

D. Teaching

Many medical physicists hold academic appointments with universities and/or teach in graduate and undergraduate medical physics and physics programs. They also teach radiology and radiation oncology residents, medical students, and radiology, radiotherapy, and nuclear medicine technologists.

E. Professional Status

COMP (www.medphys.ca) promotes the application of physics to medicine through scientific meetings, technical publications, educational programs, and the development of professional standards. COMP is linked to medical physics organizations in other countries through the International Organization of Medical Physics.

Certification of Canadian medical physicists is performed by the Canadian College of Physicists in Medicine (CCPM), which was established in 1979 to recognize proven competence in physics as applied to medicine. Candidates with suitable educational background and experience become members of the College by passing written and oral examinations. CCPM certification is widely accepted in Canada and other countries, and in many provinces is a requirement for employment and/or career advancement. CCPM supports continued professional education by sponsoring symposia on specialized topics and by providing a travel award for newer members in honour of pioneering medical physicist Harold E. Johns.

F. Employment of Medical Physicists in Canada

Historically 75-85% of Canadian medical physicists have worked in cancer treatment centres, hospitals and hospital-based research establishments. There is an approximately equal distribution of the remainder amongst government, industry, and university faculty who are not hospital-based. While medical physics is a diverse field, most medical physicists in Canada work in clinical service in one of the approximately 40 radiation treatment centres.

III. EDUCATION OF MEDICAL PHYSICISTS

With very few exceptions, medical physicists in Canada have a graduate degree in medical physics, physics or a related discipline, with the majority holding a doctorate degree. For the radiation oncology subspecialty, a further nominally two-year period of clinical residency or on-the-job training is required. In some provinces, the end of such residencies is marked by a formal review and oral examination. After two years of clinical experience, and upon successfully passing written and oral exams, a medical physicist is eligible to apply for Membership in the CCPM. The primary mandate of the CCPM is to certify that members of the College are competent medical physicists.

Certified medical physicists must participate in continuing education and demonstrate ongoing maintenance of their competency every five years through the CCPM recertification process. A point system based upon conference attendance, successfully completed courses, research and teaching activities, and development of clinical techniques ensures that the certified medical physicist keeps abreast of the rapid evolution of the profession.

Within the medical physics profession the recognized process for accrediting medical physics graduate and residency programs is through a program audit by the Commission on Accreditation of Medical Physics Education Programs (CAMPEP; www.campep.org). The CCPM is an official sponsor organization of CAMPEP together with the American Association of Physicists in Medicine, the American College of Medical Physics, and the American College of Radiology. Two CCPM members serve on the board of CAMPEP.

IV. DUTIES AND RESPONSIBILITIES OF MEDICAL PHYSICISTS

The exact duties and responsibilities of a medical physicist depend significantly upon the physicist's sub-specialty but, in general, focus on the physics and instrumentation related to diagnosis and treatment. Medical physicists have detailed knowledge of how fundamental physical principles are applied to medicine and leverage that knowledge to develop protocols to optimize both quality of care and operational efficiencies. When difficulties do arise in the delivery of optimal care, e.g., due to case complexity, equipment malfunction or breakdown, computer problems, software irregularities, or human errors, medical physicists are available to apply their expertise and problem solving abilities to rectify the situation. Medical physics is an evolving field, and the specific areas of expertise will change with new developments in the basic science and technology. Currently, medical physicists in general have expertise in at least the following areas:

A. Equipment Selection

The medical physicist must have current knowledge of developments in equipment used within their sub-specialty, provide critical assessment of manufacturer's claims, recommend selection of the best equipment to meet program requirements with the available resources, negotiate technical details with manufacturers, and specify equipment performance in purchase documents.

B. Facility Design and Shielding

Modern equipment for which medical physicists have responsibility has complex infrastructure and safety requirements. In siting new equipment, a medical physicist must ensure appropriate accommodation for electrical power, ventilation, climate control, emission monitoring, shielding that ensures the proper functioning of equipment and/or protection of personnel and the public, safety interlocks, audio and video monitoring of the patient, and other safety measures to protect anyone to whom the equipment may present a risk. When required, designs must be submitted to the appropriate regulatory authorities for approval, including the results of any relevant detailed measurements performed by the medical physicist to verify those designs and their final construction.

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C. Acceptance Testing

Following installation of new equipment or upgrades to existing equipment, it is the responsibility of the medical physicist to perform a series of tests and measurements to verify that equipment performance meets the requirements of the purchase.

D. Commissioning

Medical physicists perform detailed measurements to completely characterize the operation of medical equipment. Measured data are processed and compiled in a form appropriate to facilitate routine clinical use of the equipment.

E. Computer Systems and Networking

The modern imaging and therapy equipment for which medical physicists are responsible often relies on the transfer of large amounts of information between an assortment of commercial software operating on a variety of hardware platforms, such as Picture Archiving and Communications Systems (PACS), information systems, control systems such as record and verify, and custom software written in-house by physicists and programmers. Medical physicists, often working with information systems support personnel, can act as administrators for these systems, ensuring the accurate transfer of data between platforms, and the accurate operation of imaging and treatment delivery devices under software control.

F. Quality Assurance

Medical physicists establish and maintain ongoing comprehensive programs of quality assurance on all aspects of equipment performance. Medical physicists routinely perform a quality assurance review of equipment and system metrics with the goal of ensuring the intended use is safe, appropriate, and optimal for the patient.

G. Safety

The medical physicist is responsible for ensuring the safety of staff, patients, and the general public relative to any emissions arising from imaging or therapy equipment. Although, as mentioned in section II.B, certified medical physicists are recognized as being particularly suited to be Radiation Safety Officers (RSOs) for their institutions, such appointments are most common in cancer treatment facilities. Even when not designated the RSO, medical physicists contribute significantly to any radiation safety program, including application for and control of all licensing of facilities that house radiation emitting devices or materials, establishment and supervision of the personnel dosimetry program, monitoring of radiation levels through surveys and wipe tests, facility design including shielding and radionuclide storage, staff radiation safety training, radioactive material containment and inventory control, source acquisition and disposal, and assessment of, and communication with appropriate regulatory authorities regarding, any radiation incidents. Medical physicists assume a central role in the assurance that all aspects of license compliance are met.

In analogy with the RSO role, MRI physicists work with technologists and radiologists to establish policies and procedures under which patients may be safely scanned. MRI examinations are unsafe for some patients with implanted medical devices, e.g., cardiac pacemakers; for others such examinations are safe only under certain conditions. The physicist will determine, from the technical specifications for the scanner, discussions with the equipment manufacturers and a survey of the available literature, if the interaction between the MRI scanner and the medical device presents an unacceptable risk to the patient.

H. Technique Development

Clinical methods that medical physicists support are continually evolving with new technical capabilities necessitating a better understanding of the physics and biology pertinent to diagnosis and treatment of disease. Development, evaluation and clinical implementation of new techniques are part of the ongoing work of medical physicists.

I. Teaching and Research

Medical physicists are commonly involved in the teaching of undergraduate and graduate students in physics and medical physics. They also teach radiology, nuclear medicine, and radiation oncology residents, and radiology, nuclear medicine, and radiation therapy technologists. Many medical physicists have academic appointments at universities, hold research grants, supervise graduate students, present research at scientific or medical conferences, and/or publish in peer-reviewed scientific journals.

J. Sub-Specialty Expertise

In addition to the expertise outlined above, there are additional responsibilities explicit to the four sub-specialties of Medical Physics.

1. Radiation Oncology

The principal focus for Radiation Oncology physicists is radiation treatment preparation and delivery processes, including medical imaging, treatment planning, dose calculation, patient immobilization, mechanisms of operation of treatment delivery devices, interactions of radiation with matter, and the biological response of cells and tissues to ionizing radiation. The complex nature of modern radiotherapy requires that the process be overseen by professionals with an understanding of the spectrum of knowledge from the technical minutia through to the full scope of the operations. Medical physicists, with an education that emphasizes fundamental understanding of basic science and problem solving, are ideally suited for this role. Radiation Oncology physicists are typically considered the authoritative technical and scientific resource persons in a radiotherapy program.

a) Treatment Planning Systems

Sophisticated computer systems are used to model the delivery of radiotherapy, in order to accurately predict the dose delivered during treatment and to help optimize the planned treatment. The medical physicist is responsible for understanding the algorithms used by planning systems, investigating and documenting their capabilities and limitations, populating the software with valid data, verifying the accuracy of calculations, training and supervising technical staff using the treatment planning systems, performing system administration functions, and integrating computerized planning systems with other computer systems used in radiotherapy, such as imaging and treatment record and verify systems.

b) Imaging

Radiotherapy has an increasing reliance on medical imaging information for diagnosis, staging, and planning of cancer treatment using radiation. CT, magnetic resonance imaging (MRI), fluoroscopy, film and digital radiography, nuclear medicine, digital subtraction angiography (DSA), PET, and other imaging modalities are routinely used. Medical physicists have specific expertise in the physics and technology of these imaging techniques, and ensure their optimal and appropriate use in radiotherapy.

c) Absolute Dosimetry

Medical physicists using precise measurement equipment whose calibration can be traced to national measurement standards laboratories perform the calibration of radiotherapy equipment and radioactive sources. Medical physicists are experts in the quantification of ionizing radiation, and have current knowledge of the latest measurement protocols recommended by recognized standards laboratories and national medical physics organizations.

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 DRAFT

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d) Treatment Planning

The technical aspects of treatment planning are under the oversight of medical physicists. Radiation oncologists, treatment planners, and radiation therapists consult with medical physicists routinely regarding treatment strategies and details. Complex or unusual cases are often planned directly by the medical physicist and medical physicists are responsible for maintaining an appropriate level of review of plans to ensure optimal plans are being produced.

e) Radiobiology

The models describing the response of tumours and normal tissues to radiotherapy involve advanced mathematical models that are best understood and interpreted by physicists who have training in the biological effects of radiation, as well as statistics and mathematical modeling. For instance, medical physicists may be called upon to perform calculations based on these models to estimate dose equivalency of different radiotherapy fractionation schemes or the optimum strategy to compensate for interruptions in radiotherapy treatment delivery.

2. Diagnostic Radiology

Diagnostic Radiology physicists have a principal focus in optimizing the use and functionality of diagnostic imaging equipment. Such equipment includes conventional x-ray systems, fluoroscopy, mammography, computed tomography, and ultrasound. The goal is to maximize the clinically relevant information while minimizing risk to patients, personnel and the public, particularly that from radiation exposure. Diagnostic Radiology physicists are often the authoritative technical and scientific resource persons for a radiology department using such equipment.

a) Accreditation of Equipment

Radiology equipment may be accredited by an independent organization. This is particularly true for mammography where a medical physicist must assess equipment performance on an annual basis. Physicists who survey mammographic systems must hold a specialized accreditation in mammography given by the CCPM.

b) Equipment Purchasing

Hospitals have large amounts of imaging equipment that must be replaced regularly. The physicist is intimately involved in the equipment selection and must be able to make a quantitative comparison of the technical specifications provided by each vendor. To facilitate a comparison the physicist prepares a detailed technical questionnaire that is answered by each vendor. The physicist must review the answers and other literature provided to quantify each answer and make a recommendation as to which scanner to purchase.

c) Acceptance Testing

The medical physicist is often present during the installation of new imaging equipment. After installation it is the job of the physicist to check the equipment to ensure that all specifications are met and it is safe to use.

d) Periodic Testing

Performance is checked on a regular basis using phantoms to ensure that there is no degradation. The physicist performs annual tests. Quality assurance tests performed more frequently are typically conducted under the guidance of a physicist by technicians. As a component of testing, physicists develop phantoms and image analysis tools.

e) Safety

Safety includes dose estimation and radiation protection considerations such as shielding calculations, optimization of performance of image acquisition, and balancing the competing objectives of image quality and minimization of dose to the patient.

3. Nuclear Medicine

Nuclear Medicine physicists are primarily concerned with the use of unsealed radionuclides for diagnostic and, to a lesser extent, therapeutic applications. Many of the responsibilities of a nuclear medicine physicist mirror those of the diagnostic radiology physicist including the purchase of equipment, acceptance and routine testing, radiation protection, dosimetry, teaching, research and development.

a) Radioactive Sources

In nuclear medicine the radiation, mainly gamma photons, is emitted from a patient or patient sample. The physicist is responsible for ensuring the detectors used to measure the radiation dose given to the patient and the scanners used to detect the emissions from the patient or sample are operating as expected. Nuclear medicine physicists are proficient in handling and manipulating radioactive material into forms suitable for testing the equipment. They are also knowledgeable of the radiation safety implications.

b) Research and Development

Due to their detailed knowledge of radiation properties and the radiation detection process, nuclear medicine physicists are often involved in the development of new, and the optimization of existing, imaging techniques. They also take a lead in the implementation of techniques from the literature as applicable to the specific needs of their department, and in formulating methods to process data into meaningful images or information. The physicist will therefore often have programming and software development experience.

c) Safety

The physicist is closely affiliated with the RSO and provides guidance with regards to patient and staff radiation protection techniques, dose calculations, shielding requirements, environmental issues and legislation/regulatory issues.

d) Therapy

The use of radionuclides for therapy is supported either by a nuclear medicine or radiation oncology physicist. In either case, the physicist may be responsible for calculating or checking the patient dose, for ensuring associated equipment is properly functioning and calibrated, and for giving advice with regards to radiation safety of the patient, their family, the public and staff following a therapeutic administration.

e) Other Areas

PET depends on the detection of high-energy photons and is therefore often the responsibility of a nuclear medicine physicist or a specialist PET physicist. As such, the physicist role is almost identical to that in general nuclear medicine. Bone density testing may also be performed

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within nuclear medicine facilities and consequently also receive physics support, including advice on equipment purchasing, equipment testing, and troubleshooting on equipment and software issues.

4. Magnetic Resonance Imaging

Since the basic principles of MRI involve complex physical concepts, a comprehensive knowledge of many areas of advanced physics is required to properly understand the technology. The magnetic resonance imaging physicist, therefore, fulfils an important role on the medical team as a resource person. The responsibilities of the MRI physicist regarding purchasing, acceptance testing, and quality assurance mirror those of the diagnostic radiology physicist but are applied to the technical considerations of MRI. MRI physicists also apply their unique expertise to the optimization and advancement of magnetic resonance image acquisition and analysis techniques.

a) Pulse Sequence Development

MRI is a very versatile imaging technique with many possible acquisition procedures or “pulse sequences”, which all provide specific advantages. The expertise of the MRI physicist is required for the development, evaluation, and optimization of these highly complex pulse sequences to optimize image contrast for the enhancement of biological features of diagnostic interest, image quality, and acquisition time.

b) Spectroscopy

Magnetic resonance spectroscopy makes use of the principles of MRI to acquire information about the chemical composition of tissues in the form of spectra. The MRI physicist plays an important role in the development of acquisition and analysis procedures for MRI spectroscopy and may be consulted regarding the interpretation of spectra.

c) High Field Imaging

There is a trend towards the use of stronger magnetic field strengths in MRI since higher signal-to-noise ratios and better image quality are inherent to these higher field systems. However, there are technological and safety issues related to using high fields. MRI physicists have the expertise to assist with the development of high field MRI scanners to take advantage of the improved image quality and faster image acquisition, and to evaluate safety aspects of these high field scanners.

d) Interventional

Magnetic resonance imaging can be used for certain interventional procedures. MRI physicists have the necessary expertise to develop the specialized procedures required to make interventional MRI feasible and safe.

e) Advanced Imaging Procedures

Certain advanced MRI procedures such as functional MRI (fMRI), magnetic resonance spectroscopy (MRS), or dynamic contrast enhancement studies, due to their complex nature, often require the MRI physicist to be part of the medical team.

V. ACCOUNTABILITY OF MEDICAL PHYSICISTS

The primary responsibility of the medical physicist is to the patient, to assure the best possible procedure and outcome with the available technology, resources, and expertise of the medical team. Only an appropriately trained and experienced physician can prescribe therapeutic doses of ionizing radiation, whether delivered internally or externally. In radiation treatment the responsibility of the medical physicist is to ensure that radiation treatment is delivered in an accurate, safe and effective manner. Similarly, diagnostic procedures can only be performed when ordered by an appropriately trained and experienced physician. Regardless of the modality, the medical physicist is to ensure that the diagnostic procedure is performed in an optimal and safe manner.

In fulfilling their responsibilities, medical physicists are accountable to the patient, the physician who has requested the procedure, other members of the clinical team, the public, and to any regulatory authorities, such as the Canadian Nuclear Safety Commission, who have a legislated mandate to protect the public and the environment from the potentially harmful effects of any emissions from the clinical equipment. In addition, a certified medical physicist is answerable to the CCPM, which has in its bylaws a mechanism to revoke membership in the College for failure to abide by the COMP/CCPM Code of Ethics (www.medphys.ca/info/reports/ethics.cfm).

VI.COMMITMENT TO QUALITY ASSURANCE

Quality assurance is extremely important in the operation and clinical use of imaging and therapeutic equipment for which medical physicists are responsible. The only way to ensure that radiotherapy is actually being delivered as prescribed, or that optimal image quality is being obtained with minimal impact upon the patient, is through a routine and comprehensive program of detailed physical measurement. Medical physicists are responsible for developing, initiating and maintaining quality assurance programs to ensure that the relevant clinical procedures are delivered in a safe and effective manner. Medical physicists through organizations such as the Canadian Organization of Medical Physicists, the American Association of Physicists in Medicine, the Canadian Nuclear Safety Commission, the Canadian Association of Provincial Cancer Agencies, or even provincial entities such as the Ontario Healing Arts Radiation Protection Commission, have defined the criteria for such QA programs. Medical physicists are responsible for knowing and understanding the requirements and rationale of the QA programs recommended or mandated by these organizations, and to implement and maintain these programs to ensure optimal equipment functionality, which is safe for the patient, staff, and the public.

VII. MEDICAL PHYSICISTS MITIGATE POTENTIAL RISK

The potential health risks of exposure to the emissions associated with imaging and therapy, for the most part, have been extensively documented. Ionizing radiations are particularly well recognized because of the tissue damage, carcinogenesis, and mutagenesis associated with their use. The expected benefit of using such emissions must outweigh the potential risk to the patient, and it is the joint responsibility of the medical physicist and the physician responsible for the procedure to ensure that the estimated benefit-risk ratio is sufficiently large to justify the procedure. In addition, use of ionizing radiation poses specific risks to the staff of health care facilities, and to members of the public. Medical physicists are specifically trained and certified in radiation safety, and are responsible for administering a radiation safety program. When high-energy therapeutic beams or radionuclides are used, this program is mandated by the Canadian Nuclear Safety Commission, and includes facility shielding design and verification, dose monitoring of personnel, wipe testing and inventory control of radioactive sources, and staff education.

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Ultrasound and MR do not use ionizing radiation and consequently impose different risks such as heating of the patient, cavitation, or the physical dangers associated with strong magnetic fields. Other potential risks to the patient and staff arise from high voltage electrical systems, automatic motion of equipment, and possible exposure to hazardous materials. The medical physicist is responsible for ensuring that these risks are appropriately assessed and managed, which may require consultation with other qualified professionals, and that quality assurance programs are in place to verify the accurate and safe functioning of the equipment.

The MRI physicist in particular is responsible for the safe siting and use of the MRI scanner. The physicist must ensure that monitors on the scanner are working properly so that the patient is scanned safely. The MRI physicist must also ensure that effective policies and procedures are in place to allow only authorized and properly trained individuals to have access to the MRI magnet. The layout of the MRI suite is to comply with recognized guidelines to prevent unauthorized access to the magnet room. The physicist, in conjunction with other members of the medical team, must establish effective screening procedures to ensure that patients with implanted medical devices, e.g., cardiac pacemakers, or other contraindications are identified and appropriate steps taken to address the situation.

VIII. MEDICAL PHYSICS AS A SCIENCE

Medical physicists hold graduate degrees from accredited universities and are trained in the methodology of scientific research. The field of medical physics has evolved through a century of scientific research and development to a level of knowledge that allows radiation treatment to be delivered with impressive accuracy and has facilitated incredibly rapid advances in the clinical abilities of diagnostic imaging. Medical physics has contributed to maintaining diagnostic imaging and radiation oncology on sound, evidence-based, scientific principles by virtue of its culture of sound research, meticulous attention to detail, open communication of research results at scientific conferences and in peer-reviewed journals, and active participation in national and international associations.

Advances in the field of medical physics are published in peer-reviewed scientific journals such as *Medical Physics, Physics in Medicine and Biology* (official scientific journals of COMP and CCPM), and the *Journal of Applied Clinical Medical Physics* (official scientific journal of the American College of Medical Physics). Medical physicists also contribute to journals that are specific to their sub-specialty, for example the *International Journal of Radiation Oncology, Biology and Physics* (official scientific journal of the American Society of Therapeutic Radiation Oncology (ASTRO)), and *Magnetic Resonance in Medicine* (official scientific journal of the International Society for Magnetic Resonance in Medicine (ISMRM)). COMP publishes a quarterly newsletter called *Interactions* (ISSN 1488-6839), designed for and directed towards the Canadian medical physics community. These journals, along with participation in conferences such the annual scientific meetings of COMP, AAPM, ASTRO, ISMRM, and regional meetings such as WESCAN and the Atlantic Medical Physics Group, are the primary forums for communication of research results, developments, and new practices in medical physics.

IX. WORKPLACE SETTING AND CULTURE FOR MEDICAL PHYSICISTS

Large Canadian hospitals commonly employ a single imaging physicist in their radiology or nuclear medicine departments. The majority of therapy physicists are employed in approximately 40 outpatient radiation treatment centres. In most provinces, such centres are part of a provincial cancer agency and are attached to a host hospital, which is usually a tertiary care teaching hospital. The medical physics departments within these centres consist of one to as many as fifteen medical physicists typically accompanied by a complement of treatment planners, electronics technologists, physics assistants, mechanical technologists, computer support personnel, administrative staff, students, and/or postdoctoral fellows.

Medical physicists act in support of the clinical program in which they participate, with overall responsibility for the technical aspects of image acquisition and/or treatment. Development and implementation of new techniques is an important part of the medical physicist's role, and as a result most are involved in programs of research and/or development. It is common for medical physicists to have an academic appointment at a university, either in the Faculty of Medicine, reflecting their role in teaching medical residents, and/or in a Department of Physics, reflecting their involvement in teaching graduate and undergraduate courses, and supervision of medical physics graduate students. Other academic duties can include teaching radiation technology students, supervising summer and co-op students, teaching medical and medical physics residents, and providing in-service education to other members of the clinical team. The magnitude of the academic component of a medical physicist's role varies between institutions, but is strongly encouraged through the CCPM recertification process, which awards points for authoring peer-reviewed publications, teaching courses and attending conferences. Participation at scientific conferences is widely recognized as a vital method for communicating research results and keeping abreast of developments in the field.

Medical physicists work in a knowledge-based environment as part of a team whose goal is to provide excellent patient care. The rapidly evolving, high technology nature of modern radiation therapy and diagnostic imaging requires the integration of knowledge in such diverse areas as medicine, physiology, anatomy, radiation physics, MRI physics, patient care, mathematics, statistics, electronics, computer programming and networking, mechanics, radiation biology, and radiation safety. While different members of the clinical team are expert in different areas, it is the medical physicist who bridges the gaps between the diverse fields, and provides continuity in the form of basic scientific understanding of the clinical processes, a systematic approach to trouble-shooting, and creative problem-solving.

X. LEGAL LIABILITY AND INSURANCE IN MEDICAL PHYSICS

Given the complex nature of modern radiation treatment and diagnostic imaging, and, despite rigorous quality assurance and multiple independent checks, misadministration of therapy or sub-optimal image acquisition and analysis that results in significant compromise of the clinical intent can occasionally occur. Should an error occur upon assuming responsibility for the accuracy of radiation dose delivered or, to a lesser extent, image acquired, medical physicists place themselves in a position of potential liability. As employees of health care facilities, medical physicists performing within the scope of their employment and acting in the interests of their employers have a reasonable expectation of being shielded from liability by their employer. Any medical physicist who acts as a private consultant or who is self-employed should carry liability insurance to guard against the unlikely event that an error leads to legal action against the physicist.

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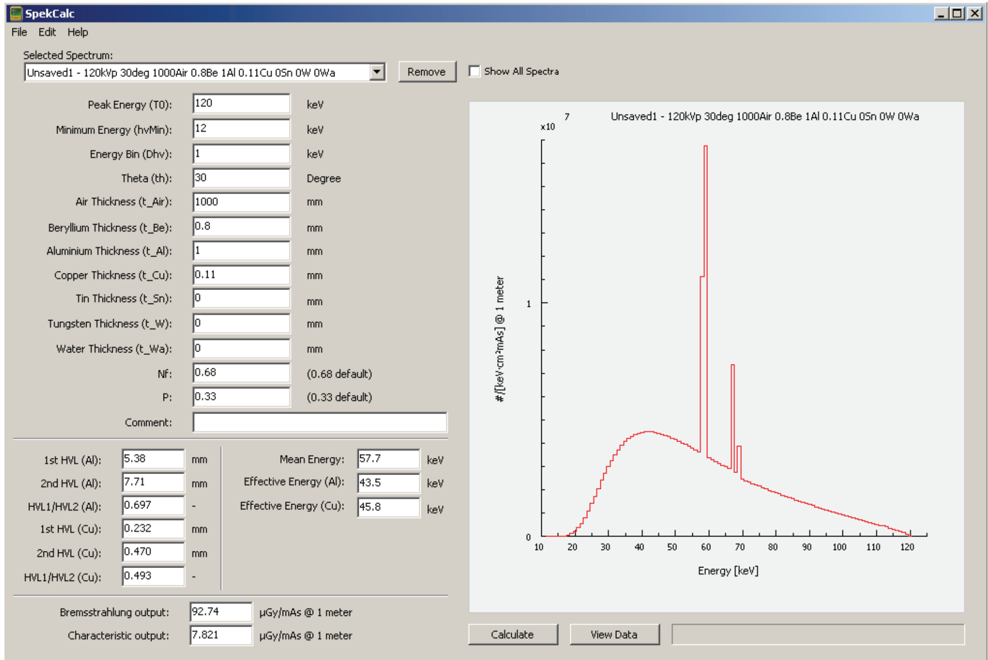
SpekCalc: a free tool for calculating x-ray tube spectra

Submitted by: Frank Verhaegen
Maastro Cancer Clinic, Maastrict, Netherlands

SpekCalc is a new and free tool for calculating x-ray tube spectra, based on research at The Institute of Cancer Research in the UK. The basic technology of an x-ray tube is over a century old, but these remain important devices in hospitals, research and industry. There are many instances where knowledge of a spectrum from an x-ray tube is needed for a specific task, and preferably at the click of a button. This is where a Graphical user Interface (GUI) like SpekCalc, created by researchers working at McGill University in Canada and the Maastro Clinic in the Netherlands, can come in useful.

The interaction processes that happen in an x-ray tube are well-understood. Electrons are directed onto a focal point on a metal target and penetrate into the metal surface. As the electrons penetrate, they scatter from electrons in the target metal and infrequently, but importantly, they emit bremsstrahlung photons via interactions with the nuclei of the target atoms. These processes produce the x-rays that emerge from an x-ray tube. Unfortunately, when we want to predict the spectral output of a particular tube, we find that the equations for the transport of electrons and photons are difficult to solve. Monte Carlo methods are the best technique for cracking this nut. Yet this method needs careful and painstaking modeling and can be very slow to produce an answer on a desktop PC.

Various ‘quick-and-dirty’ spectrum models have been developed over the years and have often been ‘empirically’ based. An example is that of Birch and Marshall (B&M), dating from a 1979 issue of the journal Physics in Medicine and Biology, which has been widely implemented and influential in the development of later models. The simple approach B&M used, meant that they had to abandon the theoretically correct equations for bremsstrahlung. The model for SpekCalc is a little different. The transport of the electrons within a metal target has been treated more thoroughly. The more correct theoretical bremsstrahlung equations have been used. The model has been tested, published in the journal Medical Physics in 2007, and it shows good agreement with experimental spectra.



The SpekCalc GUI provides an almost instant calculation of x-ray tube spectra for tungsten anodes (40-300 kVp) and has applications mainly in diagnostic radiology and kV radiotherapy. It cannot yet be used for mammography. A screenshot of the program is shown below. The user inputs values for the kVp, filtration and take-off angle and a photon fluence spectrum is calculated at the click of a button. The 1st and 2nd half-value-layers for the spectrum are presented in mm of Al and Cu and both the bremsstrahlung and characteristic contributions to the air kerma/mAs are estimated. The calculated spectrum can be conveniently saved for later use.

Those who have downloaded SpekCalc so far have used it for reasons as diverse as teaching in universities, to learn interactively about x-ray tubes, for research in radiology and radiotherapy and even, just out of curiosity. To download it free-of-charge, just visit:

http://www.icr.ac.uk/research/research_sections/physics/3544.shtml

SpekCalc is part of the development of a larger educational software package to teach x-ray imaging, ImaSim, which is currently being developed at McGill University and the MAASTRO Clinic.

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is done with 6 degrees of freedom (3 each for translation and rotation). If the difference between shifts resulting from the two matches is more than 1 cm, a physician is called in order to verify that the moves will not overdose organs at risk *e.g.* the spinal cord. The center of rotation is redefined within the GTV and table moves are calculated. One must be aware of the fact that in some situations beams might end up going through critical structures! The couch shifts resulting from soft tissue matching (> 1mm) are manually performed unlike Varian which allows remote couch control.

For radical lungs, a standard recipe comprising of 7 intensity modulated fields is optimized; each beam is limited to a maximum of 4 step-and-shoot segments. Constraints for the minimum number of MU and the minimum segment area are ≥ 4, and ≥ 25 cm^2 respectively. The prescription dose is typically 66 Gy in 24 fractions, with a mean lung dose, MLD < 16Gy, while the optimization tries to cover 99% of the PTV with at least 95% of the prescription. A beam energy of 18MV is not allowed for lungs, only 6 and/or 10MV.

In a standard CBCT, the volumetric images of organs are blurred due to organ motion. Dr. Simon Rit from Dr. Marcel van Herk's group explained the notion of 4D in CBCT: if the gantry is moved at its normal speed (~1 rpm, just as in routine CBCT) and the raw data are sorted into breath-correlated bins, it will result in aliasing artifacts due to the limited number of projections, spacing at different angular locations and data at different instants of time in the breathing cycle. Therefore, slowing down the gantry rotation (1 revolution in 4 min) can provide enough data and eliminate the streaking artifacts in 4DCBCT. The phase sorting of 4DCBCT is accomplished with the help of the position of the diaphragm in the raw images.

At the NKI adaptive planning is used for prostate patients with CBCT scans being acquired for the first 6 fractions to determine the average position of the prostate. Issues such as rectal and bladder filling can cause severe imaging artifacts and displacement of the PTV and /or organs at risk. This is addressed by advising a controlled diet with mild laxatives a week prior to the treatment.

In addition to witnessing and participating in the clinical aspects of medical physics, I also had the opportunity to meet with several research physicists. A large group is lead by Dr. Marcel van Herk; he briefed me regarding their historical invention of Liquid Ion Chamber portal imagers. Dr. van Herk explained to me the fundamentals behind his famous margin formula and its various ingredients. One of the researchers introduced me to the concept behind probabilistic planning, which would eliminate the conventional concept of PTV. During this visit I was also invited to present my current interests, I presented the implementation of 4DCT and the CBCT based localization for hypofractionated lung patients at TBCC in front of an audience of physicists and researchers at the NKI.

The basic educational requirement to enter medical physics in Holland is a university degree such as M.Sc or Ph.D. in physics. The clinical training program is accredited by the Dutch Society of Clinical Physics on behalf of the Ministry of Health. Medical physics training is 4 years long, it involves 1 to 2 research projects and an internship at another cancer facility. The clinical training is evaluated by reviewing both compulsory 6 monthly reports and the complete training record. After successful completion of training the qualified medical physicist becomes – *clinical physicist*. This is recorded in the official register of qualified medical physicists maintained by the Dutch society of medical physics (Eudaldo 2008).

Acknowledgements

The author wishes to express thanks to the medical physics colleagues, staff, post doctoral fellows, residents and students at the Finsen centre, NKI, and DKFZ. Special gratitude goes to Dr. Marika Enmark, Prof. Uwe Oelfke, and Dr. Roel de Boer for hosting and organizing a successful technical visit for the author. I'm also thankful to Dr. Peter Dunscombe for providing guidance and assistance for this visit. I'm indebted to the CCPM for awarding the prestigious HEJ for 2007 and financial assistance for this visit.

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While this definition gives some wriggle-room for other staff to be the RSO, it is my experience that there are few staff who would be able to perform all these tests without some medical physics training. Canada has very few clinical diagnostic medical physicists compared to the UK or even compared to the US, where state regulations and ACR accreditation require regular measurements by medical physicists. Ironically, Canada has some world-class centres of excellence in imaging research!

In 1979 the medical physics community took the leap of faith to form the Canadian College of Medical Physics. This has immeasurably improved the status of medical physics in Canada, and has in many respects enabled the huge increase in participation by medical physicists in cancer treatment centers across the country. We should use this new legislation as an impetus to provide the medical physics expertise now required in diagnostic radiology. COMP could also take the lead in sponsoring workshops on these test procedures, and developing new ones.

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practice changing events that were difficult to swiftly master while these technologies were introduced to Radiation Oncology practice. It is hoped that the Winter School will address the continuing education needs of all Medical Physicists by addressing subjects with the understanding that the topic may be evolving even as it is being taught. By giving faculty the opportunity to teach over a number of years, successive schools can incorporate continuity, so that any evolution of leading edge technologies can be taught as they are being introduced into the clinic.

The Winter School is not the entire focus of the Science and Education Committee, although it will be our center of attention at first. Eventually we would like to organize continuing education sessions at the COMP AGM and other continuing education opportunities for COMP members, such as web-based continuing education. The challenge here is to provide COMP members with material that will complement continuing education opportunities that they can find elsewhere. For instance areas such as the law or professional and medical ethics are not typically discussed at most professional development courses. Is there a need for this in Canada? I would welcome opinions from COMP members as to what type of continuing education material they would like COMP to offer in the upcoming years.

It is my belief that by starting this committee, there exist a real opportunity for COMP and its members to positively affect Medical Physics in Canada and the rest of the world. However, for the committee to be truly effective, much help is needed. I would be very interested to hear all Canadian Medical Physicist's ideas and thoughts about this new committee, the Winter School, or anything else related to Science or Education that you think should be of importance to COMP. Please do not hesitate to contact me at marco.carlone@rmp.uhn.on.ca. I would be happy to discuss any ideas you would like to bring to the Science and Education Committee.

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pointed times. At that time, we thought the reason was that hotels around the attack sites had gone into a lock down situation and were advising guests not to leave the premises because of security issues. Unfortunately on the Saturday we found out that Sam Jeswani, an invited speaker from Tomotherapy, had been killed along with Ravi Dara, a VP at Kirloskar Medical. A marketing executive from Kirloskar Medical was badly shot and a number of others escaped in very trying circumstances over two days or so. This news came out on Saturday and was followed by a two minute silence for our fallen colleagues.

The terrorist attacks definitely changed the tone of the meeting in a way we would never want to have to experience again. The organizers and attendees showed considerable courage and made an active decision early on the second day of the meeting not to buckle under the terrorism.

A personal note from John: Obviously we had an amazing trip; one I will never forget. The visit will help me take less for granted here in Canada. India is a very different part of the world and while I felt very comfortable and very welcome, the whole time there, the contrast somehow became very real when I returned to Canada and I realized how different the worlds really are. I believe I'll keep that lesson for many, many years to come.

John with some students at one of the evenings out in Chembur

The whole meeting was extremely interesting with excellent science, and our Indian colleagues were very gracious hosts. The organizers were very enthusiastic that visitors had joined them from Canada, the USA and Europe. They are regularly looking for colleagues from away to join them and we would encourage you to consider participating in the future.

Chandra Joshi (left) and Venkat Nara walking near the hotel

Institute of Physics and Engineering in Medicine

Wanted:

Medical physics and engineering feature articles, news and meeting reports

The Institute of Physics and Engineering in Medicine (IPEM) is the UK equivalent of the COMP. IPEM publishes a quarterly magazine for its membership, entitled SCOPE, that contains feature articles, news updates, meeting reports, book reviews etc. The SCOPE editorial board has recently decided to include an international section in the magazine to contain articles and news from around the world. To this end, I invite any, or all, of you to send me interesting news items, meeting reports, or even feature articles (3000-4000 words with figures) for publication in SCOPE.

For more details, or to submit an item for publication in SCOPE, please contact me at the address below:

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Editors Note

Submitted by: Parminder S. Basran
Vancouver Island Cancer Agency, Victoria BC (hopefully!)

Sometime between writing this Editor's Note and you reading this, I will have taken myself on a journey across Canada, from Toronto, Ontario to Victoria, BC. Given these dismal economic times, I hope that by the time I get there I still have a job to go to. My fear is that I get off the plane only to find that the peddlers and squatters outside the legislative grounds are in fact my new medical physics colleagues, recently thrown out on their ears. Seriously, I hope to pass along my new co-ordinates to everyone once it becomes available.

As you might have noticed, this issue is a bulky one, with many great articles. It is great that we were able to get so much timely and relevant information to the membership in this issue. I was pretty impressed in the quality of the HE Johns write-ups.

Shortly after publishing the January issue, I received a very nice e-mail from Doug Cormack who expressed his thoughts on my editorial in that issue, along with some nice words about the job I'm doing. Apart from a few odd phone messages, there is no way of me knowing how good, or bad, a job **we** are doing in creating and publishing this newsletter. Please remember that this newsletter really depends on our COMP membership, and if you dislike anything, have suggestions, or just want to pipe-up about something, we (i.e., the Newsletter and the Editorial Board) are here to listen. I can't guarantee the next Editor will be as favorable in publishing controversial subject matter.

Speaking of the next Editor, I need to pipe-up about the fact that the July issue will indeed be my last issue as Editor… or at-least until someone expresses some interest in taking over this responsibility. I assure you that this job is not as painful as it sounds and is extremely rewarding. If you have an interest, let me know.

I am really looking forward to the COMP meeting in Victoria. It gives us all a chance to play catch-up on the going-ons in the medical physics community. Unfortunately, some Medical Physicists are getting old enough to retire, so the likelihood of seeing some of these individuals will decrease, significantly, over the next few years. I am going to take advantage of my editorial discretion and pass along a heart-felt thanks and good-bye to **Peter O'Brien,** who has officially retired in his capacity as Head of Medical Physics at the Odette Cancer Centre. I know Peter not only as a great 'boss' during my time at the Odette Cancer Centre, but an exceptional volunteer and advocate for Medical Physics in Canada. Many of you probably know Peter as a recent COMP Chair. I'm sure many of my colleagues across Canada know how much of a positive impact Peter has made for Medical Physics during his long career. I can't imagine working at a centre for 27 years… sheesh! I'm hoping to get some pictures and write-up of his 'farewell party'. Thanks, Peter!

I'm looking forward to meeting many of you, some for the first time, at COMP'09.

Take care and have a great spring!

SCOPE OF PRACTICE ....continued DRAFT

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REGULATION OF MEDICAL PHYSICISTS

Currently medical physics is largely an unregulated profession in Canada, and there is little federal or provincial legislation defining the term "medical physicist" or restricting its use to persons with specific qualifications. The exception is physicists accredited by the CCPM in mammography, who are recognized by Health Canada mammography guidelines; otherwise there is no province where the Regulated Health Professions Act recognizes medical physicists. Efforts on the part of the Canadian medical physics community to achieve regulatory status and recognition have been hampered by the simple fact that there is a relatively small number of medical physicists practicing clinically in Canada. Regardless, a number of jurisdictions outside of Canada have accepted Canadian certification as sufficient and appropriate to practice medical physics, and there are ongoing concerted efforts within individual provinces to pursue and establish such recognitions.

Dates to Remember

Apr 28– May 1, 2009
Radiobiology & Radiobiological Modelling in Radiotherapy
Chester, Cheshire, UK

May 1st, 2009 11:59 PM EST
ABSTRACT SUBMISSION DEADLINE FOR COMP09

May 31-June 2, 2009
American Brachytherapy Society AGM
Toronto, ON

May 28-31, 2009
TCP Workshop
Edmonton AB

June 1, 2009
Deadline for July submission to InterACTIONS

June 14, 2009
Extracranial Radiosurgery Symposium
Winnipeg MB

June 13-17, 2009
SNM
Toronto ON

June 23-27, 2009
CARS 2009: Computer Assisted Radiology and Surgery
Berlin, Germany

June 24, 2009
Quality Assurance procedures for PET/CT and SPECT/CT
Malmo, Sweden

June 25-26, 2009
AAPM Summer School: Clinical dosimetry measurements in radiotherapy,
Colorado College, USA

July 21- 24, 2009
2009 COMP Annual Scientific Meeting and CCPM Symposium
Victoria, B.C.

July 26-30 2009
2009 AAPM Annual Scientific Meeting
Anaheim, CA

Sept 7-18, 2009
World Congress– Medical Physics and Biomedical Engineering
Munich, Germany

Sept 30-Oct 3, 2009
CARO
Quebec City , QC

Nov 29-Dec 4, 2009
RSNA Annual Meeting
Chicago, IL