Vol 33 No 3
Summer / Été 2012

Bulletin

Canadian Radiation Protection Association
Association canadienne de radioprotection

Post-Conference Issue

Photos and reports from the CRPA Conference in Halifax and the IRPA 13 Congress in Glasgow, Scotland

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2012 CRPA Award Winners
Gagnants des prix de l'ACRP

CRPA-ACRP May 27-30 Mai HALIFAX TIME TO PREPARE 2012

Founders' Award / prix des fondateurs — Gary Wilson

The Founders' Award is presented for outstanding contributions toward the enhancement of the association. Volunteer work by the recipients has enhanced the reputation of the association nationally and internationally, encouraged participation in association activities, advanced the role and status of the association as an important organization in radiation protection, or promoted the merits of membership in the association to others. This year's recipient was Gary Wilson. (Presented by outgoing president Lois Sowden-Plunkett.)

Le prix des fondateurs est présenté pour souligner les contributions exceptionnelles à l'amélioration de l'Association. Les lauréats de ce prix doivent avoir volontairement effectué des activités dans l'un ou plusieurs des secteurs suivants : améliorer la réputation de l'Association aux niveaux national et international ; encourager la participation aux activités de l'Association ; faire avancer le rôle et le statut de l'Association comme organisation d'importance en radioprotection ; ou faire connaître les avantages du statut de membre à des personnes qui peuvent soit bénéficier des activités de l'Association, soit contribuer à la réalisation de ses objectifs. Cette année, le prix a été présenté à Gary Wilson. (Présenté par la présidente sortante Lois Sowden-Plunkett.)

Distinguished Achievement Award / prix distinction — Jing Chen

The Distinguished Achievement Award is presented for outstanding contributions in the field of radiation protection. Recipients must have received recognition from peers, either nationally or internationally, for accomplishments of major significance to the knowledge, practice, or advancement of the radiation protection profession. This year's recipient, Jing Chen was not at the banquet.

Le prix distinction est présenté pour souligner les contributions exceptionnelles au domaine de la radioprotection. Les récipiendaires de ce prix doivent être reconnus nationalement ou internationalement par leurs pairs en raison des accomplissements majeurs apportés à la connaissance, à la pratique ou à l'avancement de la profession de la radioprotection. Cette année, le prix a été remis à Jing Chen, qui n'était pas au banquet.

Meritorious Service Award / prix mérite — Nick Sion

The Meritorious Service Award is presented for significant services provided to the association or to the radiation protection community in general. This year's recipient was Nick Sion. (Presented by outgoing president Lois Sowden-Plunkett.)

Le prix mérite est offert pour des services d'importance rendus soit à l'Association, soit à l'ensemble de la communauté de la radioprotection. Cette année, le prix a été présenté à Nick Sion. (Présenté par la présidente sortante Lois Sowden-Plunkett.)

Student Paper Contest / Concours de présentations étudiantes — Steven Bartolac

The winner of the 2012 Anthony J MacKay Student Paper Contest was Steven Bartolac. (Presented by Dave Tucker. For more, see page 17.)

Le gagnant de l'édition 2012 du concours de présentations étudiantes Anthony J. MacKay est Steven Bartolac. (Présenté par Dave Tucker. Rendez-vous à la page 17.)

Prospectus

The objective of the Canadian Radiation Protection Association (CRPA) is to advance the development and communication of scientific knowledge and practical means for protecting people and their environment from the harmful effects of radiation consistent with the optimal use of radiation for the benefit of society. To this end, CRPA will

1. further the exchange of scientific and technical information relating to the science and practice of radiation protection,
2. encourage research and scientific publications dedicated to the science and practice of radiation protection,
3. promote educational opportunities in those disciplines that support the science and practice of radiation protection,
4. assist in the development of professional standards in the discipline of radiation protection, and
5. support the activities of other societies, associations, and organizations, both national and international, having any activities relevant to the forgoing.

The association publishes the *Bulletin* four times a year and distributes it to all members. Subscription rates for non-members, such as libraries, may be obtained from the secretariat.

Members of the association are drawn from all areas of radiation protection, including hospitals, universities, the nuclear power industry, and all levels of government.

Membership is divided into five categories: full members (includes retired members), with all privileges; associate and student members, with all privileges except voting rights; honorary members, with all privileges; and corporate members. Corporate membership is open to organizations with interests in radiation protection. Corporate members are entitled to have their name and address listed in each *Bulletin*, a complimentary copy of each *Bulletin*, a copy of the *Membership Handbook* containing the names and addresses of all CRPA members, reduced booth rental rates at the annual meeting, and reduced advertising rates in the *Bulletin*.

Application forms are available on the CRPA website or from the secretariat.

CRPA-ACRP Secretariat

PO Box 83
Carleton Place, Ontario K7C 3P3

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fax: 1-888-551-0712

email: secretariat2007@crpa-acrp.ca
website: www.crpa-acrp.ca

L'objectif de l'Association canadienne de radioprotection (ACRP) est de faire progresser le développement et la communication des connaissances scientifiques et des moyens pratiques pour protéger les personnes et leur milieu contre les effets nocifs des rayonnements, en harmonie avec l'utilisation optimale des rayonnements au profit de la société. À cette fin, l'ACRP désire :

1. améliorer l'échange d'informations scientifiques et techniques liées à la science et à la pratique de la radioprotection;
2. encourager la recherche et la publication d'articles scientifiques, toutes deux vouées à la science et à la pratique de la radioprotection;
3. promouvoir les possibilités pédagogiques de ces disciplines qui soutiennent la science et la pratique de la radioprotection;
4. aider à l'élaboration de normes professionnelles dans la discipline de la radioprotection;
5. soutenir les activités d'autres sociétés, associations et organisations, tant nationales qu'internationales, ayant des activités pertinentes avec ce qui précède.

Les membres de l'association proviennent de tous les horizons de la radioprotection, y compris les hôpitaux, les universités, l'industrie nucléaire génératrice d'électricité et tous les niveaux du gouvernement.

L'association publie le *Bulletin* quatre fois par an et le fait parvenir à tous les membres. Le prix d'un abonnement pour les non-membres, par exemple une bibliothèque, peut être obtenu auprès du secrétariat.

Les membres sont classés selon cinq catégories: membres à part entière (y compris les membres retraités), avec tous les privilèges; membres associés et étudiants, avec tous les privilèges sauf le droit de vote; membres honoraires, avec tous les privilèges; et membres corporatifs.

Les membres corporatifs ont droit d'avoir leur nom et leur adresse indiqués dans chaque *Bulletin*, de recevoir un exemplaire du *Bulletin*, de recevoir un exemplaire de l'annuaire de l'association contenant les noms et adresses de tous les membres de l'association, d'avoir un kiosque à tarif réduit lors des conférences annuelles, d'avoir un espace publicitaire à tarif réduit dans le *Bulletin*.

Les formulaires de demande d'adhésion peuvent être obtenus sur le site Web ou auprès du secrétariat.

Contents/Contenu

The *CRPA Bulletin* is published quarterly and is distributed to all members of the association.

Le *Bulletin ACRP* est publié trimestriellement et distribué à tous les membres de l'association.

Canadian Publications Mail Agreement No. 41574554

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Regular Columns / Chroniques régulières

Features / Articles

Cover image, sunset at French Village not far from Halifax, Nova Scotia, by Dennis Jarvis.


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President's Message / Message du président

J'espère qu'au moment où vous lirez ces lignes, vous aurez reçu mon courriel décrivant les plans de l'année à venir. Les communications émanant du conseil d'administration ne vont pas aussi rapidement que nous le voudrions malheureusement, puisqu'il nous faut donner à notre merveilleux comité de traduction suffisamment de temps pour accomplir son travail. Cette publication n'est pas la place pour répéter tout cela mais, au risque de me répéter, je vous rappelle, chers lecteurs, que c'est vous tous qui formez l'association et que son conseil d'administration est en place pour orienter l'association selon les souhaits de la majorité des membres. Cette année, nous allons sonder les adhérents sur plusieurs questions et, selon vos réponses, nous allons décider vers où évoluera l'association et comment elle y parviendra.

Vous vous souviendrez que ma plateforme principale pour l'élection était le renouvellement des adhésions. Les données démographiques prévoient que nous allons commencer à perdre des membres à mesure que les plus âgés commenceront à prendre leur retraite, de sorte que les efforts de recrutement et de rétention prendront de l'importance au fil du temps. Et même si le conseil d'administration s'occupe du fonctionnement quotidien des affaires courantes de l'association, il ne constitue pas l'association; nous sommes tous l'association et il en revient donc à chacun d'entre nous de répondre aux questions d'envergure.

Un célèbre président des États-Unis a déjà dit : « Ne demandez pas ce que votre pays peut faire pour vous, mais plutôt ce que vous pouvez faire pour votre pays ». Certains d'entre vous reconnaîtront instantanément qui a dit cela, tandis que d'autres devront le chercher sur Google. Permettez-moi de paraphraser cette citation selon notre contexte : « Ne demandez pas ce que votre association peut faire pour vous, mais ce que vous pouvez faire pour votre association ».

Si nous voulons croître, nous ne pouvons demeurer l'association canadienne inconnue de la radioprotection. Il nous faut être visibles, attirants, et il appartient à chaque membre de participer à cet effort. Combien de vos collègues ne sont pas membres de l'association? Pourquoi ne le sont-ils pas? Pouvez-vous les encourager à se joindre? Imaginez : si chacun de nous attirait un nouveau membre cette année, nous doublerions nos effectifs. Je mets donc chacun d'entre vous au défi de faire de la publicité pour l'association et de recruter un nouveau membre. Et au cas où vous vous poseriez la question : oui, j'ai trouvé une nouvelle membre récemment et celle-ci a adhéré à l'association depuis.

suite à la page 43 . . .

I hope that by the time you read this, you have received my email message outlining the association's plans for the coming year. Unfortunately, communication from the Board of Directors is not as prompt as we would like, as sufficient time must be given for our wonderful Translation Committee to do its work—but this is not the place to repeat all of that. One redundancy is necessary, and that is to remind you that you, dear reader, are the association and that we (the Board of Directors) are in place to steer the association according to the wishes of the majority of the membership. We will be surveying the membership about several issues this year and, based on what you say, will decide on how and where the association goes.

You will recall that my main platform for the election was membership renewal. The demographics predict that we will start to lose membership as the more senior members start retiring, so recruitment and retention will become more and more important as time goes by. And while your Board of Directors runs the day-to-day business of the association, it is not in itself the association: we are *all* the association and, as such, it is up to us to respond to issues of importance.

A famous US president once said, "Ask not what your country can do for you—ask what you can do for your country." Some of us will instantly recognize who said that, and others will have to Google it. Let me paraphrase it for our context, and it becomes: Ask not what your association can do for you—ask what you can do for your association. If we wish to grow, we must not be Canada's Secret Radiation Protection Association. We must be visible, we must be attractive, and it is up to every member to take part in this effort. How many of your colleagues are not members of our Association? Why are they not members? Can you encourage them to join? Imagine: if each of us was to attract one new member this year, we would double our membership. So I challenge each and every member to go out and advertise, and get one new member. (And if you are wondering, I have already found my member, and she has joined the association.)

Finally, we need to form two new committees. The first is a recruitment committee. As its name suggests, members of this committee will actively recruit new members, but they may also improve member services to add value to

continued on page 43 . . .

Editor's Note / Message du rédacteur en chef

Nous avons dansé à Halifax

Qui a dit que les membres de l'ACRP n'étaient pas des créatures complexes et polyvalentes? C'est en jouant de la cuillère et de la planche à laver, tout en dansant et en chantant, certains affublés d'un kilt improvisé, que plusieurs membres ravis ont prouvé le contraire lors du congrès annuel de l'ACRP, à Halifax.

Hôte du banquet du congrès de cette année, le Quai 21 a en effet été témoin des singulières manifestations de la joie de vivre et de l'amitié que l'on retrouve à l'ACRP. Mais nos adhérents savent aussi être sérieux lorsqu'il s'agit de féliciter les membres qui se sont distingués au fil du temps. En effet, Gary Wilson, le père du processus d'enregistrement professionnel de l'ACRP s'est vu remettre le prix du Fondateur de l'ACRP. C'est grâce à lui que certains d'entre vous ont plus de lettres de noblesse à la suite de leur nom. Assis à ma table, Nick Sion était éberlué mais très heureux de recevoir le prix pour services méritoires, lui qui était des débuts de l'ACRP et qui a participé à plusieurs délégations canadiennes de l'IRPA, comme vous le lirez dans ce *Bulletin*. Le prix pour accomplissement distingué a été remis, *in absentia*, à Jing Chen. Le président de l'ACRP et collègue de travail de Jing, Gary Kramer, a illustré pourquoi cette distinction était bien méritée.

Mais l'ACRP à Halifax ne s'est pas illustrée que par son banquet. Les 53 présentations scientifiques étaient à la hauteur et, à elles seules, valaient le déplacement. Le conférencier d'honneur, Richard Osborne, nous a relaté l'histoire du tritium, et plusieurs conférenciers étaient dans le ton de la radioprotection avec des sujets à la fois variés et très pertinents. L'équipe aguerrie du comité organisateur a su livrer la marchandise en habillant de belle manière les murs du Lord Nelson. Enfin, les exposants occupaient une magnifique salle meublée du crépitement discret des compteurs geiger, enterrés par les anecdotes des participants.

On ne le dira jamais assez, le congrès annuel de l'ACRP est un produit de l'association qui donne de la valeur à l'adhésion de ses membres. En effet, où pouvez-vous embêter amicalement le signataire de vos permis de la CCSN en lui demandant combien « d'amis » Facebook la CCSN détient sur sa page? Parions que cette page va exploser depuis qu'elle a annoncé des « pénalités monétaires administratives »! Vous n'avez pas entendu parler de cette initiative? Elle se résume en un seul mot : « Amende ». Nous l'avons tous appris au congrès d'Halifax. Nous avons aussi assisté à des divergences d'opinion quant à la théorie linéaire sans seuil et ses ramifications et, bien entendu, au changement de garde au sein de l'exécutif de l'ACRP lors de la réunion annuelle de l'association. Personnellement je déplore la tendance lourde que prend cette assemblée, coincée entre les présentations scientifiques et le banquet, et qui consiste

suite à la page 43 . . .

We Danced in Halifax

Who said CRPA members were not complex, versatile, and adaptable creatures? Several fun-loving members demonstrated this at the CRPA annual conference in Halifax by playing the spoons, washboard, dancing, and singing (some dressed in improvised kilts).

Pier 21, where the conference banquet was held, indeed witnessed the singular *joie de vivre* and friendship we enjoy as members of CRPA. That does not mean we were not able to be serious, at least a little. At the banquet, Gary Wilson, the father of CRPA's professional registration process, received the 2012 CRPA Founder Award (see more about the awards on page 2). It is because of him that some of you have more letters of distinction after your name. Nick Sion, who sat at my table, also rose, surprised and delighted, to receive the Meritorious Service Award. Nick has supported CRPA since its very beginning, and he has been among several Canadian delegations to IRPA. You can read his report from the most recent IRPA congress on page 28 of this *Bulletin*. The Distinguished Achievement Award was presented, in absentia, to Jing Chen. Gary Kramer, CRPA's new president and a work colleague of Jing's, explained to us why Jing's award was well deserved.

The banquet was not the only interesting part of the CRPA conference in Halifax. The 53 scientific presentations met their challenge and were worth the trip. The keynote speaker, Richard Osborne, reported on the history of tritium, and the other speakers presented a variety of radiation protection topics that were very relevant. The organizing committee, an experienced team, delivered the goods—we were living in fine style within the walls of the Lord Nelson. Exhibitors occupied their rightful place in a beautiful room filled with the discrete crackling noise of Geiger counters drowned out by the voices of participants telling their stories.

We will never say enough about the annual CRPA conference—it is one of the services that add value to our memberships. Where else can you bother (in a friendly way) the person from CNSC who signed your license, asking him/her how many "friends" CNSC has on Facebook? I bet that, since the announcement of "administrative monetary fines" by CNSC at the Halifax conference, the Facebook page will explode! What? Haven't you heard about this initiative? It can be summarized in two words: "Financial Penalty."

We also witnessed disagreements about the LNT theory and its ramifications, and, of course, about the changing of the guard within the CRPA executive at the annual general meeting of the association. Personally I deplore the heavy tone this meeting has taken—squeezed in between the scientific presentations and the banquet, this meeting is increasingly limited to a face-to-face discussion with the members present. The dialogue

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CRPA-ACRP
May 27-30 Mai
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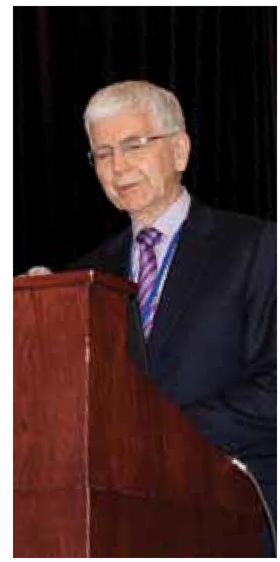
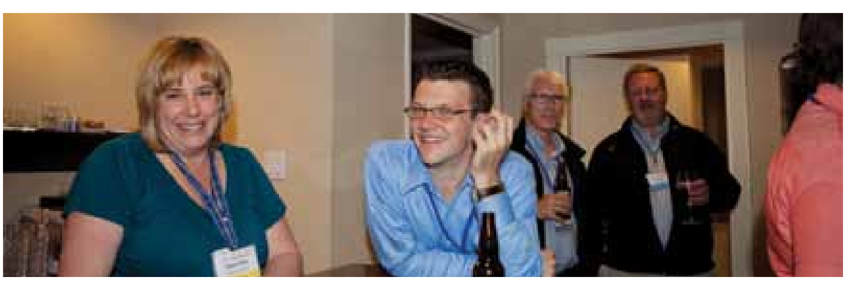
HALIFAX 2012





Conference Photographs

New CRPA Board of Directors / Nouveau Conseil d'administration de l'ACRP: (standing, left to right / debout de gauche a droite) Lois Sowden-Plunkett, Liz Krivonosov, Manon Rouleau, Jeff Dovyak, Gary Kramer, Mike Grey, Chunsheng Li; (seated from left to right / assis de gauche a droite) Ralph Bose, Petra Dupuis, Pauline Jones

CRPA members listen attentively at the annual general meeting / Des membres écoutent attentivement lors de la réunion générale annuelle

CRPA(R): (standing, left to right / debout de gauche a droite) Vani Ranganathan, Karren Fader, Diana Moscu, Nathalie Ritchot, Petra Dupuis, Jeff Dovyak, Sandu Sonoc, Joe Cortese; (seated, left to right / assis de gauche a droite) Gary Wilson, Mike Sattarivand, Susan Yeung, Pam Ellis, Leona Page, Dave Tucker, Valerie Phelan. (Missing / absente: Tanya Neretljak.) Photo by Stéphane Jean-François.

Outgoing president Lois Sowden-Plunkett passes the torch to the incoming president Gary Kramer / Présidente sortante Lois Sowden-Plunkett passe le flambeau au nouveau président Gary Kramer

Students / Étudiants: (back row, left to right / arrière de gauche a droite) Stephen Smith, Craig Olmstead, Matthew Howland, Harmanjit Sandhu; (front row from left to right / première rangée de gauche a droite) Paritosh Amin, Frédérique Piché, Merline Abraham. (Missing / absents: Saad Al Bayati, Neville Malabre O'Sullivan, Jaemin Chung, Courtney Stallman, Steven Bartolac

Honouring the outgoing Past-president Sandu Sonoc / Honorer le président sortant Sandu Sonoc

CRPA-ACRP May 26 -30 Mai 2013 Sherbrooke
Radioprotection: un monde d'interactions / Radiation Protection: a world of interactions

2013 Conference

Your conference co-chairs, Manon Rouleau & Lamri Cheriet, invite you to join them for the 2013 CRPA conference "Radiation Protection: A World of Interactions" in Sherbrooke, QC, May 26–30, 2013.

Conférence 2012

Vos coprésidents de la conférence, Manon Rouleau & Lamri Cheriet, vous invitent à les rejoindre pour la conférence de 2013: «Radioprotection:un mode d'interactions» à Sherbrooke, QC, 26 au 30 mai 2013.

The editors would like to extend special thanks to **Valerie Phelan** Radiation/Chemical/Biosafety Officer at Ryerson University, for the use of her conference photos, which were featured prominently throughout this issue of the *Bulletin*.

À la douce mémoire de : In Memoriam:

Eva Sailerova

1956–2012

C'est avec grande tristesse que nous vous annonçons le décès d'Eva Sailerová qui a perdu son vaillant combat contre le cancer le 29 juin dernier, à Winnipeg, à l'âge de 56 ans. Née le 18 mars 1956 en Tchékoslovaquie d'Eva Richterová et de Richard Richter, Eva était l'aînée de trois enfants. Elle a marié son camarade de classe Miloslav Sailer le 29 février 1980 à Prague et, ensemble, il ont élevé leurs trois fils : Frantisek, Miloslav et Antonin. Eva a obtenu son doctorat en physiologie végétale à l'Université Charles de Prague, puis a travaillé dans divers domaines reliés après que sa famille se soit installée au Canada en 1990. Plus récemment, Eva a travaillé en radioprotection,d'abord à la Winnipeg's Health Sciences Centre, puis, depuis dix ans, à l'Université du Manitoba.

Eva a été membre de l'ACRP pendant plus d'une décennie. Elle a participé à de nombreux congrès de l'association, souvent à titre de conférencière, et contribuait aussi au Bulletin. En 2005, elle a passé le tout premier examen d'agrément pour obtenir le titre ACRP(R).

Sa famille a demandé qu'afin de conserver l'esprit d'Eva, nous restions en contact avec ceux que l'on aime et vivions chaque journée à son maximum. En plus d'être une femme accomplie et intelligente, Eva était une très belle personne. Sa gentillesse, son professionnalisme et son enthousiasme pour la vie manqueront terriblement à tous ceux qui la connaissaient.

Ahoj Eva.

L'article nécrologique original d'Eva a été publié le 7 juillet 2012 dans les pages du Winnipeg Free Press. Le livre de condoléances se trouve à l'adresse

With deep sadness, we announce the passing of Eva Sailerová on June 29, 2012, in Winnipeg, at the age of 56, after a valiant fight against cancer. Born March 18, 1956, in Czechoslovakia to Eva Richterová and Richard Richter, Eva was the oldest of three children. Eva married her schoolmate Miloslav Sailer on February 29, 1980, in Prague and together they raised three sons: Frantisek, Miloslav, and Antonin. Eva completed a PhD in plant physiology at Charles University in Prague, and worked in a number of related fields following the family's arrival in Canada in 1990. Most recently, Eva worked in radiation protection, first at Winnipeg's Health Sciences Centre, then, for the past ten years, at the University of Manitoba.

Eva was a member of CRPA for over a decade. She attended many CRPA conferences and was a frequent presenter at the conference. Eva was also a contributor to the CRPA Bulletin. In 2005, Eva passed the original sitting of the CRPA(R) exam.

Eva's family has asked that, in keeping with Eva's spirit, we stay in touch with the ones we love and live each day fully. Eva was a very intelligent, beautiful, and accomplished woman. Everyone who knew her will deeply miss her kindness, her professionalism, and her enthusiasm for life.

Ahoj, Eva.

Eva's original obituary was published, July 7, 2012, in the Winnipeg Free Press. The book of condolences can be found online at

http://passages.winnipegfreepress.com/passage-details/ id-192680/ name-Eva_Sailerova

CRPA/ACRP

welcomes our new members/ souhaite la bienvenue aux nouveaux membres

Full & Associate Members / Membres à part entière et membres associés :

- Kenneth Bisson, Stantec Consulting Ltd
- Johnathon Hash, Ontario Power Generation
- Brandon Hardy, Capital Health Services
- Rod Hobbs, Memorial University
- Lynn MacDonald, Radiation Safety Institute of Canada
- Sandra McQuillan, Colchester East Hants Health Centre
- Daniel Mekonen, EnergySolutions Canada
- Sherri Lynne Menard, University of Windsor
- Michael Stoicescu, Cameco

Corporate Members / Membres corporatifs :

- Radioprotection Inc.

New Student members / Membres étudiants :

- Merline Abraham
- Saad Al-Bayati
- Paritosh Amin
- Steve Bartolac
- Jaemin Chung
- Neville Malabre-O'Sullivan
- Kelsey O'Brien
- Craig Olmstead
- Sara Omar
- Frederique Piche
- Harmanjit Sandhu
- Stephen Smith
- Courtney Stallman
- Ian Sun

Being Nuclear

Africans and the Global Uranium Trade

Gabrielle Hecht (MIT Press, Cambridge, MA, USA, 2012)

Review by Michael Grey
Candesco Corporation,
Burlington, ON

Gabrielle Hecht is an associate professor of history at the University of Michigan in Ann Arbor. Her research interests focus on the history of technology in general and nuclear technology in particular. Last year I reviewed her social and cultural history of the postwar French nuclear industry, *The Radiance of France*. *Being Nuclear*, focuses on uranium mining, primarily in the former French colonies in Africa.

Résumé

Gabrielle Hecht, auteure du livre *Being Nuclear*, se spécialise dans l'histoire de la technologie. Cet ouvrage examine tout d'abord les aspects géopolitiques de l'extraction de l'uranium dans plusieurs pays africains, et jette un regard sur les efforts déployés par les gouvernements africains pour participer à la réglementation internationale et pour surveiller leurs propres industries minières. L'auteure réfléchit comment le minerai d'uranium et les concentrés uranifères, autrefois considérés comme des matières d'importance stratégique, en sont venus à être traités comme des produits de base. Une deuxième section traite précisément des inquiétudes en ce qui a trait à la santé au travail des mineurs, surtout relativement aux questions portant sur la dosimétrie appropriée et sur la différence de traitement donné aux travailleurs Blancs et aux travailleurs Noirs. Quoique Being Nuclear aborde plusieurs sujets, l'ouvrage se lit bien.

Being Nuclear is divided into two parts; the first is devoted to geopolitical issues and the second to health and safety issues (primarily related to radon), but the author occasionally mixes the two subjects. The book incorporates some material that she has previously published in journals or presented at conferences and includes a few sections that are first-person accounts of the problems she encountered during the course of her research.

In the first section, Hecht examines when, or whether, uranium mining operations within a country make that country a "nuclear state," a question she approaches through two contrasting stories: South Africa's efforts to obtain a seat on the original Board of Governors of the International Atomic Energy Agency (IAEA) and France's efforts to dominate uranium mining in its former colonies of Niger and Gabon. South Africa claimed that uranium mining within its borders conferred special status on the nation, and it achieved its goal of representation on the IAEA Board; but neither Niger's government nor Gabon's derived any special status from uranium mining, and France continued to control mining in its former colonies. These stories lead to a larger examination of the history of the gradual transition of the status of uranium ores and concentrates from "strategic materials" to "commodities" during the sixties, seventies, and eighties.

The author describes the second section as "focusing on occupational health among African mine workers," but issues of radon measurement and, to a lesser extent, external dosimetry dominate the discussion. She begins by looking at the history of radon measurement in both the United States and France, which leads to the question of whether dosimetry should be based on radon (which was easier to measure) or radon progeny (which was more relevant). Later chapters look at the differences between the dosimetry (both internal and external) provided to black workers and white supervisors and the actions taken when these workers approached or exceeded the dose limits, as they often did.

I was quite surprised by some of the author's conclusions about the International Commission on Radiological Protection and the ALARA (as low as reasonably achievable) benchmark, but her arguments were compelling. The final chapter of the second section abandons the issue of health and safety and examines the interactions between the Namibian independence movement and operations at the Rossing mine. This chapter seems out of place where it is and probably belongs in the first section of the book.

Being Nuclear is easy to read but it sometimes seems to lack focus. At times I wasn't certain if I was reading a political/economic history of uranium mining, a social history of late-twentieth-century Africa, or a personal memoir of a research project. All three have value but they sometimes made a confusing mix.

continued on page 41 . . .

ICRP NEWS

Christopher H. Clement CHP
ICRP Scientific Secretary

ICRP Statement on Tissue Reactions

First change to a recommended dose limit in many years

The *ICRP Statement on Tissue Reactions* was approved by the ICRP Main Commission on April 21, 2011, and immediately released through the ICRP website, www.icrp.org. This short document includes a recommendation on a new equivalent dose limit for the lens of the eye, the first change to a recommended dose limit in many years: "For occupational exposure in planned exposure situations, the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv/year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv."

Résumé

La publication de la CIPR intitulée ICRP Statement on Tissue Reactions (aucune traduction française à ce jour) a été approuvée par la commission principale de la CIPR le 21 avril 2011, et immédiatement publiée par le site web de la CIPR : www.icrp.org. L'origine scientifique de cette nouvelle recommandation est contenue dans un rapport de plus de 300 pages intitulé « ICRP Publication 118: ICRP Statement on Tissue Reactions / Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context » (aucune traduction française à ce jour) et maintenant disponible. L'exposé de cette publication comprend une nouvelle limite de dose professionnelle pour les lentilles oculaires et qui est substantiellement plus faible que ce qui avait été recommandé précédemment. Ce changement à la dose est causé par de nouvelles preuves indiquant que le seuil d'induction de cataracte radiogène est approximativement dix fois plus bas que ce qui avait été soupçonné auparavant.

The scientific basis for this new recommendation is contained in a report of more than 300 pages on tissue reactions, now in press. Work on this report began in earnest in 2006, and the result is a thorough review of the literature related to many non-cancer effects on a long list of organ systems. A key finding was that for cataracts induced by acute exposures, recent studies indicate threshold values of approximately 0.5 Gy with 90–95% confidence intervals, including zero dose. This is lower by a factor of about 10 than findings in earlier studies, and also raises the possibility that there is no threshold.

There are several reasons why thresholds found in recent studies are so much lower than before. The older studies generally had short follow-up periods, failed to consider the increasing latency period as dose decreases, and had relatively few subjects with doses below a few Gy. Evidence relating to fractionated and protracted exposures also points to a threshold of about 0.5 Gy, although due to the shorter follow-up times here the studies mainly refer to opacities rather than cataracts impairing vision.

The new recommended limit was chosen to avoid cataract induction due to radiation exposure over a working lifetime. It is aligned with the effective dose limit to facilitate implementation: where there is no reason to suspect preferential exposure of the lens of the eye, demonstrating compliance with the effective dose limit also demonstrates compliance with the equivalent dose limit for the lens of the eye. Given the substantially lower threshold, a higher limit is not considered to be adequately protective.

This new limit does not represent a change to the principles or concepts of the system of radiological protection; it is a numerical change in response to clear evidence of a significantly lower threshold. However, in the statement ICRP does emphasize that "protection should be optimised not only for whole-body exposures, but also for exposures to specific tissues, particularly the lens of the eye." This reflects the uncertainty in applying a nominal threshold for the entire population, helps to keep lifetime doses below the nominal threshold, and also accounts for the possibility of the lack of a threshold.

The statement and report will soon be published together as ICRP *Publication 118: ICRP Statement on Tissue Reactions/ Early and Late Effects of Radiation in Normal Tissues and Organs: Threshold Doses for Tissue Reactions in a Radiation Protection Context.*

The abstract below refers only to the report (the two-page statement needs no abstract) and may not be final, as this publication is still in press.

continued on page 41 . . .

Fluence Field Modulated CT

Potential for Dose and Noise Optimization in Thoracic Imaging Applications

Steven Bartolac (Department of Medical Biophysics, University of Toronto)
David Jaffray (Department of Radiation Oncology, University of Toronto)

Introduction

Recently, awareness regarding the potential risks of radiation dose due to computed tomography (CT) scans has been raised both in the general public, via reports in mainstream media, as well as among medical practitioners and physicists. A notable example of the former is the article "How Dangerous Are CT Scans," which appeared in Time magazine (Guthrie, 2008). The latter has been evidenced in North America most significantly through the widespread campaigns Image Gently and Image Wisely, which have the general mandate of providing education on how to limit unnecessary dose to pediatric and adult patients respectively.

The heightened concern regarding the radiation risks of CT has been largely stimulated by a number of reports and papers within the last five years (Brenner and Hall 2007; Hillman and Goldsmith 2010; Smith-Bindman 2010), which have indicated both that the number of CT procedures being performed per capita is on a steady incline (estimates show a rise of roughly 10% per year in both the United States and the United Kingdom), and that the lifetime attributable risk (LAR) of cancer is non-negligible for certain procedures, especially when patients receive multiple scans. One study (Brenner and Hall 2007) estimates that on the order of 2% of future cancers in the

Résumé

Dans une tomodensitométrie à la fine pointe de la technologie, l'incident de la fluence des rayons X sur le patient se limite essentiellement à une certaine forme (ou modèle) entre les projections (à l'aide d'un filtre en forme de nœud papillon, par exemple), ne permettant qu'aux biais de la fluence de se modifier (par la modulation d'un courant en forme de tube, par exemple). Permettre au modèle de fluence des rayons X de se modifier indépendamment pour chaque projection constitue un nouvel aspect de la tomodensitométrie modulée par un champ de fluence et est essentiel pour créer une qualité d'image prescrites par l'utilisateur qui répondent précisément aux besoins des patients ou des tâches à effectuer, tout en réduisant l'exposition totale du patient. Dans le présent travail, les auteurs étudient les avantages liés au bruit et à la dose quant à l'application d'une tomodensitométrie modulée par un champ de fluence (FFMCT) à certaines applications d'imagerie thoracique, dont l'examen courant du thorax, le dépistage du cancer du poumon et la tomodensitométrie cardiaque. Les modèles de fluence modulée pour un ensemble de données simulées sont créés en utilisant un script d'optimisation de recuit simulé.

La dose résultante et les distributions du rapport signal/bruit (SNR) sont comparées à celles qui sont optimisées à l'aide d'un filtre en forme de nœud papillon et de la modulation d'un courant en forme de tube. Les résultats indiquent que la FFMCT a le potentiel d'accomplir des distributions du SNR variant selon les régions en bon accord avec les valeurs prescrites par l'utilisateur et avec moins de doses totales qu'avec les techniques conventionnelles de minimisation de doses.

Anthony J MacKay Student Paper Contest

WINNER

The Anthony J. MacKay Student Paper Contest is organized each year by CRPA's Student Affairs Committee. The winner receives an all-expenses paid trip to the CRPA conference to present their paper. At the conference, the winner has an opportunity to meet professionals who work in the field of radiation science—hospitals, universities, the nuclear power industry, and all levels of government. The winning paper is also published in the CRPA *Bulletin*.

The contest is open to full- or part-time students at a Canadian university or college whose post-secondary studies are related to radiation sciences (nuclear medicine, medical physics, radiation therapy, etc.). The topic of the papers must be a radiation-related topic.

This year's winner was Steven Bartolac. His paper was co-authored by David Jaffray, his graduate supervisor.

Le concours de présentations étudiantes Anthony J. MacKay est organisé tous les ans par le comité de liaison avec les étudiants de l'ACRP. Le gagnant se mérite un voyage toutes dépenses payées au congrès de l'ACRP afin d'y présenter son article. Au congrès, le gagnant a l'occasion de rencontrer des professionnels qui travaillent dans le domaine de la science du rayonnement : hôpitaux, universités, industrie des centrales nucléaires et tous les niveaux gouvernementaux. La présentation du gagnant est également publiée dans les pages du Bulletin de l'ACRP.

Le concours s'adresse à tous les étudiants inscrits à temps plein ou partiel dans une université, un collège ou un CEGEP du Canada, dans un programme lié aux sciences du rayonnement (médecine nucléaire, physique médicale, radiothérapie, etc.). Enfin, le sujet des présentations doit être lié aux rayonnements.

Le gagnant de cette année est Steven Bartolac et son article a été corédigé par David Jaffray, son superviseur d'études.

United States may be attributable to radiation from current CT studies.

Risks due to X-ray radiation arise because CT generates high-resolution three-dimensional (3D) images from a set of X-ray radiographs (or projections), which are recorded at different angles about a patient. Generally, noise and dose share an inverse relationship in CT: decreases in exposure (and therefore dose) are accompanied by increases in noise. The goal is then to achieve a diagnostic-quality image while limiting dose as much as possible. In practice, dose to the patient is managed by applying appropriate patient- and/or task-specific tube current and energy settings on the CT unit. The energy is typically fixed based on the patient size, while the tube current can vary throughout the scan to accommodate changes in patient thickness as a function of angle or longitudinal position—referred to as angular (Papadakis et al. 2007; Giacomuzzi et al. 1996; Greess et al. 2002; Kalender et al. 1999; Kopka et al. 1995; Lehmann et al. 1997) and *z*-axis tube current modulation (TCM) (Imai et al. 2009; Kalra et al. 2004; Namasivayam et al. 2006; Westerman 2002) respectively. Bowtie filters (Barrett and Swindell 1981; Graham et al. 2007; Mail et al. 2009), placed in front of the beam as shown in Figure 1, have also long been used to try to achieve more uniform exposure levels at the detector, with the benefits of decreasing dose to thinner regions of the patient while also achieving more uniform noise characteristics.

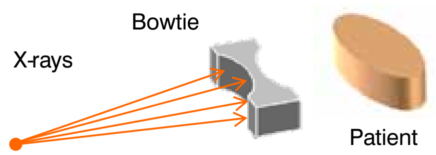


Figure 1: Schematic diagram of a bowtie attenuation filter. This filter is used to attenuate an incident X-ray beam more strongly toward the edges of a patient where the patient thickness is thinner.

More recently, innovative approaches applying more severe collimation of the beam (Chen et al. 2009; Chityala et al. 2004; Moore et al. 2006; Schafer et al. 2010; Cho et al. 2009), such that high exposure is limited to a small central region of interest, have also been proposed for large field-of-view circular CT geometries. In this case, the goal is to maintain high image quality for the target region of interest, while allowing image quality to be reduced elsewhere. These approaches have been referred to as region-of-interest imaging; however, they have not yet been adopted in practice. Dynamic collimation in the longitudinal patient direction is a recent feature that has been added to scanners to reduce radiation from the endpoints of helical scanning acquisitions, which are generally not utilized in the image reconstruction. While these techniques collectively make strides toward reduction of patient dose, the ability to manage the incident exposure is constrained to a fixed collimator or beamshaping filter, therefore greatly limiting the ability to compensate for the complexity of real patient anatomy in optimization of noise and dose to the patient.

Previous work (Bartolac et al. 2011; Graham 2006) has shown that allowing the fluence (number of photons per unit area) to change across the detector, both as a function of position across the detector, ξ, and as a function of angular position, θ, around the patient, may have the potential for achieving user-prescribed noise characteristics as well as significant decreases in dose. This concept, referred to as fluence-field-modulated computed tomography (FFMCT), is illustrated in Figure 2. FFMCT shares parallels with intensity-

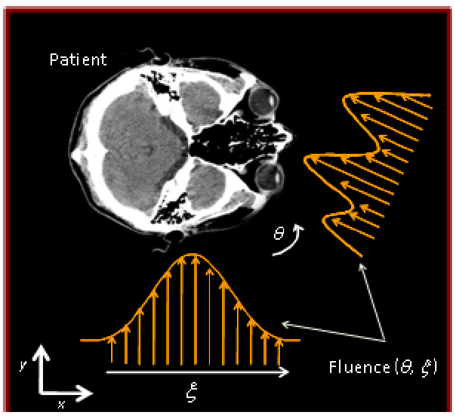


Figure 2: Schematic illustration of the method proposed for FFMCT. The pattern of incident fluence can change as a function of rotation angle about the patient as well as linear distance across the field of view.

modulated radiation therapy (IMRT), except "image quality plans" replace the target "dose plans" of IMRT.

Although FFMCT has shown potential for reducing dose while obtaining target image quality, the application considered previously (Bartolac et al. 2011) was artificial, with an arbitrarily identified region of interest. In this paper, we attempt to evaluate the dose and noise benefits of FFMCT in specific imaging applications of the thorax: lung screening, cardiac CT, and routine chest imaging. To date, delivery of modulated fluence fields in computed tomography applications remains a technical challenge. This paper, therefore, studies the potential contributions of FFMCT under simplifying assumptions in simulation.

Methods & Materials

FFMCT proceeds by optimizing the incident fluence field to deliver a prescribed image quality under dosimetric constraints. The fluence can ideally change as a function of detector position, ξ, and angular position, θ (see Figure 2). In the following study, we consider the case of a single slice acquisition of a chest CT scan, optimized for three different cases:

(1) Cardiac CT
(2) Lung Screening
(3) Routine Chest Exam

Implicit in the approach for FFMCT is that an a priori model of the patient is available. This model is used to define an image quality plan, and to predict noise and dose outcomes in order to optimize the incident fluence. In many cases, a previous CT scan of the patient may be available for this purpose. Alternatively, a population-based model could be used. In this study, a simulated anthropomorphic chest phantom, containing bony anatomy, soft-tissue, and lung-equivalent regions, was used; it is depicted in Figure 3(a).

The boundaries for the high signal-to-noise ratio (SNR) values, shown in red in Figure 3(b–d), were chosen to contain a region slightly larger than the regions

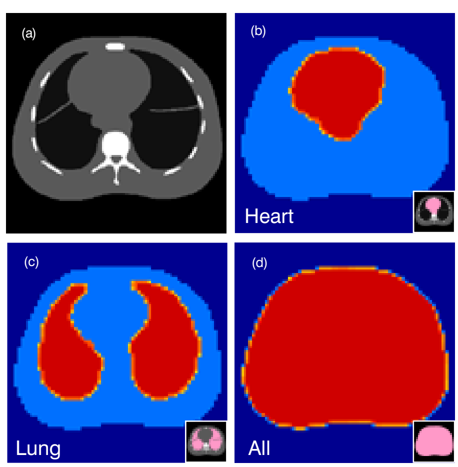


Figure 3: (a) Illustration of the simulated anthropomorphic chest phantom used in this study. Prescribed SNR distributions, where red is equivalent to a high SNR value, are shown for the cases where the scanning priority is (b) heart, (c) lung, and (d) entire patient. The region of interest delineated on image (a) is shown in the bottom right corner of images (b)–(d).

of interest. The regions of interest were selected to contain the imaging target in each application (e.g., region containing the heart for cardiac CT, lung for lung screening, etc.), and are illustrated graphically in the bottom right corners of Figure 3(b-d).

Optimization was performed considering a simplified parallel ray geometry, and considering only the primary fluence (no scattered radiation) in evaluations of dose and noise. These assumptions and their implications are discussed below in the Discussion section of this paper. The fluence arriving at the detector can then be modelled as a function of ξ and θ (with units of photon counts per detector pixel), $N(\xi,\theta)$. Optimization assumes the modulation of an arbitrary incident reference fluence field. If the reference X-ray beam is modulated by a factor of $m(\xi,\theta)$, the modulated fluence arriving at the detector can be modelled as (Bartolac et al. 2011):

$$N'(\xi,\theta) = m(\xi,\theta)\,N(\xi,\theta), \tag{1}$$

where the factor m is the *modulation factor*; the set of modulation factors over the complete angular and linear range will likewise be referred to as the *modulation profile*. In addition, the commonly employed filtered back-projection reconstruction algorithm was utilized in the present study. Optimization proceeds using an iterative optimization scheme that searches for the optimal modulation profile, $\hat{\mathbf{m}}$, by attempting to solve the following minimization problem:

$$\hat{\mathrm{m}} = \arg\min_{\mathrm{m}\in\mathrm{M}} \begin{pmatrix} \sum_{\vec{r}} W_Q(\vec{r})(\dot{Q}(\vec{r}) - Q_{\mathrm{m}}(\vec{r}))^2 + \\ \sum_{\vec{r}} W_D(\vec{r})(D_{\mathrm{m}}(\vec{r}))^2 \end{pmatrix} \tag{2}$$

where M is the set of all feasible modulation profiles m, $\dot{Q}(\vec{r})$ is the desired or prescribed quality metric at spatial position $\vec{r} = (x, y, z)$, $Q_{\mathbf{m}}(\vec{r})$ is the modulation-dependent, spatially variant quantification of the image quality within the object, $D_{\mathbf{m}}(\vec{r})$ is the local, modulation-dependent dose, and $W_Q(\vec{r})$ and $W_D(\vec{r})$ are predefined, spatially varying weighting factors that can be used to prioritize image quality and dose, respectively, at specific regions.

In the present study, the metric for image quality, $Q(\vec{r})$, was defined as the standard deviation of the reconstructed signal, $n(\vec{r})$, relative to a reference value for the attenuation coefficient of water, μ_{H_2O}:

$$Q(\vec{r}) = \frac{\mu_{H_2O}}{n(\vec{r})} \quad [3]$$

A higher Q value indicates better image quality (lower noise) and can easily be interpreted as equivalent to a high SNR with respect to water. That being said, since the noise is considered relative to a constant reference signal, it should be noted that this measure of quality is strictly a measure of the noise and is independent of the mean values in the reconstruction volume. However, since the units are the same as SNR and can be interpreted similarly, it will be useful to refer to the quality metric Q as SNR for simplicity here. Note that other quality metrics could also have been used, such as contrast-to-noise ratio (CNR).

The first term in equation causes the solution to trend toward the prescribed SNR criteria, while the second term attempts to lower the dose as much as possible. The weights can be altered to change the priority of the SNR or dosimetric terms. A logical choice of dosimetric weights might be the organ-specific weights provided by the International Commission on Radiological Protection (ICRP). In that case, the second term would attempt to minimize the effective dose. In this study, the dosimetric weighting was set to unity for all voxels, such that each voxel has equivalent priority in the optimization scheme with respect to dose minimization. A higher weighting (by a factor of 10) was applied to the prescribed high-quality region of interest for the SNR term in order to prioritize image quality in these regions. Computation of equation at each iteration required a prediction of the standard deviation as a function of voxel position. For this purpose we used a model for the variance of the noise, derived by Kak and Slaney (1988) for the case of parallel-ray, filtered back-projection reconstruction methods:

$$\mathrm{var}\left(f(\vec{r})\right) = \left(\frac{\pi\tau}{M_{proj}}\right)^2 \sum_{\theta}\sum_{\xi}\frac{1}{N'(\theta,\xi)}h^2(x\cos\theta + y\sin\theta - \xi) \quad [4]$$

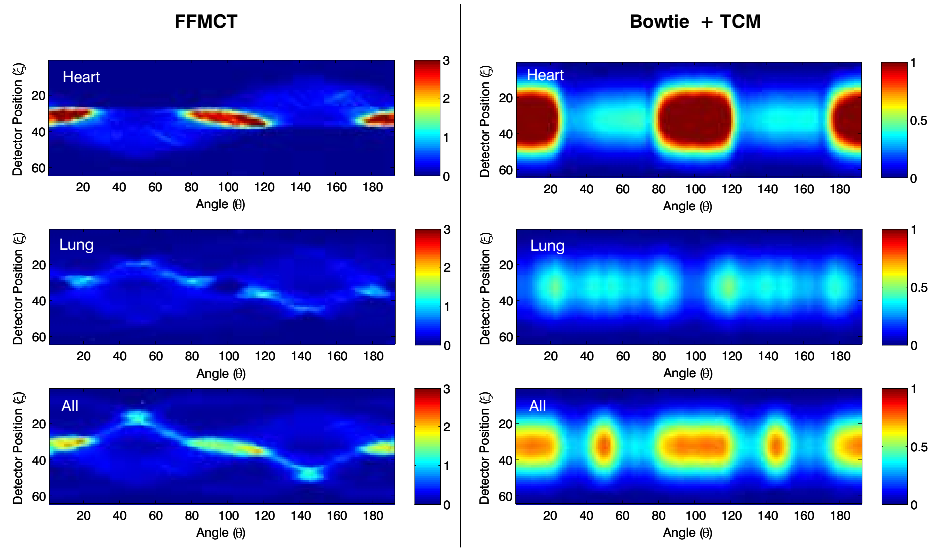


Figure 4: Modulation profiles showing the optimized modulation factors as a function of linear direction across the field of view, and the projection angle. Each column in a given modulation profile dictates the modulation applied to the fluence for a particular projection. FFMCT results show increased complexity compared with the bowtie filter results.

where *Mproj* is the number of projections, *t* is the width of the detector pixels, and *h* is the convolution kernel in the filtered back-projection operation. Simulations verified that this expression was accurate to within 5% for the prediction of the variance (or standard deviation squared). Optimization of equation was carried out using a simulated annealing optimization method, described in detail in a previous publication (Bartolac et al. 2011). Dose calculations were modelled from the collision kerma, $K_c(\vec{r})$, which accurately represents the dose at energy levels used in computed tomography:

$$D(\vec{r}) \simeq K_c(\vec{r}) = \Psi(\vec{r})\frac{\mu_{en}(\vec{r})}{\rho(\vec{r})} \quad [5]$$

where $\Psi(\vec{r})$ is the primary energy fluence, assuming each photon has an energy of 60 keV, $\mu_{en}(\vec{r})$ is the mass-energy absorption coefficient, and $\rho(\vec{r})$ is the material density. In order to reduce the computation time required for the optimization, low-resolution images were considered of the input model and for the target image quality plans (64×64 bins, 0.54×0.54×0.54 cm voxel size). For comparison of the results, the optimization was repeated by constraining the modulation profile for each projection to the shape of a bowtie filter. This situation can be viewed as equivalent to applying tube current modulation with a bowtie filter in place, except the degree of bias applied in tube current modulation is optimized using the methods defined above. In this way, the bowtie plus tube current modulation can be viewed as FFMCT applied using a constrained modulator. Dose outcomes were compared considering integral dose (in joules) as well as the relative distribution of dose achieved in each situation.

Finally, sample reconstructions of images that included Poisson noise based on the prescribed modulation profiles are shown in order to visualize the impact of fluence modulation in practice.

Results

Figure 4 shows the resulting modulation profiles for each of the three thorax CT imaging cases identified. The larger number of degrees of freedom in FFMCT resulted in more complex fluence patterns for each of the cases when compared with the patterns produced using the bowtie filter. However, it can be observed that the modulation profiles constrained to the bowtie filter show peaks in tube current at similar projection intervals to those of the FFMCT cases.

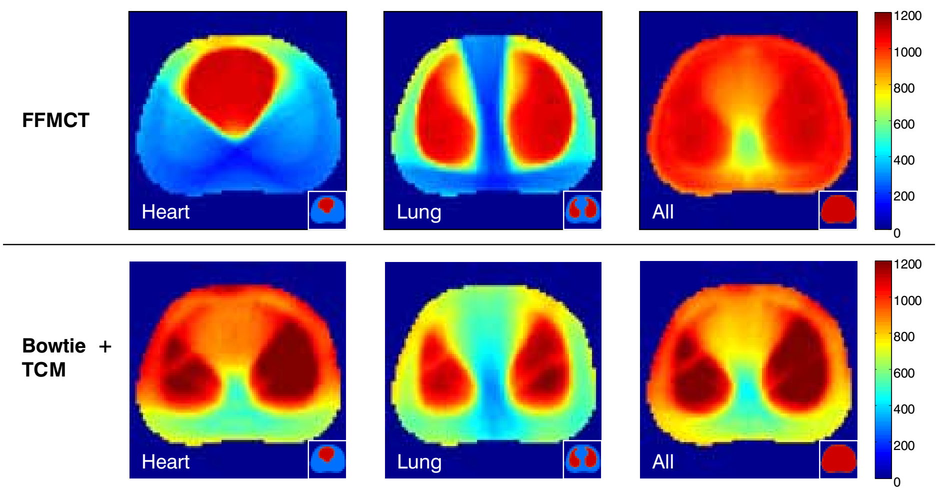


Figure 5: Predicted SNR distributions resulting from the modulation profiles shown in Figure 4. The bottom right corner of each image shows the prescribed SNR distribution. FFMCT resulted in better agreement with the prescribed values than the bowtie filter with tube current modulation.

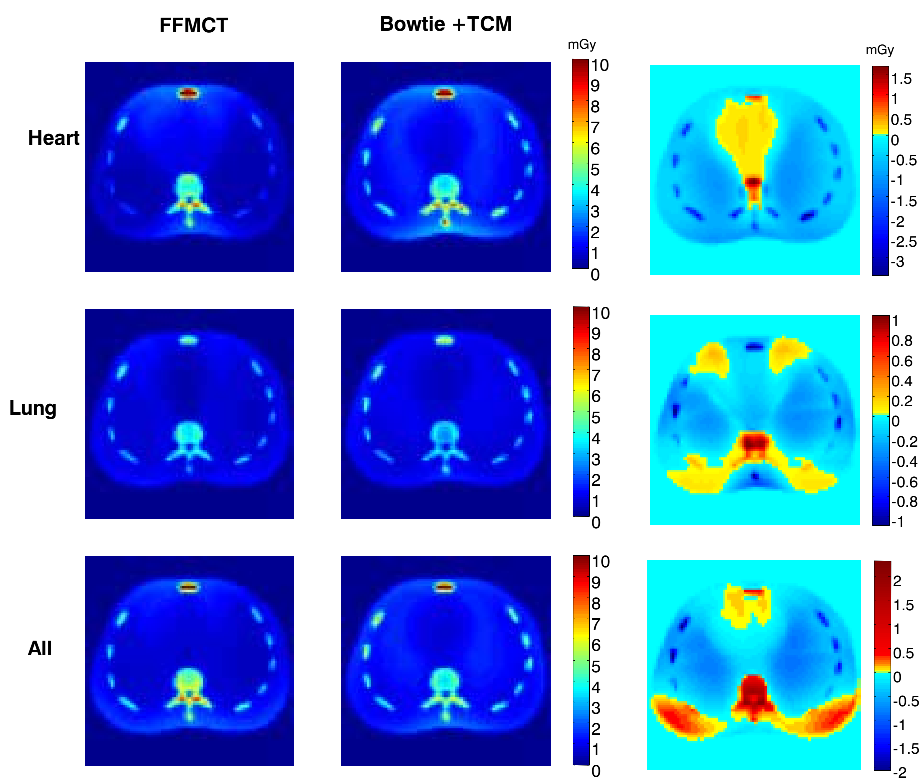


Figure 6: Dose distributions for different thoracic imaging cases when using FFMCT as compared to a bowtie filter with tube current modulation. The difference images on the right highlight regions of relative increases and decreases in dose of FFMCT with respect to the distributions arising from the bowtie filter with tube current modulation.

Predicted SNR outcomes for the FFMCT and bowtie cases are compared in Figure 5. FFMCT resulted in SNR distributions with greater similarity to the prescribed values for all three cases than use of the bowtie filter. In contrast, the SNR distributions arising from the bowtie filter showed little change in overall pattern, with the region of highest image quality consistently trending within the region of the lungs for each of the imaging cases presented. Higher uniformity over the prioritized high-SNR regions was also observed for the FFMCT cases, compared with results for use of the bowtie filter with tube current modulation.

Figure 6 shows dose comparisons for the three scenarios under the differing constraints. Integral dose decreases (in joules) were found to be 23% for the heart, 5% for the lung, and 4% for the routine diagnostic cases when compared with use of the bowtie filters. Figure 6 also shows the subtraction images of the dose distributions, indicating that both relative increases and decreases in dose occurred for the FFMCT cases, compared with use of the bowtie filter with tube current modulation (warm colours indicate increases).

High-resolution image reconstructions with added simulated noise predicted by the FFMCT modulation profiles for the routine diagnostic and lung screening exams are shown in Figure 7, for comparison with the predicted SNR outcomes. Figure 7(b) shows that greater noise and corresponding streak artifacts are evident in the lung screening case but do not impede visualization of the lesion within the region of interest within the lungs, where image quality remains consistent with that of the routine diagnostic scan. An added soft-tissue lesion with a deviation of approximately 4% in signal value is also seen in Figure 7(c), shown at a different contrast level and corresponding to the boxed region in Figure 7(b).

Discussion

This study was carried out to evaluate whether potential noise and dose benefits exist when applying FFMCT to specific imaging tasks of the thoracic region. The results indicated that FFMCT could potentially meet user-prescribed image quality criteria to a higher degree over what could be achieved by conventional modulator designs in practice today. Benefits were particularly pronounced for the case of cardiac CT, where FFMCT achieved approximately 23% integral dose reduction and higher, more uniform SNR values within the region of interest. While FFMCT application to the routine chest

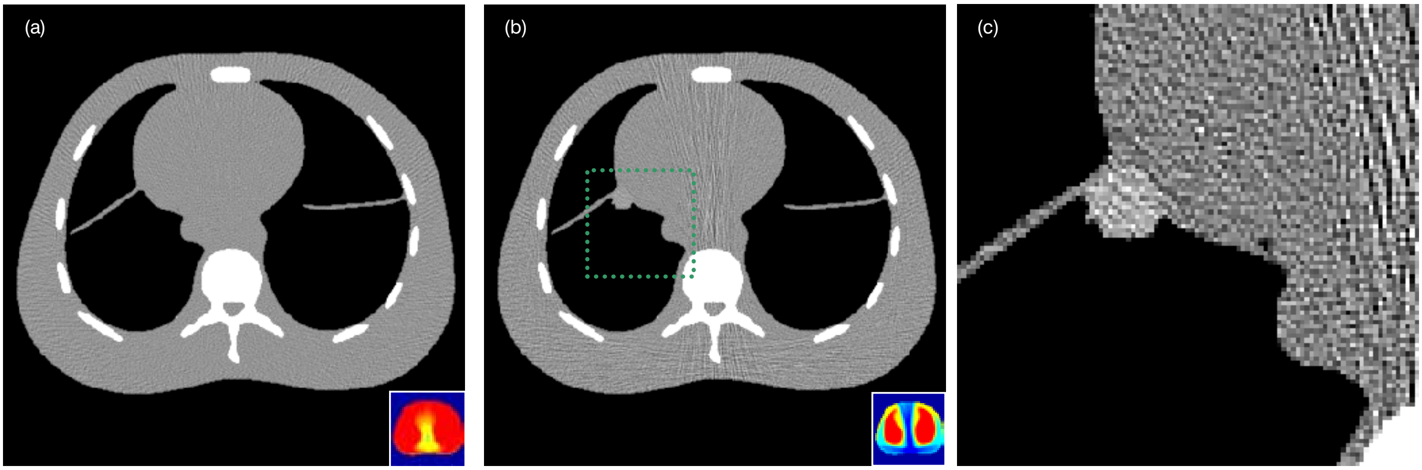


Figure 7: Reconstructed images with added Poisson noise for (a) routine chest exam and (b) lung screening test. (c) A close-up of the boxed region in (b) shows a simulated lesion with a 4% signal deviation from soft tissue, observable within the lung due to the higher SNR value within the lung. Predicted SNR distributions for (a) and (b) are shown in the bottom right corners for comparison. Streaks and noise in (b) closely follow the predicted regions of reduced image quality (blue regions).

exam achieved more modest reduction in integral dose, the SNR distribution was much more uniform, suggesting greater utility in the scan without added dose response. Similarly, high SNR values were also more uniform and consistent with the prescribed target values over the entire region of interest for the FFMCT lung screening case. Interestingly, though, the anatomic variations in the simulated phantom seemed to produce an inherent result of lower noise in much of the region of the lungs, as suggested from the different bowtie filter cases; this can be understood by considering that the attenuation is weakest through the region of the lungs, so a larger number of photons reach the detector in this case for most angles. We note that while the bowtie filter was included for comparative purposes, the manner in which the tube current modulation was optimized in itself can be viewed as an application of FFMCT, except where the modulation is placed under additional constraints (in this case, the shape of the bowtie filter). In this way, an interesting result of this study was the application of FFMCT in optimizing modulation profiles for existing compensators and tube current controls that are currently used.

One limitation of the study was the absence of scatter contribution from within the body as well as potentially from the modulator itself. Work remains to study the implications of scatter on image quality and dose contribution, which may be quite large. However, previous work suggests that image quality may be improved by scatter reduction within the high-SNR regions of interest; similarly, reductions in primary fluence suggest reductions in dose due to scatter as well.

While the technical challenge for delivering such modulated fluence fields has not been resolved, at least one application, using an "electronic bowtie" arrangement composed of multiple sources in an inverse CT geometry, has shown the potential for fluence modulation delivery in real applications, even under broad constraints. Furthermore, fluence delivery methods of IMRT could potentially be adopted in CT.

Conclusions

The results of this study support the hypothesis that FFMCT can potentially be employed to decrease dose to the patient while achieving image quality to a level prescribed by the user. Specifically, three specific thoracic imaging tasks were considered that showed that FFMCT could potentially reduce dose and significantly improve image quality in the related regions of interest when compared with conventional dose reduction methods.

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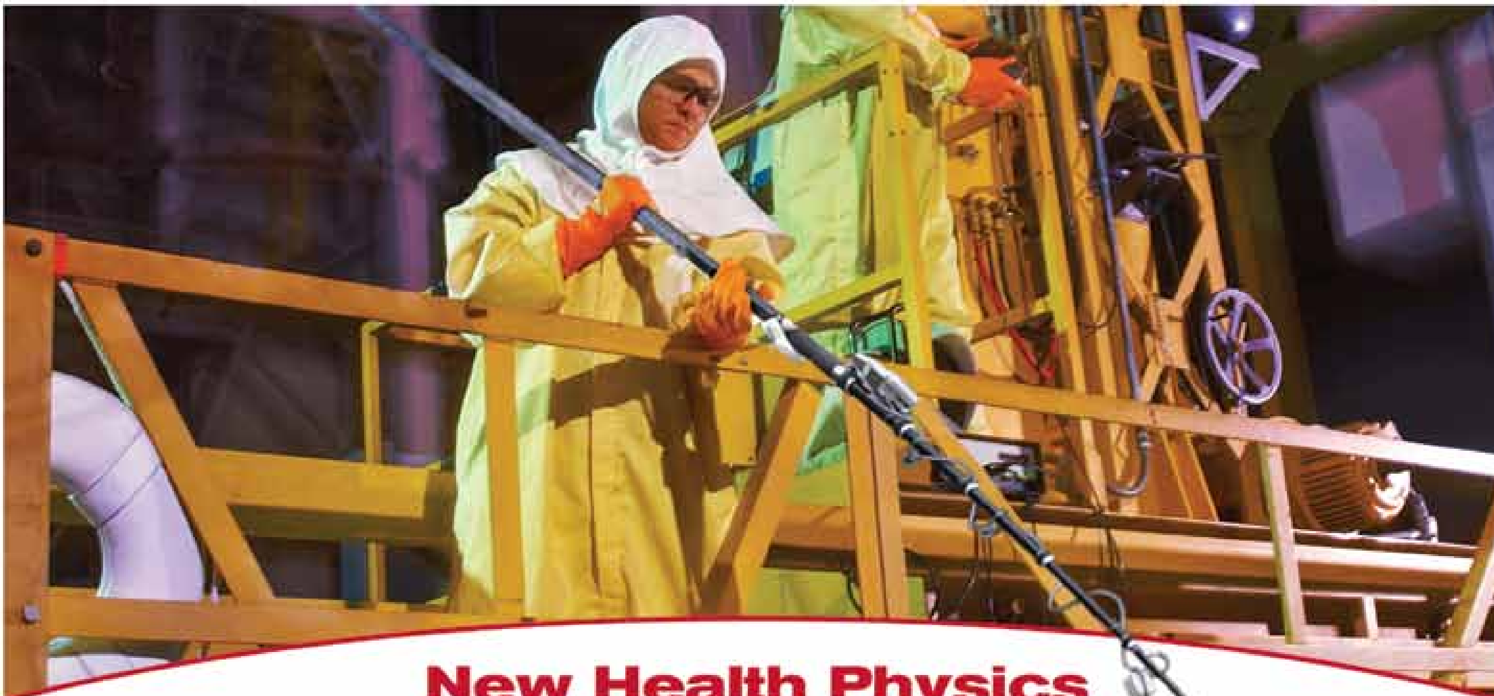

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Mistakes Happen

When and how to change the records

by Emélie Lamothe, Health Physics Specialist

Hi and welcome back.

Last Issue's Question

You are responsible for dose records at your company. Someone has identified an assigned dose that may be incorrect. On further investigation, you determined that this dose is incorrect and must be revised. However, the result has already been sent to the National Dose Registry (NDR). What do you do?

Answer

A change to a dose record is warranted when it has been found that

(a) a second (alternate) estimate of dose is more accurate than the corresponding dose assignment on record (e.g., results from a follow-up investigation into an overexposure); or

(b) the dose-related information must be changed to correct an identified error (e.g., thermo-luminescent dosimetry (TLD) actually used on a different date).

How you process this change depends very much on why the change is needed.

In October 2004, the Canadian Nuclear Safety Commission (CNSC) issued *Regulatory Standard S 260, Making Changes to Dose-Related Information Filed with the National Dose Registry*. The purpose of *S-260* is to require the licensee to seek CNSC approval of any changes to dose-related information previously filed with the NDR. The document sets out the requirements, process, and information required when seeking CNSC approval to make such changes.

Fundamentally, when a change is made to a dose record, the change must be justified; the worker and CNSC must be advised that the change is being made; and the change must be transmitted to the NDR, in a format specified by the NDR.

Let's work through this question: the dose that was reported to the NDR needs to be changed. For the purpose of this article, let's assume the change was identified as a result of a re-evaluation of an overexposure incident. The requirements of *S-260* apply.

Your first step is to conduct an investigation of the event that prompted the request for changing the dose. The findings of this investigation must be documented in a report, which will be sent to CNSC with the completed request to change the dose reported previously. The investigation report must answer the five Ws—what, when, where, who, why, and how—of the incident. The report must also include the supporting dosimetry data, assumptions, and calculations used to justify changing the assigned worker dose.

If the results of the investigation do not justify changing the assigned dose or if the magnitude of the dose change is less than the minimum dose level (MDL) for a change, the initiating request should be denied. You will need to advise the person requesting the change of this decision and the reason for it.

If, however, a change to the assigned dose is justified and is greater than the MDL, complete a CNSC Dose Information Change Request Form and send it to the affected worker for written acknowledgment that he or she has been informed of the change and understands its implications. The worker must sign the form and return it to you. The completed form is then sent to your CNSC licensing personnel, with a copy of the investigation report.

If CNSC approves the requested change, it will advise you and your dosimetry service provider. A copy of the approval will also be sent to the NDR; however, it is your dosimetry service provider that must send the official change to the NDR, in the format and process specified by the NDR. You will be required to notify the affected worker that the change has been made.

There will be times when the full rigour of *S-260* will not apply to a change being made to dose-related information contained in the NDR. However, the basic principles still apply: the change must be justified, the worker and CNSC are advised of the change, and the change is sent to the NDR. How then does this situation differ from what was discussed above? Let's work through a very simple scenario.

You've just completed the quarterly submission to the NDR when the lab advises you that it just found a dosimetry file that should have been processed and sent in the previous quarter. These results are valid and account for a total of 650 mrem of unreported dose.

These results are referred to as "Late Reports." In this instance, the dose is sent to the NDR, the affected workers are advised of the change to their total dose, and CNSC is advised through routine compliance reporting that there has been a late submission to the NDR.

Regardless of the circumstances necessitating a change to a dose previously sent to the NDR, you should have a well-documented process for handling dose record changes. It would be prudent to discuss the issue ahead of time with CNSC and come to a mutual understanding as to how grey areas will be managed (e.g., changes due to errors in a dose algorithm).

This Issue's Question

A worker at your facility no longer has sufficient renal function to provide a routine urine sample. This worker has duties that regularly take him into low-tritium (as HTO) hazard areas. What are your options for bioassay?

Have fun! Remember, this column's for you. Send your answers and suggestions for future issues by email to the CRPA Secretariat or to me at eslamothe@hotmail.com.

L'erreur est humaine

Il faut seulement savoir quand et comment modifier les dossier touchés

par Emélie Lamothe, spécialiste en radioprotection

Bonjour et bon retour

Question du dernier numéro

Vous êtes responsable de l'enregistrement dosimétrique chez votre employeur. Quelqu'un a relevé un dosage qui semble incorrect. Une étude plus poussée vous a permis de déterminer que le dosage est effectivement incorrect et qu'il doit être revu. Toutefois, le résultat a déjà été envoyé au FDN. Que faites-vous?

Réponse

Le changement à un dossier de dosimétrie est justifié lorsqu'il a été déterminé…

(a) qu'un second estimé de dose (alternatif) est plus précis que l'attribution de dose correspondante au dossier (p. ex., les résultats d'une enquête complémentaire liée à une surexposition) ou

(b) que l'information liée à la dose doit être modifiée pour corriger une erreur qui a été relevée (p. ex., la dosimétrie à thermoluminescence a été utilisée à une autre date).

La façon de procéder au changement dépend en grande partie de la raison pour laquelle le changement est nécessaire.

En octobre 2004, la Commission canadienne de sûreté nucléaire (CCSN) a publié la norme d'application de la réglementation n° *S-260 Modification des renseignements sur les doses déposés dans le Fichier dosimétrique national*. L'objectif de la norme *S-260* est d'exiger du titulaire de permis qu'il obtienne l'approbation de la CCSN pour toute modification apportée à l'information liée aux doses, préalablement enregistrée au Fichier dosimétrique national (FDN). Le document établit les exigences, les processus et l'information requise pour obtenir l'approbation de la CCSN afin de procéder à de telles modifications.

Tout d'abord, lorsqu'on apporte une modification à un dossier de dosimétrie, cette modification doit être justifiée; le travailleur et la CCSN doivent être avisés de ce changement qui doit également être transmis au FDN dans un format précisé par celui-ci.

Revoyons les données du problème : la dose rapportée au FDN doit être modifiée. Pour les besoins du présent article, supposons que le changement a été identifié des suites de la réévaluation d'un incident de surexposition. Les exigences du document *S-260* s'appliquent.

La première étape est d'enquêter sur l'événement qui a provoqué la demande de modification de dose. Les résultats de cette enquête doivent être documentés dans un rapport, à envoyer à la CCSN accompagné d'une demande de modification de la dose rapportée précédemment, dûment remplie. Le rapport d'enquête doit répondre à six questions concernant l'incident : quoi, quand, où, qui, pourquoi et comment. Le rapport doit aussi comprendre les données dosimétriques, les postulats et les calculs employés pour soutenir la nécessité de modifier la dose aux travailleurs assignés.

Si les résultats de l'enquête ne justifient pas de changer ladite dose ou si l'ampleur du changement de la dose correspond à moins que le niveau de dose minimale, la requête de modification doit être rejetée. Il vous faudra en aviser la personne requérant la modification et lui donner les raisons qui justifient cette décision.

Par contre, si la modification est justifiée et qu'elle équivaut à plus de la dose minimale, vous produirez le Formulaire de demande de modification des renseignements sur les doses de la CCSN et l'enverrez à l'utilisateur touché pour obtenir son attestation écrite stipulant qu'il a été informé de la modification et qu'il comprend ce que cela implique. L'utilisateur doit signer le formulaire et vous le renvoyer. Le formulaire rempli doit ensuite être envoyé au personnel qui distribue les permis de la CCSN, accompagné d'une copie du rapport d'enquête.

Par contre, si la CCSN approuve la modification requise, elle vous en avisera, ainsi que votre fournisseur de service de dosimétrie. Une copie de l'approbation sera également envoyée au FDN; cependant, c'est votre fournisseur de service de dosimétrie qui doit envoyer la modification officielle au FDN, en respectant le format et le processus spécifiés par le FDN. On vous demandera d'aviser l'utilisateur touché que la modification a été effectuée.

Il y aura des situations où toute la rigueur de la norme *S-260* ne s'appliquera pas à une modification apportée à des renseignements liés au dosage contenus dans le FDN. Toutefois, les principes de base s'appliquent toujours : la modification doit être justifiée; l'utilisateur et la CCSN sont avisés de la modification, qui est ensuite envoyée au FDN. Alors, en quoi cette situation diffère-t-elle de ce qui a été discuté plus haut? Étudions le scénario fort simple qui suit.

Vous venez de terminer la soumission trimestrielle au FDN lorsque le labo vous informe qu'il vient de trouver un dossier de dosimétrie qui aurait dû être traité et envoyé au cours du trimestre précédent. Ces résultats sont valides et comptent pour un total de 650 mrem de dose non déclarée.

Ces résultats portent la référence « Rapports tardifs » (Late Reports). En l'occurrence, la dose est envoyée au FDN, les utilisateurs affectés sont avisés de la modification apportée à leur dose totale, et la CCSN est informée par le biais d'un rapport de conformité régulier qu'il y a eu une soumission tardive au FDN.

Peu importent les circonstances à l'origine d'une modification à une dose envoyée précédemment au FDN, vous devriez disposer d'un processus bien documenté pour procéder aux modifications d'un dossier de dosimétrie. Il serait

suite à la page 41 . . .

Living with Radiation – Engaging with Society

13–18 May, 2012 ■ SECC ■ Glasgow ■ Scotland

Résumé

L'Association internationale pour la protection contre les radiations (IRPA) se rencontre tous les quatre ans; cette année, son congrès a eu lieu à Glasgow, en Écosse. Le thème du congrès était : « Living with Radiation and Engaging with Society ». Les deux rapports qui suivent ont été rédigés de première main par les membres de l'ACRP Lois Sowden-Plunkett et Nicholas Sion.

Lois rappelle aux lecteurs de son rapport que l'IRPA est formée de 48 associations nationales et représente 17 900 professionnels de la radioprotection. L'ACRP étant un membre affilié de l'IRPA, tous les membres de l'ACRP deviennent aussi, par extension, membres de l'IRPA. En tant que membre de l'IRPA, vous avez accès à un large éventail de ressources et de compétences spécialisées. Elle partage également quelques constatations intéressantes à partir d'un sondage mené récemment auprès des associations membres de l'IRPA.

Lois met aussi en valeur les objectifs établis de l'IRPA : améliorer l'interaction entre les sociétés affiliées et l'IRPA; procurer un plus grand soutien aux professionnels, surtout aux jeunes professionnels; et peaufiner le profil public de la profession de la radioprotection. Elle encourage les membres de l'ACRP à s'impliquer auprès de l'IRPA de façon à aider l'ACRP à réaliser sa vision, qui est « de représenter habilement les professionnels de la radioprotection du Canada, tant à l'échelle nationale qu'internationale ».

Nick, quant à lui, fournit un rapport plus approfondi des présentations et d'autres activités. Il joint également les meilleurs moments de la présentation de l'édition 2012 du prix Sievert remis à Dr Richard Osborne, fondateur de l'ACRP, mentor pour de nombreux professionnels du milieu et une légende en matière de technologie relative au tritium. Richard a également présenté sa conférence intitulée « A Story of Tritium » à l'IRPA 13.

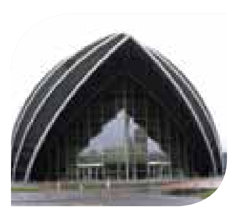
Nick résume aussi les présentations effectuées par d'autres conférenciers canadiens :

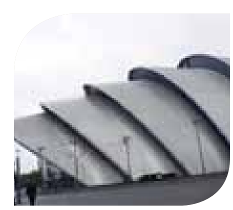
- Cheri Hall, de la University of Ontario Institute of Technology (UOIT), a exposé une présentation par affiches sur la caractérisation des doses canines provenant de l'imagerie par tomodensitométrie et intitulée « Characterizing Canine Dose from Computed Tomography Imaging »
- James Cleary et Professeur Edward Waller, tous deux de la University of Ontario Institute of Technology (UOIT) ont présenté une affiche intitulée « Contact Dose Rates from Encapsulated Sources »
- Nick lui-même a présenté une affiche et un article complet intitulé « Hazards and Countermeasures on Extended Space Missions ».

Enfin, Nick a aussi partagé les faits saillants d'un grand nombre de présentations et a discuté de leurs liens avec le thème du congrès : « Living with Radiation and Engaging with Society ». Pour télécharger les articles, affiches et webémissions de l'IRPA 13, visitez la page www.irpa13glasgow.com/2012/05/irpa13-downloads-page.

The International Radiation Protection Association (IRPA) meets every four years. This year the congress was held in Glasgow, Scotland. Following is a first-hand report by CRPA member **Nicholas Sion**, Technical Director at Intercan Technologies.

IRPA is the international voice of radiation protection. The recent IRPA13 congress brought together the world's largest assembly of radiation specialists—1,500 delegates (with 92 companions) from 77 countries, 150 exhibitors, 1,400 abstracts, and 350 oral presentations in 65 sessions. The event attracted a contingent of some 30 Canadians (see more on page 30).





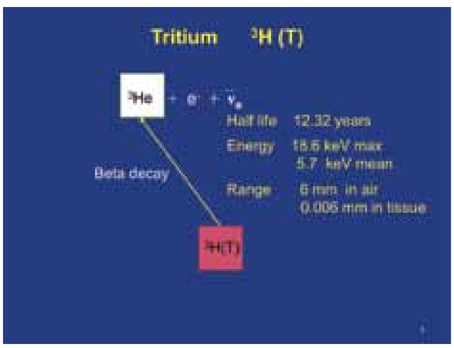
The venue for IRPA13 was the vast Scottish Exhibition Conference Centre (SECC), where the main sessions were held at the Clyde Auditorium, affectionately dubbed by the locals as the "armadillo." The venue and the presentations at the conference were great, but these were offset by daily rain and cold blustery weather.

IRPA13 went digital this time—questions were tweeted or emailed during sessions rather than being asked at a microphone. Podcasts and live webcasts were also used during the congress and remain accessible in the downloads section of the IRPA13 website (www.irpa13glasgow.com/information/downloads).

Awards

2012 Sievert Award

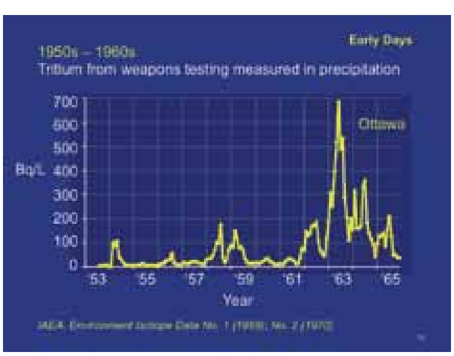
The scientific program began with the presentation of the 2012 Sievert Award to our most deserving Dr. Richard Osborne, CRPA founder, a mentor to many (including me), and a legend in tritium technology. He presented his lecture, "A Story of Tritium." Following are some highlights from that keynote address.



Source: Osborne, "A Story of Tritium." Paper presented at IRPA13, Glasgow, May 13–18, 2012. Available from www.irpa13glasgow.com/information/downloads. (1000 mon clyde osborne.pptx)

Tritium can be produced in a variety of ways:

- Cosmic ray neutrons acting upon ^{16}O and ^{14}N
- Fission in nuclear reactors and weapons
- Neutron capture by deuterium D (^{2}H) and by (n, p) on ^{3}He in heavy water reactors
- Neutron capture by ^{6}Li.



Source: Osborne, "A Story of Tritium." Paper presented at IRPA13, Glasgow, May 13–18, 2012. Available from www.irpa13glasgow.com/information/downloads. (1000 mon clyde osborne.pptx)

IRPA president, Kenneth R. Kase, presenting the 2012 Sievert Award to CRPA's founding member, Dr. Richard Osborne, at the 2012 IRPA congress in Glasgow. Scotland.

During the 1950s and1960s, at the height of hydrogen weapons testing, atmospheric tritium levels peaked in the Ottawa region and worldwide, resulting in international agreements to forego atmospheric weapons testing. Richard pioneered the dual ionization chamber method of detecting tritium in the presence of gamma.

Natural tritium in air is 0.01 Bq/m^3 and the public dose is <20 μSv/a. Tritium is a low-energy beta emitter, and Richard stressed that we need to rethink the effects of chronic low-dose radiation with respect to linear no-threshold (LNT) dictum.

I, too, followed the tritium path and using the basis of dual ion chambers developed a Tritium monitor that detected, measured, and discriminated between the Tritium oxide version and the elemental Tritium (Sion 2002). This is important in the regulatory reporting of tritium-stack emissions, since the oxide version has 20,000 times greater impact on health than elemental tritium. An earlier tritium monitor (Sion 1988) had already been designed for the Tritium Removal Facility at Darlington. Both of these designs are in current operation at the CANDU nuclear sites at Pickering, at Darlington, and at Bruce.

NOTE: The Sievert Lecture, as well as several others, can be viewed on talkingslides.net: www.talkingslides.net/index.php?pre=irpa13

Young Professionals

IRPA offers a prize for the best presentation by a young professional or scientist. To be eligible, candidates must be nominated by their IRPA associate society. The selected candidates from each society make an oral presentation of their paper at the IRPA congress. Of the eighteen candidates, Jad Farah (France) took first place to win a prize of £1,000; Olaf Marzocchi (German-Swiss) took second, winning £500; and Nataly Shagina (Russian Federation) won the third prize of £250.

Session Highlights

The Canadian delegation at IRPA13: from left to right (back) John Takala, Director at Cameco, Saskatoon; John Chase, Senior Technical Expert, External Dosimetry at Ontario Power Generation; Nick Sion, Technical Director at Intercan Technologies; (front) Lois Sowden-Plunkett, then president of CRPA, with Randy Plunkett; and Sylvain St. Pierre, Vice President of Marketing, Europe, for Senes Consultants of Canada.

Canadian Contributors

Cheri Hall

Among the other Canadian presenters at the congress was Cheri Hall, University of Ontario Institute of Technology (UOIT), with a poster presentation on "Characterizing Canine Dose from Computed Tomography Imaging" (Hall 2012). It dealt with the growing concern about the effects from low-dose imaging in computed tomography (CT) scans. Cheri reported on a study developed at Colorado State University to model the stochastic effects in dogs that set the foundation for a canine translational model. Radiation effects were projected to follow the low-dose LNT model as developed by the Biological Effects of Ionizing Radiation (BEIR) VII committee from the Lifetime Survival Studies. Results indicate strong implications at high-dose levels, but there is little evidence to support the theory at low-dose levels. Cheri advocates more research to link stochastic effects at low doses of radiation. This is yet another case for a review of the LNT dictum.

Nicholas Sion presented both a poster and a full paper (Sion 2012) titled "Hazards and Countermeasures on Extended Space Missions." It lists the known hazards potentially encountered by astronauts when on extended interplanetary missions to planets or an asteroid. The main hazard is ionizing galactic radiation of incessant chronic not-so-low-level radiation amounting to 400–900 mSv/a on planet Mars or on route to Mars (NASA Data) versus 2.4 mSv/a on Earth, i.e. about 167–375 times greater, and that defies the dose exposure limits set by NASA. The paper also draws attention to a revised paradigm for dose limits that differs from ICRP 132 and that NASA will be using to calculate the safe days for astronauts in outer space for either gender. The countermeasures to reduce the radiation effects require faster propulsion, and/or improved shielding, and/or enhancing the immune system, which seems to be the area to focus upon.

James Cleary

Edward Waller

James Cleary and Professor Edward Waller, both from the University of Ontario Institute of Technology (UOIT), presented a poster titled "Contact Dose Rates from Encapsulated Sources" (Cleary & Waller 2012). Sealed sources emit significant amounts of secondary electron radiation that need quantification for accurate contact dose estimation. The relative contributions of these secondary electrons were modeled and were found to be in good agreement with published values for ^{137}Cs, ^{60}Co, ^{192}Ir, and ^{226}Ra. However, the objective of this study was to generate revised contact dose rates from Monte Carlo modeling software and compare this to results published in NCRP Report No. 40. It was found that the NCRP40 published contact dose rates are 3–4 times higher than those estimated in this work. The implication is that dose calculations based on NCRP40 values will overestimate dose and lead to underestimated risk when compared to biological indicators.

Space

In addition to my presentation on the hazards and countermeasures of extended space missions, there was another space-oriented paper: "Comparisons of Carrington-class Solar Particle Event Radiation Exposure Estimates on Mars Utilizing the CAM, CAF, MAX, and FAX Human Body Models." This presentation estimated the radiation dose for four human body models in an aluminum-shielded habitat on Mars and compared them to NASA's permissible exposure limits (PELs) (Adamczyk 2012). NASA's On-Line Tool for the Assessment of Radiation in Space (OLTARIS) was used for the radiation exposure assessments.

The results of this estimation showed that even the light CO_2 Martian atmosphere offered enough additional shielding to skew the differences between the phantom models of both genders. Blood-forming organs and heart doses substantially exceeded NASA 30-day PELs. However, it was found that male and female astronauts older than 40 and 45 years, respectively, will not exceed effective dose limits when located in a permanent habitat. Moreover, the current shielding used in Martian landers and in space suits would not provide adequate radiation protection should a Carrington event[1] occur.

Engaging with Society

In keeping with the theme of this congress, many of the presentations explored the advantages of engaging society and encouraging public participation in the decision-making process. One of these was a paper that discussed a survey carried out in Belgium (Turcanu & Perko 2012) on the intended level of involvement in decision making concerning new installations for nuclear research (see Table 1).

Table 1 Intended level of involvement regarding new installations for nuclear research.

Survey	Result
I want to be an active partner in decision making	12 %
I want to participate in dialogue towards a consensual decision	12 %
I want to receive information and express my opinion	28 %
I want to receive information about the installation	18 %
Don't know/No answer	1 %
I don't want to be involved	29 %

Source: Turcanu & Perko, "Public participation in decision-making on nuclear research installations." Paper presented at IRPA13, Glasgow, May 13–18, 2012. (TS4b.1)

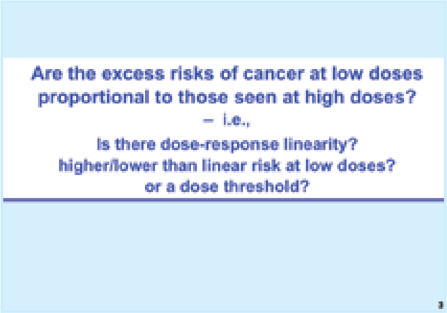
Results, which were based on empirical data from a large-scale public opinion survey in Belgium, clearly indicate that most people (70%) would like to get involved in some aspect of the decision processes. Today, "public participation is an imperative for the formulation and implementation of good policies in the environmental and health domains. It has also become a key determinant in decision-making processes related to the development of science and technology in general, in the framework of 'responsible research and innovation'" (Turcanu & Perko 2012, p.1).

Public engagement has indeed come to the fore after the Fukushima episode, which highlighted "the persistent nature of public fears about ionizing radiation, as well as the need to develop and implement better communications strategies both prior to and in the wake of such accidents" (Hartwell 2012, p.2). This helps to improve public confidence and trust, and establish bilateral communication.

Medical and Nuclear Medicine

Low-Dose Radiation

A plenary session (Shore et al. 2012) gave an overview of low-dose/low-dose-rate epidemiology of cancer, with many questions to be answered.



Source: Shore et al., "Epidemiologic Data on Low-Dose Cancer Risk." Plenary presented at IRPA13, Glasgow, May 13–18, 2012 (PL2.1)

Are there subgroups at greater risk for cancer or groups with genetic susceptibility? Again, the LNT theory comes into question. The discussion can be summarized as follows:

- A-bomb data show an upward curve for leukemia, but little or no curve for solid cancers. This suggests a risk at low doses.
- Variations in radiation-cancer susceptibility only partly accounts for dose response linearity.
- Methodoligical issues can be exacerbated for low-dose studies.
- There is evidence of solid-cancer risk from low, fractionated, or protracted (LFP) exposures, but there is too much heterogeneity to determine a good estimated dose and dose rate effectiveness factor (DDREF).
- Therefore there is a risk at low doses, particularly leukemia.

Mayak studies indicate that dose-response risks increase significantly when the dose is above 0.5 Gy, and the increased risk of circulatory disease is comparable to that of cancer.

The issues raised at the congress included the question of where science should obtain risk values. Is there a dose-response relationship for cancer among people who are not equally sensitive to radiation? Are males and females genetically equal in their susceptibility to radiation? How are the micro-RNAs (ribonucleic acid), which are essential to the survival of cells, regulated by radiation? What pathways do they influence? Are they consistent with LNT? And what switches them on? The discussion seemed to suggest that genes can influence sensitivity to cancer. If a cell is irradiated, it affects the telomeres and causes instability. So what does this mean for radiation protection?

1. New processes occur after irradiation—the non-coding RNA transcriptome becomes activated. Alterations in pathways suggest a unified response. Responses occur at 200 mGy and are persistent.
2. Susceptibility to cancer is through genetic instability, and that is the end point.

Other presentations (Lambrozo 2012) dealt with implantable cardioverter defibrillators and possible interferences (e.g., via damaged batteries and circuitry that may cause an electric shock and even death).

Challenges in Nuclear Medicine

Sweden has used isotopes for diagnostic procedures and for therapy. Some typical examples are shown in Table 2 (pg. 33).

The required accuracy for external therapy should be better than ± 5% whilst for diagnostics it should be ± 25%. The stochastic risks cannot be assessed for individual patients, but can be for an entire population. The absorbed dose

continued on page 33. . .

1 The Carrington Event was the largest solar storm on record and occurred in 1859. Its aurora was observed even in the Caribbean and was bright enough to allow one to read a book at night.

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- intrinsically safe
- colourful backlit display
- dust tight and waterproof up to 1 m
- dose range: 0 to 10 Sv

Tracerco T401
contamination monitor

- displays calibration due date
- backlit bar graph display: 0 to 1000 CPS
- CPM option available
- detects alpha, beta and gamma radiation
- uses one 9 V battery
- weighs 850 g
- detachable probe with 1.5 m cable

. . . continued from page 31

for individual irradiated organs needs to be known. Computational models (phantoms) are made to compare information between hospitals and to investigate different methods; and can be used for individual patients. Since their weights and heights differ, so does the distances between their organs.

Table 2 Therapeutic Nuclear Medicine

Condition	Therapy
Hyperthyroidism Thyroid cancer	^{131}I - iodide
Polycytemia	^{12}P - orthophosphate
Severe pain in metastatic bone disease	^{89}Sr - chloride ^{153}Sm or ^{177}Lu - EDTMP ^{186}Re - EHDP ^{223}Ra - chloride
Liver tumours	^{90}Y - microspheres (SIRT)

* Source: Mattsson, "Challenges in Nuclear Medicine Radiation Dosimetry." Paper presented at IRPA13, Glasgow, May 13–18, 2012. (TS7b.1)

Can the accuracy requirements be met? For therapy the answer is both "no and yes," but for diagnostics it is "yes and no"! "...the accuracy of quantifying the concentration of a radionuclide in regions within the body can be < 5% with SPECT or PET imaging, and, provided there are no overlapping structures containing radioactivity, similar accuracy can also be obtained with planar gamma camera imaging" (Mattsson 2012, p. 25). A review of CT protocols for SPECT/CT and PET/CT imaging is called for.

The challenges in therapy are that dose planning—such as knowing the patient biokinetics, prescribing individual dose calculations, and taking into consideration the dose received during treatment—must be carried out prior to therapy.

There were numerous posters related to the overdosing of patients. This required the implementation of procedures of dose optimization in interventional therapy. One poster (Labattuet al. 2012) was on the evaluation of patient skin dose in interventional radiology using radiochromic film technology. In pediatrics, it is feasible to reduce the head radiation dose by using CT examinations on single and 64-slice CT scans. In summary, enhanced medical practice can reduce CT scan irradiations.

Non-Ionizing Radiation

In recent years, our understanding of the health effects of electromagnetic fields has greatly improved, allowing the International Commission on Non-Ionizing Radiation Protection (ICNIRP) to revise its exposure guidelines (Vecchia 2012). Following are some of the highlights from the ICNIRP presentation.

Static Magnetic Fields

A study on the effects of static magnetic fields was done using no observed adverse effect level (NOAEL). The exposure limit was set at up to 2 tesla. Beyond that, patients suffered phosphenes (light flashes on the eye/retina, but without actual light), vertigo, and nausea. Under special conditions, 8 tesla was attained as an acceptable exposure, but beyond that is uncharted territory.

Low-Frequency Electric and Magnetic Fields (1Hz – 100 kHz)

Phosphenes were reported at frequencies of around 20 Hz, which is well below the threshold for health effects. These are due to stimulation of the electrically excitable tissues (i.e., nerves and muscles). Hence, phosphenes should be considered in the revised guidelines.

High-Frequency Electromagnetic Fields (100 kHz – 300 GHz)

Health effects from high-frequency electromagnetic fields are due to the absorption of electromagnetic energy (i.e., thermal effects). There is some indication of non-thermal effects below basic restrictions, but the health consequences remain unclear.

Long-Term Effects

Based on current research, the ICNIRP maintains that "the causal relationship between magnetic fields and childhood leukemia has not been established, nor have any other long-term effects been established. The absence of causality means that this effect cannot be addressed in the basic restrictions." (Vecchia 2012, p. 13)

However, REFLEX (an extensive European study), indicates that the risk of leukemia doubles when the magnetic fields are >0.4 μT. Genetic damage is similar to that caused by ionizing radiation (e.g., chromosome aberration). The effects are more pronounced in older people. (Touzet & Ferrari 2012)

Mobile Phones and Long-Term Effects of High Frequency Fields

ICNIRP did an interphone study where cell phone use—cumulative number of calls, and cumulative call durations—were considered. The data was combined with the results of biological and animal studies, epidemiological studies, and brain tumour incidence trends. The results for the first 10–15 years of mobile phone use indicate that the material risk of adult brain tumours is unlikely. But, again, REFLEX did their own studies, which indicated that it takes some 15 years for tumours to develop. Therefore, there appears to be no short-term (less than 10 years) risk increase (Touzet & Ferrari 2012).

Risk increases significantly for heavy phone users; cumulative use of half an hour per day shows a risk of of glioma (type of malignant brain tumour) of 30%. Precautions are technically feasible and were applied in Switzerland about 12 years ago. (Touzet & Ferrari 2012; Pantinakis & Batski 2012)

Lasers and Retina Hazards

Lasers and LEDs have the potential to impair visual function. Their effects are wavelength and duration dependent. The eye can focus lasers and collimated light to a fine pinpoint, creating a high power density in the retina. A 2 mW laser can create a power density of 5,000 W/cm^2. Safety issues can be assessed using an "artificial eye" measurement device. (Amitzi & Margaliot 2012).

Geological Disposal

This discussion (Weiss 2012) dealt with the radiological protection of workers, members of the public, and the environment following the disposal of long-lived radioactive waste in deep geological facilities. Dose guidelines, in plain language, should be as follows:

- 0.01–1 mSv is the planned dose
- 1–20 mSv is considered high
- 20–100 mSv is considered emergency

The ICRP system of protection during different time frames in the life of a geological disposal facility should be applied.

Near-surface facilities were not addressed. Verification is required to ensure there is no oversight for the projected eons of time.

Nuclear Security and Emergencies

Following nuclear plant accidents or 'dirty bomb' attacks, only the source terms are generally considered. However, the physico-chemical forms of the contaminants and their volatility should also be considered (e.g., ruthenium strongly depends on oxidizing conditions during its release process) (Caro 2012). Also, there is post-deposition migration and the possible inhalation of these contaminants to contend with. A design basis threat is to be implemented that distinguishes between an accidental emergency and an attack-caused emergency and provides an itemized agenda and planned response for each.

Other

A study evaluating the radiological impact of siting a new nuclear facility in Pelindaba, located 27 kilometres west of Pretoria, South Africa, was presented (Seals 2012). The facility will have a hot-cell complex plus a waste facility. Among the issues considered was liquid discharges and possible ingestion by residents, local farmers, and tourists.

A UK Regulator presented the 31 issues to be resolved by industry before new builds can commence, requiring some 350 meetings per reactor, 4,700 days of Regulatory work, £25 million in regulatory charges per reactor, involving 35 inspectors and 20 support staff. Public exposure should be less that 30 μSv/y (Ingham & McCready-Shea 2012).

Fukushima Daiichi – Lessons Learned

There were two sessions on the Fukushima Daiichi incident and a full plenary where many high-calibre speakers from the International Atomic Energy Agency (IAEA) and their Japanese counterparts made presentations detailing the incident itself, the aftermath, and the lessons learned.

The chronology begins with a severe foreshock (of magnitude 7.2) two days prior to the accident (on March 9, 2011), followed by three other foreshocks (in excess of magnitude 6.0) that same day. The main quake (of magnitude 9.0) occurred on March 11, 2011, followed by aftershocks of magnitudes 7.0, 7.4, and 7.2 respectively later that day. There were numerous other aftershocks of varying intensity (some 536 with an average magnitude of 4.5) over the next four days.

The Pacific Plate moved by about 20 metres eastwards. The northeastern corner of Honshu, Japan, moved by approximately 2.4 metres towards North America. Some 400 kilometres of affected coastline subsided about 0.6 metres, allowing the tsunami easier access further inland.

At the time of the earthquake, units 1, 2, and 3 in the Fukushima Daiichi plant were operating in rated-power operation, while units 4, 5, and 6 were in shutdown mode for refueling. When the earthquake hit, all operating units scrammed, and emergency generators (EGs) started. The tsunami (which was anticipated to be 5.7 metres, but was actually ~15 metres) hit about an hour later, disabling the EG fuel supply and causing a blackout. Passive cooling worked for a while, but fuel began to melt about two or three hours later, generating hydrogen that caused an explosion that released radioactive material (Matsuura 2012).

Following the Fukushima incident, one criticism was that hasty decisions were immediately made, followed by some contradictory ones, leaving the public somewhat confused. The lack of information on the effects of radiation led to misconceptions by the public, such as, "School girls in Fukushima are not able to have a baby in future," and "I was told to terminate my pregnancy" (Sakai 2012, p. 3–4). Both are invalid statements—such actions are not justified when the fetal dose is less than 100 mGy.

There is a need for a perpetual passive cooling system in the interim after an accident. A major decision facing Japanese authorities is whether to back-fit the other nuclear plants to survive 15 metres tsunamis? Japanese authorities have recently voted to restart units 3 and 4 of the Ōi nuclear plant due to severe power shortages.

The Fukushima accident triggered many activities in several countries. The United States Nuclear Regulatory Commission (NRC) Emergency Center, which employs 4,000 people, was activated 24/7 for 9 weeks and dispatched 150 expert advisors to Tokyo during the crisis. Special inspections of United States nuclear power plants were conducted to verify preparedness beyond design basis events and that severe-accident management guidelines were implemented. The United States revisited their emergency preparedness and enhanced their nuclear safety measures, but NRC believes there is "no imminent risk from continued nuclear power plant operation and licensing activities" (Magwood 2012, pg. 9). In fact, work continues on two new nuclear power plants in Georgia. However, NRC has decided that the US should use International Systems Units (SI units) to enhance consistency with the international community.

The French Institut de Radioprotection et de Surete Nucleaire (IRSN) (or Institute for Radiological Protection and Nuclear Safety) did a diagnostic assessment to reconstruct the plume and compared their findings with those of the Nuclear and Industrial Safety Agency (NISA). Their results are shown in Table 4. One of their lessons learned was that new tools and modeling techniques are required for accurate crisis assessment and management. (Mathieu et al. 2012)

Table 3: Measured Earthquake Intensity Compared to Design Basis Earthquake (DBE)

Fukushima Plant Number	Power Output	Observed Ground Acceleration (max. Gal) and Direction			Plant Design Basis Earthquake (max. Gal) and Direction		
		N - S	E - W	Vertical	N - S	E - W	Vertical
Fuku 1	460	460	447	258	487	489	412
Fuku 2	784	346	550	302	441	438	420
Fuku 3	784	322	507	231	449	441	429
Fuku 4	784	281	319	200	447	445	422
Fuku 5	784	311	548	256	452	452	427
Fuku 6	1,100	298	444	244	445	448	415

Source: Matsuura, "Fukushima: Lessons and Challenges in Japan." Paper presented at IRPA13, Glasgow, May 13–18, 2012. (PL5.4)

Notes:

1. **Gal**, sometimes referred to as galileo, is the centimetre-gram-second (CGS) unit of length for seismic ground acceleration (defined as 1 cm/s²).
2. **SCRAM** is the acronym for Safety Control Rod Axe Man and refers to the emergency shutdown of a nuclear reactor. The SCRAM setpoints for ground acceleration, for the basement of reactor building is 135–150 Gal horizontal and 100 Gal vertical.
3. Comparison: CANDU 6 and CANDU 9 (Bruce and Darlington) are conservatively designed to design basis earthquake (DBE) peak ground acceleration of $0.2g \equiv 1.96\ m/s^2$ (196 Gal), but can be qualified to $0.3g \equiv 2.9\ m/s^2$ (290 Gal) (Touzet & Ferrari 2012).

Table 4 Assessment of Plume Deposition

Radionuclides	IRSN	NISA
^{133}Xe (Bq)	5.9 e^{+18}	1.1 e^{+19}
^{131}I (Bq)	2.0 e^{+17}	1.6 e^{+17}
^{137}Cs (Bq)	2.1 e^{+16}	1.5 e^{+16}

Source: Mathieu, "Assessment of Atmospheric Dispersion for the Fukushima Dai-ichi Nuclear Power Plant Accident. Assessment of atmospheric dispersion and radiological consequences for the Fukushima Dai-ichi Nuclear Power Plant accident." Paper presented at IRPA13, Glasgow, May 13–18, 2012. (TS12a.1)

Germany's Deutscher Wetterdienst measured the gamma radiation dose rates at 1,800 measuring sites, including aircraft measurements of the upper atmosphere (Steinkopff et al. 2012). Among the lessons learned was the importance of providing accurate information. The demand for information was higher than expected, so, in future, important and accurate information should be distributed through social media to meet this demand.

The Czech Republic conducted air sampling in the days following the Fukushima incident (Hyza 2012). The range of values was slightly higher than those found during a similar survey in 1986, following the Chernobyl disaster (see Table 5). Their embassy staff in Japan were issued iodine pills following the accident. In their presentation, they were promoting international co-operation and a harmonized approach to emergency management.

Table 5 Maximal observed values

Nuclides	1986	2011
^{131}I	70 Bq/m³	0.013 Bq/m³
^{137}Cs	23 Bq/m³	0.00072 Bq/m³

Source: Hyza, "Monitoring of Radionuclides in the Air in the Czech Republic After the Fukushima NPP Accident." Paper presented at IRPA13, Glasgow, May 13–18, 2012. (TS12a.3)

In Korea, over-reaction following the Fukushima incident was noticeable (Lee 2012). Bottled water, and facemasks were immediately sold out. Following rumours about its protective action against radioiodine, brown seaweed, and for unknown reasons, even sun-dried salt were in short supply. The public searched for KI tablets and the import of Japanese foodstuffs stopped. "Anti-nuke" sentiments increased. The detected activity in air for ^{131}I was ~1 mBq/m³ compared to the mean outdoor radon concentration of 20–30 Bq/m³. In rain, the detected activity for ^{131}I was 1Bq/L, whilst the normal range for ^{7}Be is ~3 Bq/L. It appears the fear was unnecessary.

A presentation from Denmark (Andersson 2012) identified the need to improve the European decision support systems, which were originally created to predict radiological consequences of nuclear accidents. A key point was that knowledge of the source term is imperative. "Traditionally, the 'source term' in decision support models is simply a radionuclide vector, but the physicochemical forms of the released contaminants are crucial to consider. . . It should be stressed that model and parameter refinements are urgently needed to provide reliable consequence estimation for this particular category of scenarios" (Andersson 2012, pg. 6).

A presentation from the United Kingdom (Temple 2012) identified the following lessons learned. Increased monitoring and decontamination is required, as well as provide medical assistance to evacuees, casualties, and intervention personnel. It is important to take countermeasures against ingestion and to take long-term protective actions.

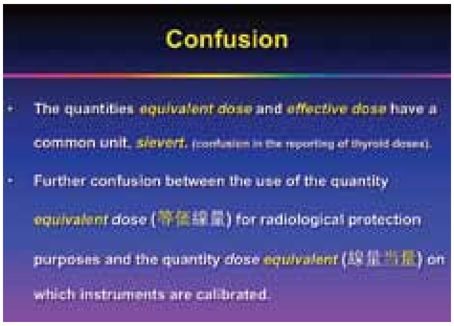
A presentation from the United States (Andersen 2012) reported that, as part of the enhanced environmental monitoring for radioactivity from Fukushima, the Nuclear Energy Institute (NEI) detected negligible amounts of extra radioactivity from ^{131}I and ^{137}Cs in air and water samples. However, the report indicated that Americans demonstrated heightened concern due to mixed messages from government departments and media. As a "way forward," the report suggested more-coordinated industry activities, and that the safety of US 104 reactors be maintained and improved.

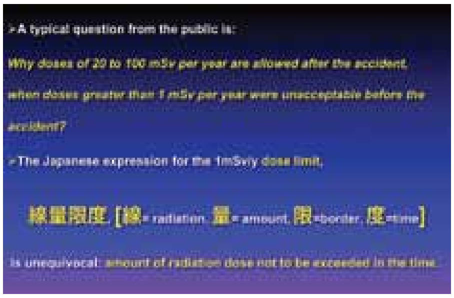
France's Agence Energie Nucleaire (AEN) suggested a protective criteria for affected populations where evacuation is implemented at exposure of > 20 mSv/y (LeGuen 2012). The long-term goal for remediation is at 1 mSv/y, and reference levels for all areas need not be the same at the same time. EDF (Électricité de France) immediately formed a rapid-response nuclear task force, Force d'Action Rapide du Nucléaire (FARN). With a staff of 300, FARN will be able to respond as part of the EDF corporate emergency process and comply with their procedures. This "nuclear accident strike force is deployed as part of a pre-planned process" (LeGuen 2012, pg. 22).

A presentation on behalf of the International Atomic Energy Agency (IAEA) reported that IAEA received news of the earthquake within 40 minutes of the event (Buglova 2012). On March 14, 2011, briefings to member states were initiated and assistance was offered, and two safety teams were formed. IAEA monitoring teams were sent to Japan between March 18 and April 18, and support labs were set up. IAEA's "Action Plan on Nuclear Safety" included three modes: Full Response Mode, Basic Response Mode, and Normal Response Mode. The IAEA is prepared to respond 24/7 and can provide service for sustained periods.

In summary

Nuclear accidents and emergencies call for accurate information, transparency, and communication to avoid confusion. The area of confusion and language issues are best illustrated in the following slides:





Source: Gonzàlez , «Fukushima: Lessons being learned and radiation.» Paper presented at IRPA13, Glasgow, May 13–18, 2012. Available from www.irpa13glasgow.com/information/downloads. (1030 fri clyde gonzalez.ppt)

Site Visits

Among the possible visits to some of the interesting technical sites in and around Glasgow (www.irpa13glasgow.com/scientific-programme/technical-visits) were a tour of the Sellafield nuclear site and the nuclear submarine base, Her Majesty's Naval Base Clyde, at Faslane. Both visits required stringent security clearances prior to the visit, and some conference participants were turned away at the gates.

Sellafield

Sellafield began its nuclear operations in the early 1950s and was focused on a weapons program, nuclear generation, and storage and chemical separation of nuclear fuel. The legacy of a hurried program, these facilities are now the site of the largest and most complex nuclear cleanup operation in the world, involving 170 major nuclear facilities and 2,200 other buildings that housed activities spanning the entire nuclear fuel cycle. The site has become the most innovative and complex nuclear decommissioning project to date.

Photo taken by Simon Ledingham (www.nwgyro.co.uk) and reprinted with permission from www.visitcumbria.com.

The Sellafield nuclear reprocessing plant includes the Windscale and Calder Hall nuclear reactors, both of which are being decommissioned and dismantled. While these facilities are being decommissioned, the main activity on the site is creation of MOX fuel at the thermal oxide reprocessing plant (THORP).

It was most interesting to view decommissioning in action. There are about 10,000 employees and 2,000 contractors involved. The waste products are at some 2,000 Sv/h, and the operational dose limit is kept at 0.8 mSv/y for employees and contractors. The spent fuel is kept in 10 metres deep open-air ponds under regular water, but caustic (alkali) is added to maintain a high pH factor and prevent corrosion.

The Windscale reactors were the first to produce weapons-grade ^{239}Pu using 2,000 tonnes of graphite as a moderator. Carbon dioxide, used as the coolant, reached 640°C at a pressure of about 40 bar (580 psi). Leftovers from the nuclear research and weapons programs were housed in aging ponds when safe disposal and storage was not a priority. The reprocessing operation at Sellafield separates the uranium, the plutonium, and the fission products (strontium, ^{14}C, and other such nuclides). The uranium is recycled into new fuel bundles and the plutonium is made into MOX (7–10% Pu content was only achieved in October 2001) for fast breeder reactors in aircraft carriers.

Background radiation, measured while we were visiting the site, was 3 μSv/h in the separation room. In other areas it varied from 0.1–0.7 μSv/h. No Cherenkov glow was observed in the ponds, indicating that the resident fuel was far too decayed. The site is being considered for a new-build reactor to be completed before 2025.

Decommissioning work at the Sellafield site cost over £1.1 billion (40% of the budget of the Nuclear Decommissioning Authority) in 2009, and is expected to cost £1.5 billion per year for several years to come.

Her Majesty's Naval Base Clyde

My second site visit was to the nuclear submarine base at Faslane, 40 kilometres northwest of Glasgow. Operated by some 6,500 civilian and service personnel, it is the headquarters of the Royal Navy in Scotland. Commonly known throughout the Navy as Faslane, this is an operational base for nuclear submarines and their associated nuclear weaponry used for patrol and operational missions.

This base assists the Royal Navy to maintain continuous at-sea deterrence by ensuring at least one Vanguard-class submarine is on patrol at sea every day. Faslane is home to Astute, Vanguard, and Trafalgar nuclear submarines. The Astute class is a hunter-type submarine and is the most capable. It is fitted with the latest equipment, has no periscope, and has a classified navigation system.

These submarines are powered by pressurized water reactors (PWRs) that are claimed to operate for 27 years without refueling. Dose rates are 10–20 μSv/h within the submarine, and about 10 μSv/h measured 1m from the hull. Some tritium is detected . . . sometimes.

Faslane is also home to the NATO Submarine Rescue Centre (NSRS),

Nuclear submarine HMS Vanguard arrives back at HM Naval Base Clyde, Faslane, Scotland following a patrol. Published with permission from www.defenceimagery.mod.uk under the open government license.

the central components of which are the Submarine Rescue Vehicle (SRV), which weighs 30 metric tonnes and can be transported by an Antonov or a C-17 aircraft; an Intervention Remotely Operated Vehicle (IROV); and a Portable Navigation, Tracking and Communication System (PNTCS). For a submarine rescue mission, these can all be air transported. Rescue missions are attempted up to a depth of 600–700 metres below sea level, below which it become unfeasible.

Since World War II, 37 submarines have sunk as a result of various accidents (not in combat), 13 of which were Russian. After the Russian Kursk submarine incident in August 2000, when 118 sailors and officers died because rescuers were not able to get to them in time, the need for an internationally coordinated response to peacetime submarine disasters became clear. Initially established by NATO, the International Submarine Escape and Rescue Liaison Office (ISMERLO) was created in 2003. An international team of submarine escape and rescue experts, based at Norfolk, Virginia, aims to establish international standards for submarine escape and rescue through consultation and consensus among submarine-operating nations.

In a typical rescue mission, the IROV is sent down first to ascertain signs of life and to scope out the layout of the damaged sub. The rescue submarine then goes down and aligns itself above the universally sized escape hatch of the damaged submarine; linkage can occur at angles of up to 33 degrees. When the two pilots and a rescue officer (i.e., a crew of three) on the rescue submarine are assured there is no leakage and the rescue submarine is properly pressurized to that depth, the hatches are opened and the transfer of people begins. (The capacity of the rescue submarine ranges from 9 to 13.) Upon resurfacing, the rescued submariners are placed into a hyperbaric chamber (with a capacity of up to 36 people) until depressurization is complete. This can take days.

Business Side of IRPA

The IRPA 13 General Assembly was held on Wednesday, May 16, 2012. At that meeting, delegates elected and appointed the following representatives.

Elections

- **President (elected)** Renate Czarwinski, of IAEA, was selected to replace Dr. Ken Kase.
- **Vice-President (elected)** Roger Coates moved from vice president of Congress Affairs to vice president, IRPA
- **Executive Officer (appointed)** Bernard Le Guen, who has been an member of the executive council for the past four years, was appointed executive officer.
- **Treasurer (appointed)** Dick Toohey continues as IRPA Treasurer.
- **Publications Director (appointed)** Chris Clement, who ICRP's scientific secretary and a member of CRPA, was appointed publications director.
- **Executive Council Members (elected)** Four new executive council members were elected: (1) Ana Maria Bomben, Argentina; (2) Alfred Hefner, Austria; and (3) Sigurdur Magnusson, Iceland were elected for eight-year terms; (4) Richard Vetter, United States, was elected for a four-year term to complete the term of Bernard Le Guen, who became Executive Officer.
- **Vice-President Congress Affairs** Thiagan Pather representing South Africa is the new vice president of Congress Affairs

Dr. Gary Kramer, the Canadian representative on IRPA's council, was honored with an award for his diligent services rendered to IRPA over two terms (8 years).

Future locations

Also at the business meeting, the following locations were approved for 2016 and 2020.

- IRPA14 (2016) will be held in Cape Town, South Africa.
- IRPA15 (2020) will tentatively be held in Seoul, South Korea. The fallback plan is Adelaide, Australia. Brazil's proposal for Rio de Janiero came in third.

Contenders for IRPA 15

Nick Sion in traditional Korean attire at the dinner hosted by Korean delegation.

In order to garner the required votes to bring IRPA15 to Seoul, South Korea, the Korean delegation hosted a lavish evening with a four-course dinner, open bar, and soothing Korean music. Entertainment for the evening included the opportunity to have your photo taken in Korean attire (see photo of Nick above). They won by a large margin. Other contenders included Rio, Brazil, who featured bikini-clad dancers at their exhibitor booth doing a five-minute Samba every 15–20 minutes, and Australia, who offered a glass of wine to anyone who passed by their booth.

Nick Sion with a piper who is guarding the entrance to the banquet venue.

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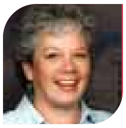
Following is a first-hand report from the recent IRPA13 congress by CRPA member **Lois Sowden-Plunkett**, assistant director, Office of Risk Management, University of Ottawa

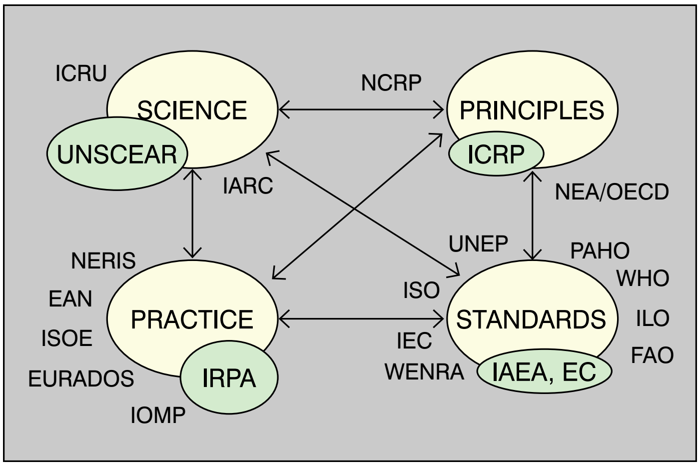


CRPA & IRPA

IRPA is composed of 48 national associations and represents 17,900 radiation safety professionals. CRPA is an affiliate member of IRPA; therefore, all CRPA members are by extension also members of IRPA. As a member of IRPA you have access to a great range of expertise and resources.

Perhaps you are a little unsure about the relationship IRPA has with CRPA and other radiation safety associations internationally? If you are, you are not alone. IRPA recognized that this was an appropriate time to clarify its place within the larger context of international associations whose mandates included radiation protection. IRPA developed the diagram below to illustrate how some of the associations are related and where their focus

The Four "Pillars of Radiation Protection"



SCIENCE

- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)
  - International Commission on Radiation Units and Measurement (ICRU)
  - International Agency for Research on Cancer (IARC)

PRACTICE

- International Radiation Protection Association (IRPA)
  - NERIS (European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery)
  - European ALARA Network (EAN)
  - Information System on Occupational Exposure (ISOE)
  - European Radiation Dosimetry Group (EURADOS)
  - International Organization of Medical Physics (IOMP)

PRINCIPLES

- International Commission on Radiological Protection (ICRP)
  - National Council on Radiation Protection and Measurements (NCRP)
  - OECD Nuclear Energy Agency (NEA)

STANDARDS

- European Commission (EC)
- International Atomic Energy Agency (IAEA)
  - United Nations Environment Programme (UNEP)
  - International Organization for Standardization (ISO)
  - International Electrotechnical Commission (IEC)
  - Pan American Health Organization (PAHO)
  - World Health Organization (WHO)
  - International Labour Organization (ILO)
  - Food and Agriculture Organization of the United Nations (FAO)
  - Western European Nuclear Regulator's Association (WENRA)

is in relation to what they call the four Pillars of Radiation Protection: science, principles, practices or standards.

During the congress in Glasgow, IRPA reported the results of a recent survey of member associations. The participation rate was high (70% of its association responded). In some cases, a great diversity among the associations was evident. For example, while the average number of members in an association was 160, the range was 15–800. The ability of an association to meet within a year also reflected great diversity—a range of 0–30 meetings per year were reported, but the average was 3 or 4.

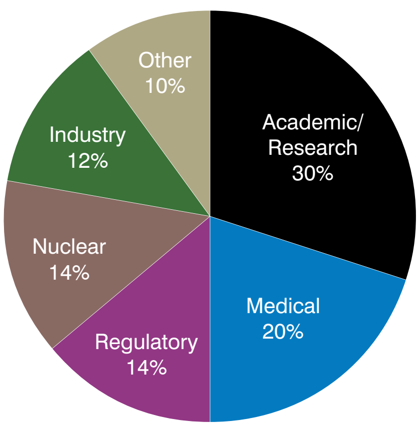


Figure 2 Profile of IRPA Affiliated Associations

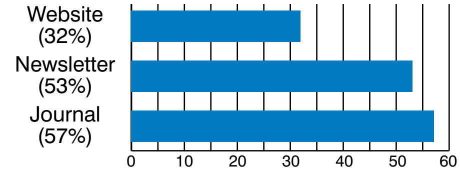


Figure 3 Communication Tools Used by IRPA Affiliated Associations

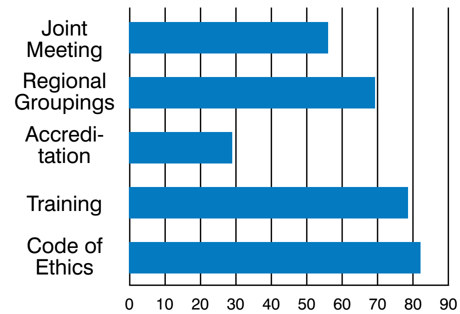


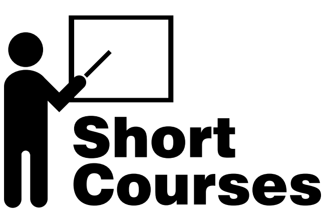
Figure 4 Activities of IRPA Affiliated Associations

To give you a better understanding of how CRPA and its current activities compare to other associations, I have included a sampling of the IRPA data with this article.

IRPA identified the following goals: to enhance interaction between affiliated societies and IRPA; to provide greater support for professionals, especially young professionals; and to enhance the public profile of the radiation safety profession.

The congress theme was "Living with Radiation and Engaging with Society." As you may have expected, the reoccurring theme was public engagement and defining what that means. Given that over a year has passed since Fukushima, many sessions focused on the lessons learned during that event. Communication was seen as key—consistent messaging, ensuring the message is audience appropriate, and building public trust. Finally, meeting the need for future radiation safety professionals through outreach to secondary and primary schools (teachers and students) was discussed by many associations around the world.

IRPA 13 documents, papers, posters, and webcast are now posted on the IRPA website and are available for download (www.irpa13glasgow.com/information/downloads). I encourage you to both visit the website and become involve with IRPA by sharing your expertise. CRPA's involvement with IRPA helps us realize our vision, which is "to be the expert voice of Canadian radiation safety professionals, both nationally and internationally."



The following courses are being offered by CRPA member organizations. If you are a CRPA member and would like to advertise your short course in the *Bulletin*, email michelle.com@shaw.ca.

Cost: $10 per column inch (approx. 50 words per inch).

TECHNICAL MANAGEMENT SERVICES

Depleted Uranium Workshop

October 15-17, 2012

PLACE: Phoenix, AZ

FEE: $1095

This 3-day course will provide an introduction to depleted uranium. Topics covered will include: health physics fundamentals for uranium (U) and depleted uranium (DU), including atomic structure, isotopes of U, radiations emitted, radioactive decay mechanisms, half-life and radioactive decay equation, dose limits, inhalation classes, DACs and DAC-hours, biological effects of radiation, and radiation risk; radiological and chemical properties of U and DU; specific activity; brief overview of the uranium fuel cycle, including U mining and milling, conversion, enrichment methods, fuel fabrication, and HLW storage, disposal and reprocessing, and methods of DU production for industry and the military; uses of DU in industry and in conflicts (e.g. the Gulf Wars and the Balkans); external and internal exposure to DU and their effects; DU exposure case studies (Department of Defense, Capstone DU Aerosol Report, Sandia National Laboratory, and others); guidance on exposure to U and DU; monitoring and treatment of individuals exposed to DU; and cleanup of DU-contaminated sites. Examples of specific activity, radioactive decay, and internal dose calculations for soldiers in tanks and vehicles struck by DU armor-piercing rounds will be discussed. Calculations of DU uptake in the kidneys, given a DU intake into the body, will be performed. Information on the current state of evaluation of DU-exposed veterans by the Baltimore VA Hospital, as provided in annual reports to Congress, will be provided. Comprehensive references, glossary, and examples OSHA/NIOSH U hazards information sheets will be provided as well. Students should bring a scientific calculator to class.

For More Information

Robin Rivard
860-738-2440 / fax: 860-738-9322

Email: rrivard@tmscourses.com

Website: www.tmscourses.com

ICRP NEWS

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Early and Late Effects of Radiation in Normal Tissues and Organs: Threshold Doses for Tissue Reactions in a Radiation Protection Context

Abstract

This report provides a review of early and late effects of radiation in normal tissues and organs with respect to radiation protection. It was instigated following a recommendation in ICRP *Publication 103* (2007), and it provides updated estimates of "practical" threshold doses for tissue injury defined at the level of 1% incidence. Estimates are given for morbidity and mortality endpoints in all organ systems following acute, fractionated, or chronic exposure. The organ systems comprise the hematopoietic, immune, reproductive, circulatory, respiratory, musculoskeletal, endocrine, and nervous systems; the digestive and urinary tracts; the skin; and the eye.

Particular attention is paid to circulatory disease and cataracts because of recent evidence of higher incidences of injury than expected after lower doses; hence, threshold doses appear to be lower than previously considered. This is largely because of the increasing incidences with increasing times after exposure. In the context of protection, it is the threshold doses for very long follow-up times that are the most relevant for workers and the public: for example, the atomic bomb survivors with 40–50 years of follow-up. Radiotherapy data generally apply for shorter follow-up times because of competing causes of death in cancer patients, and therefore risks of radiation-induced circulatory disease at those earlier times are lower.

A variety of biological response modifiers have been used to help reduce late reactions in many tissues. These include antioxidants, radical scavengers, inhibitors of apoptosis, anti-inflammatory drugs, angiotensin-converting enzyme inhibitors, growth factors, and cytokines. In many cases, these give dose modification factors of 1.1–1.2, and in a few cases 1.5–2, indicating the potential for increasing threshold doses in known exposure cases. In contrast, there are agents that enhance radiation responses, notably other cytotoxic agents such as antimetabolites, alkylating agents, anti-angiogenic drugs, and antibiotics, as well as genetic and comorbidity factors.

Most tissues show a sparing effect of dose fractionation, so that total doses for a given endpoint are higher if the dose is fractionated rather than when given as a single dose. However, for reactions manifesting very late after low total doses, particularly for cataracts and circulatory disease, it appears that the rate of dose delivery does not modify the low incidence. This implies that the injury in these cases and at these low dose levels is caused by single-hit irreparable-type events. For these two tissues, a threshold dose of 0.5 Gy is proposed herein for practical purposes, irrespective of the rate of dose delivery, and future studies may elucidate this judgment further.

Election Nominations
CRPA Board of Directors

The Nominations Committee is seeking individuals for consideration to stand for election for the following positions:

President Elect • Secretary • Director (2) •

All full members are encouraged to submit the name of a person(s)who they would like to be considered as a candidate(s) for the upcoming election. Members nominated must be CRPA members in good standing.

If you are interested or know a member who should be considered, please email Debbie Frattinger at Debbie.frattinger@usask.ca.

Deadline is November 30.

Nomination pour élection
Conseil d'administration de l' ACRP

Le comité des nominations recherche des individus qui désirent soumettre leur nom afin d'être considérés pour les élections aux postes suivants :

Président(e)-élu(e) • Secrétaire • Directeur (2) *

Tous les membres à part entière sont encouragés à proposer des personnes qui aimeraient être considérés comme candidats pour les prochaines élections. Les candidats potentiels doivent être des membres en règle de l'Association.

Si vous êtes intéressé(e) ou connaissez une autre membre pouvant l'être, veuillez contacter Debbie Frattinger par courriel à Debbie.frattinger@usask.ca.

La date limite est le 30 novembre.

Coin des spécialistes en radioprotection

. . . suite de la page 27

prudent de discuter d'une modification au préalable avec la CCSN et d'en arriver à une entente mutuelle quant à la gestion des zones grises (p. ex., les modifications à apporter en raison d'erreurs sur l'algorithme d'une dose).

Question du présent numéro

Les fonctions rénales d'un travailleur de votre division l'empêchent de fournir un échantillon d'urine systématique. Les tâches de ce travailleur l'amènent régulièrement dans des zones dangereuses renfermant de faibles niveaux de tritium (telles HTO). Quelles sont vos options en terme de biodosage?

Amusez-vous! Souvenez-vous que cette rubrique s'adresse à vous! Envoyez vos réponses et vos suggestions pour les prochains numéros au secrétariat de l'ACRP ou encore faites-les-moi parvenir par courriel à eslamothe@hotmail.com.

Book Review

. . . continued from page 14

I read *Being Nuclear* shortly after finishing both Adam Hochschild's history of the Belgian Congo (*King Leopold's Ghost*) and Andrew Feinstein's encyclopedic *The Shadow World: Inside the Global Arms Trade,* and there is considerable overlap among the three books. Uranium mining in Africa began in the Democratic Republic of Congo toward the end of the colonial period, and the area around the Shinkolobwe mine--which provided the uranium for the Manhattan Project--remains contaminated by tailings. More recently, the fate of the Rossing mine in Namibia has been tightly intertwined with the politics of the Namibian civil war and the associated arms embargo. Many of the profits from the uranium mines in Niger and Gabon also found their way into the illicit arms trade. *Being Nuclear* stands on its own, but my previous knowledge certainly provided some additional insight into the subject matter.

Radiation Monitoring?

LCS
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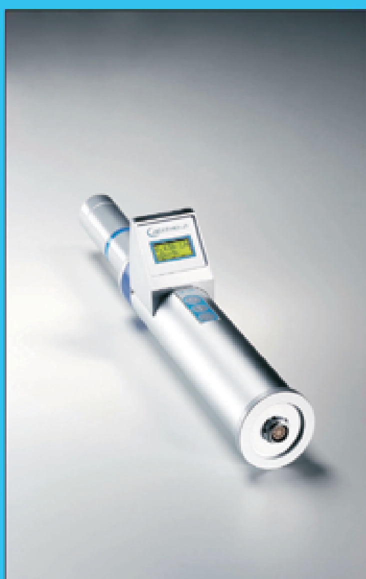
Presents Berthold Technologies…



LB126

This handheld monitor is also suited for fixed applications. The LB126 provides measurement of ambient dose equivalent H*(10) for photon radiation, with integrated energy compensated proportional counter tube LB 6006-H10.

This gamma sensitive monitor is used to measure ambient gamma dose or dose rate as a handheld probe, wall mounted as a stand alone Fixed Area Alarming Gamma monitor, or integrated into a networked dose rate monitoring system with up to 15 stations.

- ☑ **50 nSv/h - 50mSv/h**
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- ☑ **uSv/h or mrem/h**
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Extremely high sensitivity surface contamination monitor for alpha and beta-gamma radiation; ideal for nuclear medicine, waste monitoring and clearance applications.

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- **Berthold Technologies Instruments**
- **Arrow Tech, Dosimeter Corp and Rados Instruments**
- **Custom instrumentation software**
- **Scientific & radiation instrument repair service**

Submission Procedures

Authors submitting manuscripts for consideration are asked to follow these guidelines.

1. Submit manuscripts (in English or French) electronically as attachments (in Microsoft Word®).
2. Include the title of the paper, author(s) name(s) and affiliation(s), and email address to which correspondence should be sent.
3. Include an abstract of no more than 200 words and a biographical note of not more than 50 words for the author and any co-authors.
4. Submission of a manuscript implies that it is not being considered for publication elsewhere. Once accepted for publication in the *Bulletin*, consent from the editor must be obtained before a manuscript, or any part of it, may be published elsewhere in the same form.
5. Authors are invited to submit manuscripts at any time during the year to

   Editor (c/o CRPA Secretariat)

   ph: 613-253-3779
   email: secretariat2007@crpa-acrp.ca

Deadlines

Materials must be received by the editor no later than the following dates:

Number 1 .... December 1
Number 2 .... March 1
Number 3 .... June 1
Number 4 .... September 1

Advertising

While advertisements are sought after and accepted to offset the production costs of the *Bulletin*, the newsletter is published primarily for, and on behalf of, CRPA / ACRP members. Therefore inclusion of advertisements is entirely at the discretion of the association. CRPA / ACRP reserves the right to reject, omit, or cancel any advertisements that are not in keeping with the professional nature of the *Bulletin* or in any other way inappropriate for our members.

Advertorials

Advertorials are a new advertising feature for the *Bulletin* and are available at the same rate as display advertising. If a client requires assistance with writing, editing, or production of their advertorial, these services can be negotiated with the production company responsible for producing the *Bulletin*. For more information, contact Michelle Boulton at michelle.com@shaw.ca.

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Message du rédacteur en chef / Editor's Note

de plus en plus à ne discuter qu'avec les membres présents. Il faudrait peut-être rétablir le dialogue candide et les échanges d'opinions qui caractérisaient jadis cette assemblée. En réponse à cette opinion éditoriale, certains me diront que je n'ai qu'à me représenter si je ne suis pas content! Toutefois, j'admets admirer le travail colossal accompli par ces membres élus.

Je m'en voudrais de passer sous silence le travail de Tatjana Neretlja et de Dave Niven qui ont métamorphosé la nouvelle page web de l'association, présentée à Halifax. La relève se porte très bien si l'on se fie à ces deux membres!

Parlant de relève, comme toujours dans ce *Bulletin*, nous vous présentons le gagnant du concours étudiant, Steven Bartolac, qui a rédigé le meilleur article scientifique. Les participants de la cuvée 2011–2012 étaient de calibre élevé et plusieurs d'entre eux se sont fait entendre à Halifax cette année. Vous pourrez lire également les rapports de Nick Sion et de Lois Sowden-Plunkett sur ce qu'ils ont vu et entendu au congrès IRPA 13 à Glasgow plus tôt cette année, de même que les articles de nos fidèles collaborateurs, Mike, Émelie et Chris.

Je vous écris ces lignes en pleine canicule, tandis que vous les lirez entre vos nombreuses tâches de la rentrée. J'adore ce décalage inévitable qui nous tient en alerte. Bonne lecture.

Stéphane
Rédacteur en chef, *Bulletin* de l'ACRP

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and candid exchanges of opinions that once characterized this meeting should perhaps be re-established. Of course, this is just my opinion, you understand, and if I'm not happy, I will have to run for election to the board again! Regardless, the tremendous work being done by the elected members must be recognized. I would be remiss to ignore the work of Tatjana Neretlja and Dave Niven on the metamorphosis of the new CRPA web page, which was unveiled in Halifax. Succession is doing very well, if we base our assessment on these two!

Speaking of succession, as always, we are presenting the winner of the student contest for the best scientific paper in this post-conference issue of the *Bulletin*—Steven Bartolac. The contestants this year were of high caliber and we heard many of them presenting in Halifax.

Also in this issue, you can read reports by Nick Sion and Lois Sowden-Plunkett on their experiences at IRPA 13 in Glasgow earlier this year. We also have our consistent contributors: Mike, Chris, and Émelie.

I am writing this during the dog-days of summer, you will read this between your many back to work tasks. I love this time lag that lives in these pages and keeps us alert. Happy Reading.

Stéphane
Editor-in-chief, CRPA *Bulletin*

Message du président / President's Message

Pour finir, nous devons former deux nouveaux comités. Le premier est un comité de recrutement qui, comme son nom l'indique, tentera activement de recruter de nouveaux membres et de créer une valeur ajoutée à l'adhésion, s'il le souhaite. Le second est un comité des finances qui aidera le trésorier à imaginer de nouvelles sources de revenus afin que nous puissions maintenir la cotisation au niveau actuel. Si vous voulez aider un de ces comités (ou même les deux), je vous prie d'envoyer un courriel au secrétariat (secretariat2007@crpa-acrp.ca).

Gary H. Kramer
Président, ACRP

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your membership. The second is a finance committee, which will assist the treasurer in developing new revenue streams so we can keep membership dues static. If you would like to help with either (or both) of these committees, please email the Secretariat (secretariat2007@crpa-acrp.ca).

Gary H. Kramer
President, CRPA

Coming Events / Événements à venir

- **31st International Congress on Application of Lasers & Electro-Optics (ICALEO)** September 23–27, 2012, Anaheim, CA. This is the conference where researchers and end-users meet to review state-of-the art laser materials processing and predict where the future will lead. ICALEO is devoted to the field of laser materials processing and is viewed as the premier source of technical information in the field. For more information, visit www.lia.org/conferences/icaleo/conference

- **24th Nuclear Simulation Symposium** October 14–16, 2012, Ottawa, ON. The Canadian Nuclear Society (CNS) will be hosting its 24th symposium in the nation's capital. Under the purview of the Nuclear Science and Engineering Division of CNS, the symposium will provide a forum for discussion and exchange of information, results, and views among scientists, engineers, and academics working in various fields of nuclear engineering. For more information, visit www.cns-snc.ca.

- **12th South Pacific Environmental Radioactivity Association Bi-annual Conference** October 16–19, 2012, Sydney, Australia Focus areas will include the release of radionuclides into the environment following the earthquake and tsunami in Japan; Environmental Radioactivity in the Atmosphere; NORM & TENORM, Radioecology, Radioactive Contaminant Transport, Isotopes in Water Resources, Instrumentation and Radiochemistry, Isotopes in Sedimentation and Erosion, Nuclear Forensics, Radioactivity Impact Assessment, Marine Radioecology & Radioactivity. For more information, visit www.ainse.edu.au/events2/conferences/spera_2012

- **2012 Council on Ionizing Radiation Measurements and Standards Annual Meeting—Confidence Through Measurement Traceability** Oct 22–25, 2012 Gaithersberg, MD. This conference will feature plenary speakers from academia, industry, and government discussing topics ranging from domestic and international traceability of radiation measurements and standards to confidence in metrics used to asses food irradiation, materials processing, homeland security, radiation protection, and medical devices and procedures. For more information, visit www.cirms.org/conferences/2012.

- **National Council on Radiation Protection (NCRP) 49th Annual Meeting—Radiation Dose and the Impacts on Exposed Populations** March 11–12, 2013, Bethesda, MD. This meeting will include discussions about both past and present exposed populations, including atomic-bomb survivors, medical patients/caregivers, public exposures from reactor accidents (Chernobyl, Fukushima), occupational exposures from industrial energy work, and veteran's exposures from nuclear testing. Presentations will include some of the leading subject matter experts in each area. For more information, visit www.ncrponline.org.

- **Health Physics Society 46th Midyear Topical Meeting** January 27–30, 2013, Scottsdale, AZ. For more information, visit http://hps.org/meetings.

- **IAEA International Conference on Effective Nuclear Regulatory Systems** April 8–12, 2013, Ottawa, ON. Nuclear safety and security regulators worldwide routinely undertake efforts to review issues that are important to the global nuclear regulatory community. This conference, hosted by CNSC, will evaluate and assess ways of further improving the effectiveness of regulatory systems for facilities and activities, taking into account lessons learned from the Fukushima Daiichi nuclear accident. For more information, visit www.iaea.org.

- **CRPA Annual Conference** May 26–30, 2013, Sherbrooke, QC. For more information, visit http://crpa-acrp.org/conference.

- **Conférence annuelle de l'ACRP** 26 au 30 mai 2013, Sherbrooke, QC. pour de plus amples informations, visitez http://crpa-acrp.org/conference/?lang=fr.

- **Health Physics Society 58th Annual Meeting** July 7–11, 2013, Madison, WI. For more information, visit http://hps.org/meetings.

- **2013 IEEE Nuclear & Space Radiation Effects Conference** July 08–12, 2013, San Francisco, CA. This conference offers a one-day "short course" and 3 1/2 days of technical sessions. For more information, visit www.nsrec.com.

Index to advertisers

CRPA-ACRP May 26 -30 Mai 2013 Sherbrooke
Radioprotection un monde d'interactions
Radiation Protection a world of interactions

2013 Conference

Your conference co-chairs, Manon Rouleau & Lamri Cheriet, invite you to join them for the 2013 CRPA conference "Radiation Protection: A World of Interactions" in Sherbrooke, QC, May 26–30, 2013.

Conférence 2012

Vos coprésidents de la conférence, Manon Rouleau & Lamri Cheriet, vous invitent à les rejoindre pour la conférence de 2013: «Radioprotection:un mode d'interactions» à Sherbrooke, QC, 26 au 30 mai 2013.

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Contributors / Collaborateurs

Steve Bartolac has a bachelor's degree in engineering physics from Queen's University and a master's degree in medical physics from the University of Toronto. Steve is completing his doctorate in medical physics, also at the University of Toronto, on the topic of fluence field modulated computed tomography. Steve's interest in this topic was inspired by it's potential for greatly reducing dose to patients during CT scans. In addition to winning CRPA's 2012 Anthony J. MacKay Student Paper Contest, Steve also received first place for his presentation at the Young Investigators Symposium at the 2012 American Association of Physicists in Medicine (AAPM) meeting in Charlotte, North Carolina.

Steve Bartolac détient un baccalauréat en génie physique de l'Université Queen et une maîtrise en physique médicale de l'Université de Toronto. Steve termine présentement son doctorat en physique médicale à l'Université de Toronto également, et celui-ci porte sur tomodensitométrie modulée par un champ de fluence. L'intérêt de Steve pour ce sujet a été inspiré par le potentiel de réduction significative de la dose administrée aux patients lors de tomodensitométries. En plus de remporter l'édition 2012 du concours d'écriture pour étudiants Anthony-J.-MacKay orchestré par l'ACRP, Steve s'est également hissé au premier rang pour sa présentation au Young Investigators Symposium lors de l'édition 2012 de la renconre de l'American Association of Physicists in Medicine (AAPM) à Charlotte, en Caroline du Nord.

Chris Clement, a certified health physicist, has worked in radiation safety since the 1980s, first on environmental restoration projects, then with the Canadian Nuclear Safety Commission (CNSC), where he was the director of radiation protection when he left in 2008. He is currently the scientific secretary of the International Commission on Radiological Protection (ICRP).

Chris Clement, expert de radiophysique médicale sanitaire agréé, travaille en radioprotection depuis les années 1980, d'abord dans des projets de restauration environnementale, puis avec la Commission canadienne de sûreté nucléaire, où il portait le chapeau de directeur de la radioprotection à son départ en 2008. Aujourd'hui, il occupe le poste de secrétaire scientifique de la Commission internationale de protection radiologique (CIPR).

Michael Grey is a senior analyst with Candesco Corporation in Toronto, Ontario, and past-president of CRPA.

Michael Grey est analyste principal chez Candesco Corporation de Toronto, Ontario, et ancien président de l'ACRP.

Dr. David Jaffray graduated from the University of Alberta with a BSc in physics and completed his PhD in medical biophysics at the University of Western Ontario. Internationally recognized for his leadership in the development of image-guided radiation therapy, Dr. Jaffray is a senior scientist with Princess Margaret Hospital's research arm, the Ontario Cancer Institute, as well as an associate professor in the Departments of Radiation Oncology and Medical Biophysics at the University of Toronto. He holds the Orey and Mary Fidani Family Chair in Radiation Physics at Princess Margaret Hospital. He has pioneered the development of Cone Beam CT and is the recipient of many research awards.

Docteur David Jaffray est diplômé de l'Université de l'Alberta (BSc en physique) et a obtenu un doctorat en biophysique médicale de l'Université de l'Ontario. Reconnu internationalement pour son leadership dans la création de la radiothérapie guidée par l'image, Dr Jaffray est un préposé principal à la recherche pour l'aile de la recherche de l'Hôpital Princess Margaret, l'Ontario Cancer Institute, et professeur agrégé aux départements de radiooncologie et de biophysique médicale de l'Université de Toronto. Il détient la chaire de la famille Orey et Mary Fidani en physique des rayonnements de l'Hôpital Princess Margaret. Il a été le pionnier de la création des tomodensitomètres Cone Beam et est le titulaire de plusieurs bourses de recherche.

Emélie Lamothe is a health physicist and member of CRPA. In her professional life, she has worked in the fields of research and development, dosimetry, quality assurance, health and safety, and emergency preparedness.

Emélie Lamothe est spécialiste de radioprotection et membre de l'ACRP. Au cours de sa carrière, elle a travaillé dans les domaines de la recherche et du développement, de la dosimétrie, de l'assurance qualité, de la santé et sécurité en milieu de travail et de la protection civile.

Lois Sowden-Plunkett has over 25 years of experience in the field of radiation safety. During that time she has actively participated in CRPA activities. Most recently, she was president of CRPA and is still a member of the board of directors. She is assistant director, in the Office of Risk Management at the University of Ottawa, where she oversees the development of numerous corporate programs, including both ionizing and non-ionizing radiation safety.

Lois Sowden-Plunkett possède plus de 25 ans d'expérience dans le domaine de la radioprotection. Au cours de cette période, elle a activement participé aux activités de l'ACRP. Plus récemment, elle a occupé le poste de présidente de l'ACRP et est toujours membre de son conseil d'administration. Elle est aussi directrice adjointe du Bureau de la gestion du risque de l'Université d'Ottawa où elle chapeaute le développement de nombreux programmes corporatifs, dont la radioprotection ionisante et non ionisante.

Nicholas Sion is a graduate of London University, United Kingdom, and did his postgraduate studies at Birmingham University, United Kingdom. He was employed at Ontario Power Generation (OPG) for about 28 years designing radiation monitoring instrumentation and reactor control. His discriminating tritium monitor, stack monitor, and C-14 monitor designs are operational at OPG and at Bruce Power. Sion was also a consultant at Atomic Energy of Canada Limited (AECL) for two and a half years on the MDS Nordion Medical Isotope Reactor (MMIR), MAPLE project.

Nicholas Sion est diplômé de l'Université de Londres, au Royaume-Uni, et a terminé ses études supérieures à l'Université de Birmingham, au Royaume-Uni. Il a œuvré auprès de Ontario Power Generation (OPG) pendant environ 28 ans dans la conception d'instruments de surveillance des rayonnements et dans le contrôle de réacteurs. Ses conceptions discriminantes d'appareils de surveillance du tritium, de surveillance de faisceau, de surveillance du C-14 sont à l'oeuvre chez l'OPG et chez Bruce Power. Sion a aussi joué le rôle de conseiller auprès de Énergie atomique du Canada limitée (EACL) pendant deux ans et demie sur le projet MAPLE de MDS Nordion destiné à la production d'isotopes à des fins médicales (MMIR).

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