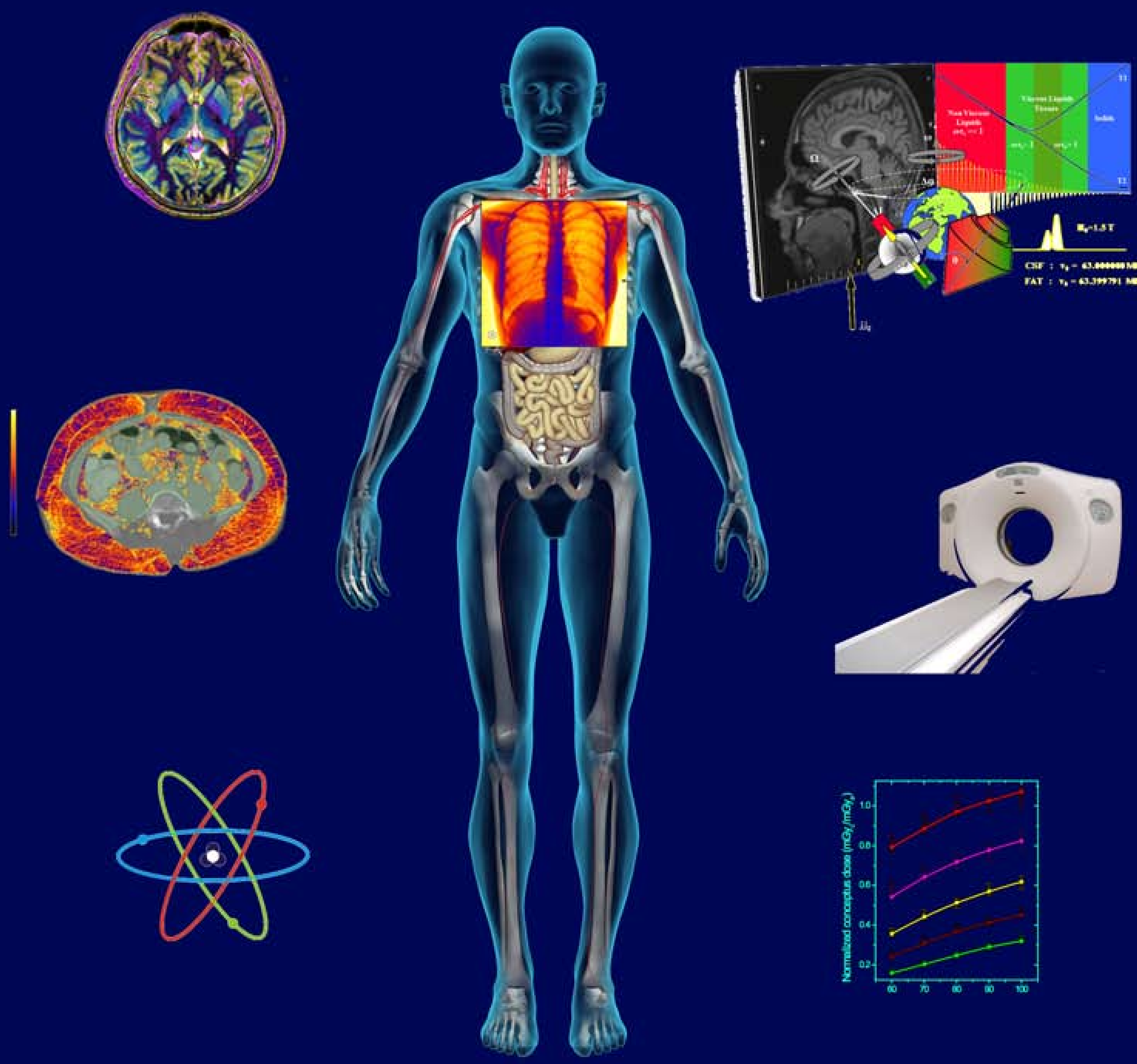
MEDICAL PHYSICS
International

The Journal of the International Organization for Medical Physics

Volume 2, Number 2, November 2014

MPI



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MEDICAL PHYSICS INTERNATIONAL

THE JOURNAL OF

THE INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS

International Organization for Medical Physics

Volume 2, Number 1, March 2013

MEDICAL PHYSICS INTERNATIONAL

The Journal of the International Organization for Medical Physics

Aims and Coverage:
Medical Physics International (MPI) is the official IOMP journal. The journal provides a new platform for medical physicists to share their experience, ideas and new information generated from their work of scientific, educational and professional nature. The e- journal is available free of charge to IOMP members.

MPI web address: www.mpijournal.org

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EDITORIAL
The Spectrum Of Medical Physics Publications

Perry Sprawls, Co-Editor

The various medical physics and related clinical journals provide the network that connects the medical physics profession around the world. This provides for the sharing of information that enhances and enriches the practice of medical physics in all countries. Just as there are many areas of work in medical physics, including research, teaching, clinical applications, radiation safety, etc. there are journals that give emphasis to these various topics. Generally, the various journals have different readers, depending on their interests and access to the publications. This should be considered by authors of manuscripts so that they can reach the greatest number of physicists and other medical professionals who will benefit from their work.

A distinguishing feature of this journal, Medical Physics International, is that it does not publish research papers that would go through a normal peer review process. We recommend and collaborate with the other journals that provide these publishing opportunities. In each edition we publish an article with details on these individual journals. In this edition we are pleased to publish an article by the editors of Physica Medica: European Journal of Medical Physics (EJMP) describing the scope of topics covered the history of their development and growth, and accessibility of the journal to readers.

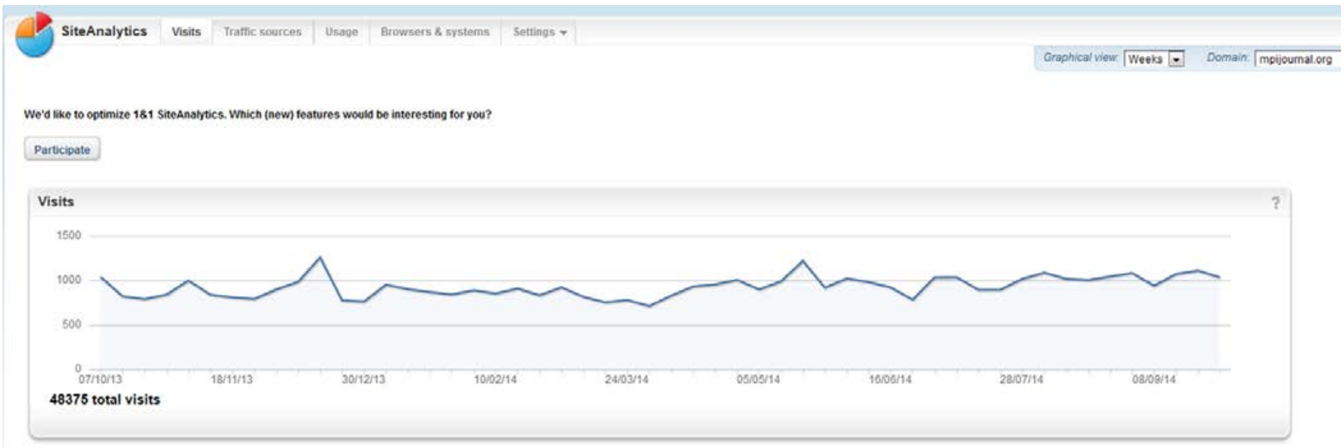
EDITORIAL
IOMP support for the developing countries

Slavik Tabakov, Co-Editor

Two years after IOMP initiated the Medical Physics International Journal, it has reached a large audience from all IOMP member societies and has a steady number of readers (about 1000 per week). A significant percentage of colleagues from the developing countries are following the MPI Journal as a source of information about various educational, professional and scientific issues. The Editorial Board of the Journal was updated recently with the Chairs of the IOMP ETC and IOMP PRC Committees to strengthen this trend. Also, the Journal now started links with other Medical Physics Journals, aiming to bring more content to our readers and in particular to supply information to colleagues from less affluent Societies.

A major part of IOMP activities is related to helping the professional development in such Societies and countries. The recent IOMP project aiming to help medical physics in Africa gets increasing support. Recently IOMP supported the inclusion of more African colleagues (proposed by FAMPO) in the ICTP College on Medical Physics 2014, and also supported the two new activities of ICTP – the MSc in Medical Physics and the School of Radiotherapy. IOMP also seeks collaboration with other large member/sister societies as IPEM, AAPM, IFMBE, IRPA in order to inform medical physicists from the continent about possible education/ training/ professional activities organized by these. We plan the MPI Journal to provide our readers with information about these activities.

Another important step supporting education and training of our member Societies is related to the planned move of the Emitel Encyclopaedia (www.emitel2.eu) and related e-learning materials EMERALD and EMIT under the IOMP. These large educational web sites are now major references for the profession. Their regular update will be carried by a specific IOMP Work Group, which is being created at the moment. Colleagues who want to contribute content to these reference web sites are welcome to submit information to us.



COLLABORATING JOURNALS

PHYSICA MEDICA: A LONG HISTORY OF SERVICE FOR THE INTERNATIONAL MEDICAL PHYSICS COMMUNITY

Alberto Del Guerra[1] and Paolo Russo[2]

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[2]Università di Napoli Federico II, Dipartimento di Fisica, Napoli, Italy

Abstract – A short materials from the European Journal of Medical Physics (Physica Medica) – the journal in service of the Medical Physics community

Keywords – Physica Medica, International, European journal, EJMP

Physica Medica: European Journal of Medical Physics (EJMP) is an international scientific journal covering scientific, educational and professional aspects of Medical Physics. It is published by Elsevier B.V. for the European Federation of Organisations for Medical Physics (EFOMP) and Associazione Italiana di Fisica Medica (AIFM) and is the official journal of EFOMP, AIFM, the Irish Association of Physicists in Medicine and Société Française de Physique Médicale.

EJMP publishes research manuscripts and reviews in specific fields including Medical Imaging, Radiation Therapy, Radiation Protection, Measuring Systems and Signal Processing, Education and Training and Professional issues in Medical Physics. Publications on applications of Physics to Biology and Medicine cover such fields as Molecular Imaging, Hadron Therapy, System Biology, Nanoparticles and Nanotechnologies. Papers in the field of Small Animal Imaging, Radiobiology, Synchrotron Radiation diagnosis and therapy, Computer Analysis of Medical Images are also encouraged.

EJMP is a fully international journal, with an international Editorial Board including 24 scientists from 14 countries of 4 continents, and 12 Associate Editors. Alberto Del Guerra (Italy) is the Honorary Editor, Fridtjof Nuesslin (Germany) is the past (2008-2012) Editor and Paolo Russo (Italy) is the Editor-in-Chief since 2013.

EJMP is currently publishing Volume 30. The original journal, "Fisica Medica" was first published in 1978 as the scientific journal of the Associazione Italiana di Fisica Medica (at that time Associazione Italiana di Fisica Biomedica) with papers in the Italian language only. In 1985 the name was changed to "*Physica Medica*" and published in English language only. At that time it became an international journal with Alberto Del Guerra (Italy) as Editor-in-Chief.

Beginning in 2007 EJMP was published by Elsevier B.V. with one issue per quarter. In 2013 six issues were published and eight issues will be published in 2014. This reflects the great increase in the number of submissions and accepted papers. A major factor contributing to this growth has been the efforts of EFOMP, AIFM and affiliated Societies responding to the increasing needs of a growing international community of medical physicists for a large, authoritative forum for scientific and professional issues in the field. EJMP serves an international community: in the last five years, 61% of all corresponding authors were from outside Europe. EJMP encourages the affiliation and the support of national societies of Medical Physics in Europe.

For 2013, the key figures of the journal are the following: the EJMP Impact Factor: 1.849, 5-year Impact Factor: 1.712, Source Normalized Impact per Paper (SNIP): 0.998, SCImago Journal Rank (SJR): 0.668. The average number of weeks it takes for an article in EJMP from submission to first decision is 6.8 weeks, and from submission to final decision is 12.3 weeks. EJMP is ranked 51 out of 121 journals in the category of Radiology.

The journal is published both in printed form and online at the website (http://www.physicamedica.com) where all volumes from volume 21 can be accessed. Via the HINARI Access to Research in Health Programme, *Physica Medica* is freely available to local, not-for-profit institutions in developing countries.

Physica Medica has no page charges; The journal offers authors a choice of publishing their research on a subscription basis or open access. We are pleased to be a collaborating journal with *Medical Physics International* and readers are warmly encouraged to consider publishing their best research papers in EJMP!

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A NEW MILESTONE IN THE DEVELOPMENT OF THE MEDICAL PHYSICS PROFESSION: THE EFOMP POLICY STATEMENT ON MEDICAL PHYSICS EDUCATION AND TRAINING IN EUROPE 2014

Caruana, C.J.

Past-Chair, Education and Training Committee, EFOMP.
EFOMP Lead for Education and Training and Role Development, 'European Guidelines on the Medical Physics Expert' Project.
Head, Medical Physics Department, Faculty of Health Sciences, University of Malta.

The European Federation of Organizations for Medical Physics (EFOMP) has just published an updated policy statement on Education and Training, the "European Federation of Organizations for Medical Physics (EFOMP) Policy Statement 12.1: Recommendations on Medical Physics Education and Training in Europe 2014". In 2010, EFOMP had issued Policy Statement No. 12: "The present status of Medical Physics Education and Training in Europe. New perspectives and EFOMP recommendations". At the same time, new recommendations regarding qualifications frameworks were published by the European Parliament and Council which introduced a new European qualifications framework - the European Qualifications Framework (EQF) for lifelong learning. Moreover, a new European all-encompassing directive involving the use of ionizing radiations (including medical) was being developed. The latter has now been realized as Council Directive 2013/59/Euratom of 5 December 2013 and has superseded all previous directives concerning ionizing radiation. A European Commission financed project "Guidelines on the Medical Physics Expert (MPE)" (henceforth referred to as the 'Guidelines') was subsequently published which took into consideration these developments. The Guidelines are very comprehensive and include a mission statement, key activities and qualification framework for the MPE and curricula in the specialty areas of Medical Physics relating to radiological devices and protection from ionizing radiation, namely Diagnostic and Interventional Radiology, Radiation Oncology and Nuclear Medicine. These developments necessitated a revision of PS12 and Policy Statement 12.1 provides the necessary update. The new policy statement departs from previous formats as it is more strategic with respect to role development and provides an intimate link between the professional role of the Medical Physicist / Medical Physics Expert and education and training policy.

The main elements of the Guidelines with a direct impact on the present EFOMP policy statement are the mission statement, key activities, qualification framework and curriculum framework. The new policy statement incorporates these four elements and generalizes them to make them applicable to *all* specialties of Medical Physics, that is to not only those specialties of Medical Physics involving radiological medical devices and ionizing radiation (addressed in the Guidelines) but also to those specialties involving non-radiological medical devices (such as physiological measurement, neurology, audiology) and protection from other physical agents (such as electromagnetic static and RF fields, ultrasound, optical radiation, vibration). In those states where the scope of the roles of the Medical Physicist (MP) and Medical Physics Expert (MPE) are presently delimited to radiological medical devices and ionizing radiation, the policy statement may if so desired may be amended simply by replacing 'medical devices' with 'radiological medical devices' and 'physical agents' by 'ionising radiations'.

The new mission statement for medical physicists and medical physics experts is as follows: "Medical Physicists and Medical Physics Experts will contribute to maintaining and improving the quality, safety and cost-effectiveness of healthcare services through patient-oriented activities requiring expert action, involvement or advice regarding the specification, selection, acceptance testing, commissioning, quality assurance/control and optimized clinical use of medical devices and regarding patient risks from associated physical agents including protection from such physical agents, installation design and surveillance, and the prevention of unintended or accidental exposures to physical agents; all activities will be based on current best evidence or own scientific research when the available evidence is not sufficient. The scope includes risks to volunteers in biomedical research and carers and comforters". The purpose for the formulation of this mission statement is to make the role of the MP and MPE more understandable to policy makers and the management of healthcare organizations.

This mission is expressed in many aspects of medical physics practice and the following key activities of the Medical Physicist have been identified and defined in the policy statement: scientific problem solving service, dosimetry measurements (*all* physical agents e.g., effective dose in ionising radiation, SAR in MRI, thermal and mechanical indices in ultrasound), patient safety / risk management (including volunteers in biomedical research, carers, comforters and persons subjected to non-medical procedures using medical devices), occupational and public safety / risk management when there is an impact on medical exposure or own safety, clinical medical device management, clinical involvement, development of service quality and cost-effectiveness, expert consultancy, education of healthcare professionals (including medical physics trainees), health technology assessment (HTA) and innovation.

The development of the qualification framework for the MP and MPE was guided by the following principles:

1. All qualification frameworks in Europe should be referred to the EQF. *Henceforth the MPE is defined as a clinically qualified MP who has reached the highest EQF level (level 8) in his/her own specialty of clinical Medical Physics* (e.g., Diagnostic and Interventional Radiology, Radiation Oncology, Nuclear Medicine, Physiological Measurement, Neurology, Audiology).
2. The qualification framework would make it possible for more individuals to achieve clinically qualified MP and MPE status through its flexibility, cost-effectiveness and lifelong learning approach.
3. The qualification framework would facilitate the mobility of the clinically qualified MP and MPE in Europe through an agreed set of minimum criteria for achievement of such status.
4. Owing to the rapid expansion of medical device technology and physical agent research publication, it is becoming increasingly difficult for a MP and MPE to become competent in more than one specialty of medical physics; therefore, early specialization has become a necessity and the MP and MPE should be independently recognised in each specialty of medical physics.

Explanatory notes to the qualification framework plus associated rationales are presented.

The curriculum framework is based on the concept of learning outcomes expressed in terms of knowledge, skills and competence (KSC) as specified and defined in the EQF. The curriculum framework was designed with a core medical physics KSC and specialty KSC structure. By emphasizing areas of commonality in the various specialties within the core KSC the framework makes it easier for MP and MPE in different specialties to cooperate in the interest of the patient and also makes it possible to avoid undue fragmentation of the profession. The new curriculum framework is expressed as a structured inventory of required KSC underpinning the above key activities of the MP and MPE. In addition, the KSC are classified in two categories, Generic and Subject Specific skills as specified in the documents of the European Higher Education Area:

1. *Generic skills* consist of transferable skills which are expected of all professionals at a particular level of the EQF.

2. *Subject specific* KSC are specific to a profession. These are further classified into sub-categories as determined by the particular profession. In the case of Medical Physics the sub-categories are:

   Medical Physics core KSC: these KSC are expected of all MP/MPEs irrespective of their specialty:
   - KSC for the MP/MPE as physical scientist: these are fundamental physics KSC expected of all physical scientists
   - KSC for the MP/MPE as healthcare professional: these are KSC expected of all healthcare professionals
   - KSC for the MP/MPE as expert in the clinical use of medical devices and protection from associated physical agents: these represent medical device and safety KSC required by all specialties of medical physics.

   Medical Physics Specialty KSC: these KSC are highly specific to each specialty of medical physics

A candidate seeking recognition as an MP and MPE in a given specialty of medical physics should reach the corresponding level (level 7+ of the EQF if a Medical Physicist and level 8 of the EQF if Medical Physics Expert) in the core KSC of medical physics and the KSC specific to that particular specialty.

The full policy statement can be found in Physica Medica – the European Journal of Medical Physics (Elsevier) which is the official journal of the European Federation of Organizations for Medical Physics (EFOMP). It can be downloaded freely from the following link: http://www.physicamedica.com/article/S1120-1797%2814%2900103-3/fulltext

EDUCATIONAL RESOURCES

IOMP COLLABORATION WITH CRC PRESS / TAYLOR & FRANCIS

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[6]BME/UW-Madison, Madison, WI 53706-1609 USA

I. INTRODUCTION

The International Organization for Medical Physics (IOMP) has a longstanding collaboration with the publishing company CRC Press / Taylor & Francis. This has been subject to several official agreements and has been mainly related to the book series entitled the *Series in Medical Physics and Biomedical Engineering*. Based on these agreements the series has been adopted as the official book series of the IOMP and a brief description of the role of the IOMP appears in every book in the series. The IOMP (Publications Committee) and its sister organisation IFMBE (International Federation for Medical and Biological Engineering) nominate joint Editors for the series.

The series aims to describe the applications of physical sciences, engineering and mathematics in medicine and clinical research and to meet the need for up-to-date texts in this rapidly developing field of science. Books in the series range in level from upper-level undergraduate and graduate textbooks to practical handbooks and advanced expositions of current research. The authors are leading experts in the field, often recommended by the IOMP and IFMBE.

The book series was initiated in 1985 with *Fundamentals of Radiation Dosimetry, Second Edition* by J G Greening and the next books appeared in 1991 (*Prevention of Pressure Sores: Engineering and Clinical Aspects*, Webster J G) and in 1993 (*The Physics of Three Dimensional Radiation Therapy: Conformal Radiotherapy, Radiosurgery and Treatment Planning*, Webb S). The latter already used the distinctive red colouring on its cover. The series intensified after 1997, when three books were published. The Series Editors at that time were R F Mould (UK), C G Orton (USA), J A E Spaan (The Netherlands) and J G Webster (USA).

45 books in various fields of the profession have been published since the beginning of the collaboration between IOMP and CRC Press / Taylor & Francis. In about 30 years the *Series in Medical Physics and Biomedical Engineering* has established itself as a leading international book series in the field. Four of the world's leading academics in the field – Kwan-Hoong Ng, Russell Ritenour, Slavik Tabakov and John G. Webster – serve as current Series Editors, curating the series and carefully selecting the highest quality publications for inclusion. The current Commissioning Editor from CRC Press is Francesca McGowan.

Recent and forthcoming publications in the Series include: Muftuler, *Quantifying Morphology and Physiology of the Human Body Using MRI*; Kuiken, *Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs*; Willson et al., *Medical Equipment Management*; Webster, *The Physiological Measurement Handbook*; and Lehnert, *Radiosensitizers and Radiochemotherapy in the Treatment of Cancer*. A full listing of books in the series can be found at http://www.crcpress.com/browse/series/chmephbioeng.

The books are priced in such a way as to make them affordable to as many medical physicists and biomedical engineers worldwide as possible (both professionals and students). In addition, all books in the series are available at a 25% discount to members of the IOMP. As a member of the IOMP, simply enter code DZM10 when ordering at www.crcpress.com to save 25%.

We warmly welcome new book proposals, or suggestions of valuable books, for the series. Colleagues who are interested in writing or editing a book for the series should contact Francesca McGowan, Editor for Physics books (francesca.mcgowan@tandf.co.uk) or write to any of the Series Editors. The proposal guidelines can be accessed at http://www.crcpress.com/resources/authors.

II. BOOKS AND HYPERLINKS

Books resulting from the collaboration between IOMP and CRC Press / Taylor & Francis:

-*Statistical Computing in Nuclear Imaging*
2014, Arkadiusz Sitek

-*Radiosensitizers and Radiochemotherapy in the Treatment of Cancer* 2014, Shirley Lehnert

-*The Physiological Measurement Handbook*
2014, Editor: John G. Webster

-*Diagnostic Endoscopy*
2013, Editor: Haishan Zeng

-*Medical Equipment Management*
2013, Keith Willson, Keith Ison, Slavik Tabakov

-*Targeted Muscle Reinnervation: A Neural Interface for Artificial Limbs*
2013, Editors: Todd A. Kuiken, Aimee E. Schultz Feuser, Ann K. Barlow

-*Quantifying Morphology and Physiology of the Human Body Using MRI*
2013, Editor: L. Tugan Muftuler

-*Encyclopaedia of Medical Physics*
2012, Editors: Slavik Tabakov, Franco Milano, Sven-Erik Strand, Cornelius Lewis, Perry Sprawls

-*Monte Carlo Calculations in Nuclear Medicine, Second Edition: Applications in Diagnostic Imaging*
2012, Editors: Michael Ljungberg, Sven-Erik Strand, Michael A. King

-*Vibrational Spectroscopy for Tissue Analysis*
2012, Ihtesham ur Rehman, Zanyar Movasaghi, Shazza Rehman

-*Webb's Physics of Medical Imaging, Second Edition*
2012, Editor: M A Flower

-*Correction Techniques in Emission Tomography*
2012, Editors: Mohammad Dawood, Xiaoyi Jiang, Klaus Schäfers

-*Physiology, Biophysics, and Biomedical Engineering*
2012, Editor: Andrew W Wood

-*Proton Therapy Physics*
2011, Editor: Harald Paganetti

-*Stem Cell Labeling for Delivery and Tracking Using Noninvasive Imaging*
2011, Editors: Dara L. Kraitchman, Joseph C. Wu

-*Practical Biomedical Signal Analysis Using MATLAB®*
2011, Katarzyn J. Blinowska, Jaroslaw Zygierewicz

-*Physics for Diagnostic Radiology, Third Edition*
2011, Philip Palin Dendy, Brian Heaton

-*Nuclear Medicine Physics*
2010, Editors: Joao Jose De Lima

-*Handbook of Photonics for Biomedical Science*
2010, Editor: Valery V. Tuchin

-*Handbook of Anatomical Models for Radiation Dosimetry*
2009, Editors: Xie George Xu, Keith F. Eckerman

-*Handbook of Optical Sensing of Glucose in Biological Fluids and Tissues*
2008, Editor: Valery V. Tuchin

-*Fundamentals of MRI: An Interactive Learning Approach*
2008, Elizabeth Berry, Andrew J. Bulpitt

-*Intelligent and Adaptive Systems in Medicine*
2008, Editors: Olivier C. L. Haas, Keith J. Burnham

-*An Introduction to Radiation Protection in Medicine*
2008, Editors: Jamie V. Trapp, Tomas Kron

-*A Practical Approach to Medical Image Processing*
-2007, Elizabeth Berry

Biomolecular Action of Ionizing Radiation
-2007, Shirley Lehnert

-*An Introduction to Rehabilitation Engineering*
2006, Editors: Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson

-*The Physics of Modern Brachytherapy for Oncology*
2006, Dimos Baltas, Loukas Sakelliou, Nikolaos Zamboglou

-*Electrical Impedance Tomography: Methods, History and Applications*

2004, Editor: David S. Holder

-*Contemporary IMRT: Developing Physics and Clinical Implementation*
2004, S. Webb

-*The Physical Measurement of Bone*
2003, Editors: C.M. Langton, C.F. Njeh

-*Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine*
2002, Editors: H. Zaidi, G Sgouros

-*Minimally Invasive Medical Technology*
2001, Editor: John G. Webster

-*Intensity-Modulated Radiation Therapy*
2001, S. Webb

-*Physics for Diagnostic Radiology, Third Edition*
1999, Philip Palin Dendy, Brian Heaton

-*Achieving Quality in Brachytherapy*
1999, B.R. Thomadsen

-*Ultrasound in Medicine*
1998, Editors: Francis A. Duck, A.C Baker, H.C Starritt

-*Medical Physics and Biomedical Engineering*
1998, B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose

-*Design of Pulse Oximeters*
1997, Editor: John G. Webster
-*Linear Accelerators for Radiation Therapy, Second Edition*
1997, David Greene, P.C Williams

-*The Physics of Conformal Radiotherapy: Advances in Technology*
1997, S. Webb

-*Rehabilitation Engineering Applied to Mobility and Manipulation*
1995, Rory A Cooper

-*The Physics of Three Dimensional Radiation Therapy: Conformal Radiotherapy, Radiosurgery and Treatment Planning*
1993, S. Webb

-*Prevention of Pressure Sores: Engineering and Clinical Aspects*
1991, J.G Webster

-*Fundamentals of Radiation Dosimetry, Second Edition*
1985, J.R Greening

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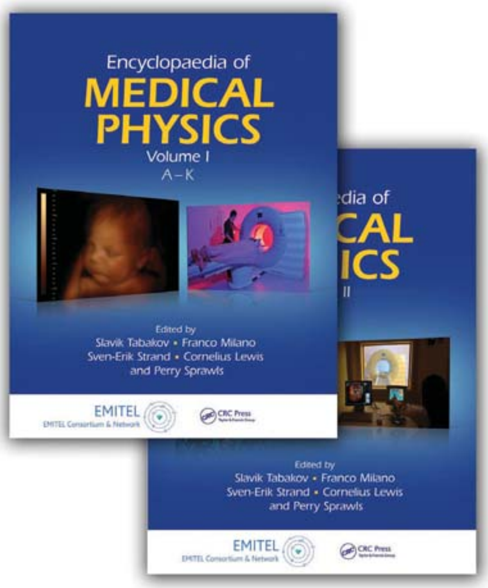
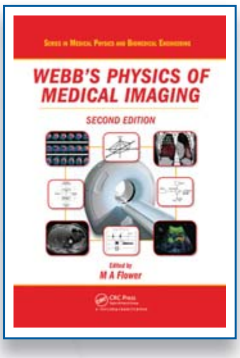


Encyclopaedia of Medical Physics

Edited by Slavik Tabakov, Franco Milano, Sven-Erik Strand, Cornelius Lewis, and Perry Sprawls

Co-published by the EMITEL consortium and supported by the IOMP, this all-encompassing reference contains nearly 2,800 cross-referenced entries relating to medical physics and associated technologies. Featuring over 100 contributors who are specialists in their respective areas, the encyclopaedia describes new and existing methods and equipment in medical physics. It covers x-ray diagnostic radiology, MRI, nuclear medicine, radiation protection, radiotherapy, and ultrasound imaging. Most articles include references, further reading, images, graphs, formulas, and examples.

December 2012 | $719.00 / £458.00 | 908pp
Catalog no: K12085 | ISBN: 978-1-4398-4652-0



Webb's Physics of Medical Imaging, Second Edition

Edited by M.A. Flower

Since the publication of the best-selling first edition, the technology and clinical applications of medical imaging have changed significantly. Gathering these developments into one volume, this comprehensive second edition presents the basic physics, modern technology, and up-to-date examples of clinical application across all the modalities of medical imaging.

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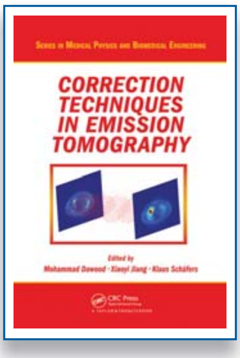
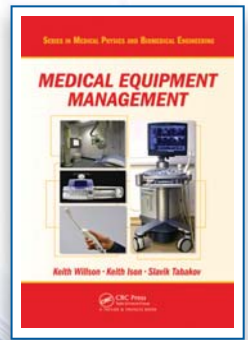


Correction Techniques in Emission Tomography

Edited by Mohammad Dawood, Xiaoyi Jiang, and Klaus Schäfers

Written by an interdisciplinary team of medical doctors, computer scientists, physicists, engineers, and mathematicians, this volume presents various correction methods used in emission tomography to generate and enhance images.

April 2012 | $119.95 / £76.99 | 287pp
Catalog no: K10659 | ISBN: 978-1-4398-1298-3



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Medical Equipment Management

Keith Willson, Keith Ison, and Slavik Tabakov

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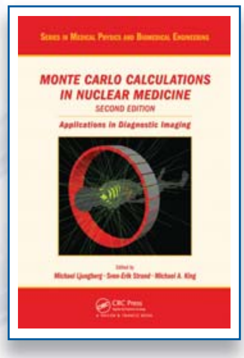

Monte Carlo Calculations in Nuclear Medicine, Second Edition

Applications in Diagnostic Imaging

Edited by Michael Ljungberg, Sven-Erik Strand, and Michael A. King

A guide for researchers and students developing methods to improve image resolution, this book also demonstrates how Monte Carlo techniques can be used to simulate complex imaging systems. New chapters in this edition cover codes and applications in pre-clinical PET and SPECT.

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i.TREATSAFELY.ORG: AN OPEN ACCESS TOOL FOR PEER-TO-PEER TRAINING AND EDUCATION IN RADIOTHERAPY

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Abstract—**Limitations of current training and education delivery models result in suboptimal clinical proficiency with equipment, procedures, and techniques. Educational and training opportunities offered by vendors and professional societies are by their nature not available at point of need or for the life of clinical systems. The objective of this work is to leverage modern communications technology to provide peer-to-peer training and education for radiotherapy professionals, in the clinic and on demand, as they undertake their clinical duties. We have developed an open access web site (https://i.treatsafely.org) using Google App Engine and datastore (NDB, GQL), Python with AJAX-RPC, and Javascript. The site is a radiotherapy-specific hosting service to which user-created videos illustrating clinical or physics processes and other relevant educational material can be uploaded. Efficient navigation to the material of interest is provided through several radiotherapy-specific search tools. Videos can be rated by users, thus providing comprehensive peer review of the site content. The site also supports multilingual narration\translation of videos, a quiz function for competence assessment and a library function allowing groups or institutions to define their standard operating procedures based on the video content. The website was launched in August 2013 and has over 890 registered users from 50 countries as of August 29, 2014; 30.2% from the United States, 9.2% from India, 8.6% from the United Kingdom, 7.3% from Brazil, and 44.7% from other countries. The users include physicists (56.1%), oncologists (10.6%), therapists (9.7%) and dosimetrists (4.9%). There are over 75 videos on the site to date with narrations in languages including English, Spanish, French, Portuguese, Mandarin, and Thai. Based on the initial acceptance of the site, we conclude that this open access web-based peer-to-peer tool is fulfilling an important need in radiotherapy training and education. Site functionality will expand in the future to include document sharing and continuing education credits.**

Keywords—**Web-based, Learning, Standardization, Education, Peer-to-peer.**

I. INTRODUCTION

Radiotherapy is a technology-driven specialty with many complicated steps which, in spite of our best efforts, are prone to errors with potentially disastrous consequences for the patient [1]. Inevitably, in the complex and rapidly changing clinical environment of radiotherapy, there are gaps remaining in our understanding and proficiency in what is technologically possible and clinically realized. This is true for both basic and advanced users.

Filling these gaps is challenging because equipment and procedures are diverse and constantly changing. There are always new users. These include internal users such as rotating a therapist from the treatment machine to the CT simulator, and external users such when a new employee is hired. There are also limits to the training provided by vendors and professional societies. Professional societies' training is typically delivered at meetings and vendor training is restricted to how to use the equipment, not advice about appropriate clinical procedures or how to treat a patient. Furthermore, it is noteworthy that 3 of the 5 most downloaded papers from the International Journal of Radiation Oncology • Biology • Physics in 2012 (i.e., the Red Journal; a major *research* journal for radiotherapy) [2] were specifically related to education and training [3, 4, 5]. Those papers essentially described how to perform critical clinical processes. In other words, if the reader followed those papers, then they would increase their competence in the procedure of interest. Competence (defined as the application of knowledge, skill and attitude to the task at hand) is increasingly recognized as an essential attribute of healthcare practitioners. The purpose of a research journal should not, of course, be training and education. However, in the absence of suitable alternative vehicles this is a role that many journals have accepted.

The overall aim of education, training and competence development for health care professionals is to provide the patient with safe, high quality medical care. It is also recognized that safety and quality are both enhanced through standardization of procedures. High reliability industries, such as the airline industry, employ very standardized procedures. For example, a typical commercial flight in North America requires no fewer than 9 checklists to be completed. Similarly in healthcare, the adoption of standard operating procedures is recognized by the National Patient Safety Foundation (www.npsf.org) Hierarchy of Actions as a Strong Action for patient safety. There are indications that standardization of practice can also lead to quality and safety improvement for radiotherapy [6]. To facilitate education and training that lead to standardization in radiotherapy, we have developed a peer-to-peer education and training web site, which is described below.

II. MATERIALS AND METHODS

The i.treatsafely.org site is a web-based software tool designed to deliver effective peer-to-peer education and training in radiotherapy, on demand, and at the point of need. The software system leverages newer learning models (e.g., Khan Academy) in an easy to use delivery method (YouTube–like) to facilitate peer-to-peer communication and educational collaborations. The peer-to-peer aspect means that video and document content is created and uploaded to the site by users and users can comment on the site content.

Technical Aspects

The site was created using Google App Engine and Google datastore (NDB, GQL). This environment allows for flexible expansion of content and site usage management. The web site was created using the Python programming language with AJAX-RPC and Javascript calls to the datastore. An advantage of the Google App Engine is that it leverages Google's server infrastructure so that the site can handle rapid increases in either short- or long-term usage in a cost effective way.

Content Management

Content in the form of videos and documents is supplied by actual clinicians. The site has a feature where clinicians can upload their content. Once uploaded, the content is vetted by domain experts to qualify the submitted content for inclusion in the site. The domain experts are looking for any factually incorrect statements and inappropriate practice guidance recommendations. They are not filtering for presentation style or visual quality of the videos or documents. Any questionable material is sent back to the content creator to respond and modify if it is deemed necessary.

There are two other mechanisms for site content to be vetted. One is that users can rate the content after they have watched a video or read a document. Another way is that each video and document has an icon associated with it. When used, the icon will launch a dialogue box for the user to note a suspected inaccuracy in the video or document and will also send an anonymous email to the site moderators who will then follow up on the notification. Three separate actions will be the result of the investigation: 1) the video or document will be removed from the site, 2) the content creator will modify the content to alleviate the inaccuracy, or 3) the video or document will remain unedited – if determined to be factually correct.

Peer-to-Peer Education and Training

Videos can be "pushed" to other colleagues and staff members. Enhancement of competence, at the user's pace and in the real clinical environment, is one unique feature of this tool. Each video can be associated with a quiz to test the user's understanding of the material. Comments can be left by the user about the video they just watched and those comments go directly to the video creator so the creator can respond if desired or necessary.

Several videos can also be combined to create a comprehensive learning module. This is useful as the videos tend to be short, specific learning experiences. Combining several videos into a learning module then allows the user to create a full educational session, for example, as a 'continuing medical education' lecture for credit.

Standardization and Competence Development

If they chose, groups and institutions can also adopt a subset of the hosted videos to define their approved standardized clinic practice. Such a video library, which could constitute the institution's standard operating procedures, is only available to the institution via the user's email domain. The library can then be used to standardize procedures within the clinic or across clinics for larger organizations thus enhancing quality, safety and efficiency. In the future, content could then be pushed to staff members for the purpose of ensuring competency training. The system facilitates true competence development as the videos constitute a knowledge base and repeated performance of a task under the "guidance" of a video module steadily enhances skill.

Equipment life can span decades but vendor training is usually only provided for the latest version of equipment. The i.treatsafely system provides a repository for training material that will be available for the lifetime of equipment.

III. RESULTS AND DISCUSSION

The site is 100% free for general use and can be accessed from https://i.treatsafely.org. In order to access and contribute content, users are asked to create an account and to verify their account by responding to a validation email.

The site has over 890 registered users from 50 countries (as of August 2014); 30.2% from the United States, 9.2% from India, 8.6% from the United Kingdom, 7.3% from Brazil, and 44.7% from other countries. The users include physicists (56.1%), oncologists (10.6%), therapists (9.7%) and dosimetrists (4.9%). There are over 75 videos on the site to date with narrations in languages including English, Spanish, French, Portuguese, Mandarin, and Thai. There are over 2700 unique views of the videos on the site. A unique view occurs when a user watches any video for the first time. Multiple views of the same video by the same user are not recorded in this number. This means that, on average, each user watched at least 3 videos on the site.

An unedited sampling of user comments is provided in Table 1. This gives an indication of the innovation and impact of the i.treatsafely.org site from the users' point of view.

Table 1 Unedited user comments about the i.treatsafely.org site.

User type	Country	Comment
Physicist	USA	Found the website on Medicalphysicsweb. As a new clinical medical physicist, I intend to stay aware, learn, implement and share the best safe practices in Radiation Therapy Tx, delivery, and QA. The goals of this website seem to comply with this professional pledge that I took as a medical physicist, and so I joined.
Physicist	Germany	I know this homepage from the MedicalPhysicsWeb Newswire. I hope to learn practical things for my future job as a medical physicist. Right now I'm finishing my PhD in the same field.
Dosimetrist	USA	Found the website searching for Continued Education Credits. I'm glad for this resource in our very important and trusting medical field.
Educator	USA	Colleague at the University I work for. Intention - to provide additional instructional material for students.
Radiation Oncologist	South Africa	I am a trainee radiation oncologist and would like to get access to practical material to help enrich my training.

The i.treatsafely.org site was designed to fill a specific training need and offers a unique learning opportunity in comparison to other education and training models in radiotherapy. The site has the following attributes:

- Users of the site have access to information on demand and at the point of need using any internet connected device.
- The peer-to-peer model provides more efficient and cost effective training than traditional approaches.
- The content is tagged to specific equipment versions, techniques, or procedures so a user can easily find exactly what they are looking for.
- The system incorporates the ability for an administration component that allows content to be pushed to other health care professionals, for example, to acquire continuing medical education credits.
- The system has applicability in developing countries with limited training resources, as is evident from the initial site membership. The site also promotes training in multiple languages, providing native-language training opportunities.

IV. CONCLUSIONS

The i.treatsafely.org site has been recognized by the American Association of Physicists in Medicine through the 2014 Award for Innovation in Medical Physics Education. i.treatsafely.org represents a paradigm shift in education, training and competence development in the radiation oncology community. Standardization of procedures, with recognized benefits for quality, safety and efficiency, can be easily facilitated utilizing current or specially submitted content. Uptake has been high approaching 1000 registered users in the first year of operation.

ACKNOWLEDGMENT

We would like to acknowledge all of the content contributors to the i.treatsafely.org site as well as Varian Medical Systems for their support of TreatSafely activities.

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50 YEARS ICTP AND ITS ACTIVITIES IN THE FIELD OF MEDICAL PHYSICS

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Abstract – ICTP (the Abdus Salam International Centre for Theoretical Physics) is an unique institution aiming to support the development of science knowledge in developing countries. It has supported the medical physics profession for more than 30 years. Many of the medical physicists from the developing countries have undergo training in the regular ICTP College on Medical Physics (starting from 1983). Last year ICTP initiated a regular School of Medical Physics (Radiotherapy) and an MSc Programme on Medical Physics. Acknowledging this support for the profession IOMP presented ICTP with its Plaque of Gratitude on the occasion of the ICTP Golden Jubilee this year.

This year ICTP (the Abdus Salam International Centre for Theoretical Physics) celebrates its Golden Anniversary. This international research institute for physical and mathematical sciences operates under a tripartite agreement between the Italian Government, United Nations Educational, Scientific and Cultural Organization (UNESCO), and International Atomic Energy Agency (IAEA). ICTP was founded in 1964 by Mohammad Abdus Salam, a Nobel Laureate in Physics of Pakistani nationality. The Centre buildings are in Trieste, Italy. The mission of ICTP is: To foster the growth of advanced studies and research in physical and mathematical sciences, especially in support of excellence in developing countries; To develop high-level scientific programmes keeping in mind the needs of developing countries, and provide an international forum of scientific contact for scientists from all countries; To conduct research at the highest international standards and maintain a conducive environment of scientific inquiry for the entire ICTP community. The Centre is an institution that is run by scientists for scientists. It regularly hosts meetings with Nobel Award winners and encourages research and teaching in physics.

By coincidence Abdus Salam was connected with medical physics through his Nobel Award in 1979, when he receives the Nobel in Physics (for the electroweak theory), together with Godfrey Hounsfield and Allan Cormack, receiving Nobel in Medicine (for the X-ray Computed Tomography).

Nobel Award winners 1979, including Abdus Salam (third from right), Godfrey Hounsfield and Alan Cormac (first and third from left) – image courtesy to ICTP Archives

The medical physics activities in ICTP had been initiated soon after - at the beginning of 1980-ties by Prof. Giorgio Alberi (ICTP) and a group of medical physicists including Anna Benini, John Cameron and Sergio Mascarenhas, and have been firmly supported by Prof. Luciano Bertocchi, Deputy Director of ICTP.

The first medical physics activity in ICTP took place in 1982 - an International Conference on the Applications of Physics to Medicine and Biology in 1982 (organised by Giorgio Alberi). Another successful conference and several workshops were organised in the following years, revealing the need of medical physics education for the Third World countries. On this background ICTP expanded their training activities in medical physics. This way the first College on Medical Physics took place in 1988. The regular series of Colleges begun in 1992 and since this time it runs on a regular basis (usually bi-annually).

From the beginning corner stones for the ICTP involvement in Medical Physics were Luciano Bertocchi (then Deputy Director of ICTP) and Anna Benini (then IAEA Officer). Additionally, a number of prominent professionals were engaged with the College on Medical Physics, including John Cameron (USA), Sergio Mascarenhas (Brazil), Perry Sprawls (USA) and Slavik Tabakov (UK). The current Co-Directors include also Franco Milano (Italy), George D Frey (USA) and Mario De Denaro (Italy).

ICTP International College on Medical Physics – students and Co-Directors, September 2010

The transfer of knowledge and experience to the developing countries is a major objective of the College. Each participant receives a full set of lecturing materials, including Power Point slides, e-Learning materials, access to web sites, etc. These have triggered tens of Medical Physics activities and courses in the developing countries and helped hundreds of colleagues from these countries to practice the profession. Due to this reason the College is always one of the most over-subscribed training activities of the ICTP. Some students from the College also take part in research activities organised by ICTP, namely as Associate Members and as participants in the Programme of Research and Training in Italian Laboratories (TRIL).

Alongside the College (focussing on Medical Imaging and Radiation Protection), ICTP hosts many other medical physics workshops, courses and conference, mainly related to IAEA activities. During 2005 ICTP was Co-organiser of the High-level UNESCO-led Conference in Durban "Physics and Sustainable Development". One of the decisions of this Conference was to identify areas of special interest for applied physics during the XXI century – one of these areas was agreed as "Physics and Medicine".

ICTP also took active part in the International projects EMERALD, EMIT and EMITEL, developing new e-learning and training materials in medical physics, as well as the first Medical Physics Encyclopaedia EMITEL. This way the first International Conferences for Medical Physics Training were held in ICTP, Trieste (1998, 2003, 2008).

EMITEL Medical Physics Encyclopaedia Conference, ICTP, November 2008
(the photo includes members of EMITEL project Consortium and Network, as well as Past and Present Presidents of IOMP and 21 National Medical Physics Societies and Regional Federations)

Inauguration of the new MSc course in Medical Physics, February 2014
(the photo includes the students, the Course Directors and Board, the EFOMP President,
the Head of the IAEA Human Health Division, the Rector of University of Trieste and the Director of ICTP)

ICTP also Co-organised medical physics activities outside Trieste – e.g. the Medical Physics College in Mumbai India (2007) and the Radiotherapy School in Guatemala (2013)

During 2013-2014 the ICTP medical physics activities expanded by organising a dedicated Master Programme in Medical Physics (led by Renata Longo and Renato Padovani). This MSc operates as a joint programme (in English) with the University of Trieste and is specially directed to students from developing countries. From the beginning IOMP supported this MSc programme, which attracted significant interest (for 2014 the programme received 440 application from developing countries).

Another new activity, initiated by Renato Padovani in 2013, is the new Radiotherapy School, headed by M DeDenaro, G Hartmann, M R Malisan and R Padovani. From 2015 the School will be a regular medical physics activity in between the years of the Medical Physics College. The School will include as Co-Directors also C Orton (IOMP), G Hartmann (EFOMP) and Y Pipman (AAPM).

From its foundation ICTP has been a pivot for the dissemination and development of various fields of physics in the world and in particular – in the developing countries. The medical physics activities organised by ICTP have helped thousands of young medical physicists from developing countries to firmly enter the profession and further spread the knowledge in their countries and regions. The International Organization for Medical Physics (IOMP) congratulates sincerely ICTP with its 50th anniversary and expresses its high appreciation and gratitude to the Centre as one of the strongest supporters of the medical physics profession.

Presenting an IOMP Plaque to ICTP Director Prof. Fernando Quevedo at the 50th Anniversary ICTP Conference, 7 Oct 2014

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ANNEX

The International College on Medical Physics (2014) included also a Poster session where students described the professional development and education/training activities in their countries. These Poster sessions, initiated 10 years ago are now an important part of the College, aiming exchange information and expertise between students, as well as helping the focus of the international activities supporting the global development of the profession.

The 2014 College had a focus on Africa and included a number of colleagues from the continent (some suggested by FAMPO – the Federation of African Medical Physics Organisations, a Regional Federation of IOMP). The best posters and presentations received the Binesh Award and an ICTP Diploma. Here below is a list of all Posters presented. The Award-winners authors have been asked to submit short paper for publication at the Medical Physics International. Here we include the presentations from Ghana and Bangladesh.

List of Poster presentations at ICTP College on Medical Physics (Advances in Medical Imaging Physics to Enhance Healthcare in the Developing Countries): 1/09/2014 – 19/09/2014

Medical physics in Vietnam, *Trinh Thi Mai*

Status of medical Physics In The United Republic of Tanzania, *W.E. Muhogora*

Overview of Medical Physics in Iran, *Afsaneh Lahooti; Hossein Aslian*

Medical Physics in Zimbabwe, *Edwin Mhukayesango*

Medical Physics in Indonesia: 'Nuclear for Welfare', *Eka Djatnika Nugraha*

Medical Physic Profession Uganda, *Musisi Alen*

Medical Physics Professional Status in Nepal, *Ram Narayan Yadav*

Academic Education, Clinical Training and Professional Recognition of Medical Physicist in Argentina, *Ruggeri Ricardo Miguel*

Present Status of Medical Physics in Bangladesh, *Hasin Anupama Azhari, M. N. Hossain*

Medical Physics Status in Cuba; Current Situation and Future Deveplopment, *Haydee Maria Linares*

Status of Medical Physics Education and Training in India, *Yalavarthy K. Phaneendra*

Development of Radiation Protection and Medical Imaging in Malaysia, *Anis Suhana Ahmad Sabri, Noor Zaimah Zainol Abidin*

Medical Physics Education in Turkey and the Statistical Distribution of CT, MRI and Mammography Devices, *Kandemir Recep*

Medical Physics in Ghana, *E. K. Sosu, F. Hasford, T. B Dery, E.W. Fiagbedzi, Y. Serfor-Armah, A W K Kyere*

Advances in Medical Imaging Physics to Enhance Health care in Developing Countries -Eritrea, *T. H. Teclehaimanot*

Medical Physics Education, Training and Professional Status in Brazil, *MARTINS Juliana Cristina, SANTOS Josilene Cerqueira, REINA Thamiris*

Medical Physics at Institute of Nuclear Physics in Tashkent, Uzbekistan, *JURAEVA Nozima*

Medical Physics Development in Serbia, *CEKLIC Sandra*

Education and Clinical Training of Medical Physics in Thailand, *Kitiwat KHAMWAN, Thunyarat CHUSIN*

Control of Unwarranted Radiation Exposures in Medical Applications – Sri Lanka, *Gunaratna Mudiyanselage, Nadeera Hemamali*

Medical Physics Applications and Actions in Mexico, *Medel Baez Eva*

Medical Physics in the Philippines, *Taguba Dona May Opiniano, Margallo Victor Angelo Caballero*

Advance in Medical Imaging in Zambia, *Nkonde Kangwa Alex*

Inclusion of Medical Physicists in Radiology – Venezuela, *Yanez Sanchez Miguel Angel*

Medical Physics in the Sudan: Continuous Development and Innovation, *Ahmed Murtada Ahmed*

Status and Progress of Ethiopia in Medical Physics, *Gebre Mesay Geletu, Yacob Alemiye Mamo*

Medical Physics Development in Nigeria: Personnel and Equipment, *AKPOCHAFOR Michael Onoriode, ARAGBAYE Adebola, EVWIERHURHOMA Omuvwie Bernard, ISIAKA Babatunde*

Awards were distributed to the Posters/Presentations from the following countries: Bangladesh, Cuba, Ghana, Sudan, Thailand

The Abdus Salam
International Centre
for Theoretical Physics
www.ictp.it

SCHOOL ON MEDICAL PHYSICS FOR RADIATION THERAPY:

DOSIMETRY AND TREATMENT PLANNING FOR BASIC AND ADVANCED APPLICATIONS

13 - 24 April 2015

Miramare, Trieste, Italy

The Abdus Salam International Centre for Theoretical Physics (ICTP) will organize, with the support of the International Organization for Medical Physics (IOMP), the European Federation of Organisations for Medical Physics (EFOMP) and the American Association of Physicists in Medicine (AAPM), a School on Medical Physics for Radiation Therapy to take place from 13 to 24 April 2015.
The topic will be: Applied Physics of Medical Radiation Therapy - Dosimetry and Treatment Planning for Basic and Advanced Applications. The School will specifically address the needs of Healthcare in low and middle income countries.

OBJECTIVE OF THE SCHOOL

The objective of the School is to contribute to the understanding of Physics applied to Radiation Therapy and the development of competent medical physicists who can make a direct contribution to the improvement of health care in their countries through better radiation therapy.
This will be achieved by providing participants with education and practical training to enhance their effectiveness as future disseminators of this knowledge, who can provide in turn educational and training opportunities to other medical professionals and students.

PROGRAM

The program of the School will consist of lectures, interactive discussions and problem solving sessions and applied learning experiences in local hospitals.
The two-week School will be devoted to the physics applied to radiation therapy with the aim to introduce to conventional and advanced therapy principle, methods and technology:

- disseminating information about issues on radiotherapy physics and defining innovations that could improve the quality of radiotherapy services;
- outlining a systematic approach to the assessment of the appropriateness of conventional and advanced radiotherapy techniques; and
- facilitating the creation of a network for the exchange of information on radiotherapy physics among scientists in developing and developed Member States.

Traditionally, medical physicists have played a significant role in driving development in radiation medicine. This school will take a comprehensive approach for the implementation of conventional and advanced therapy methods, including the integration in treatment planning and patient setup of imaging modalities relevant in radiation therapy.

PARTICIPATION

Medical physics scientists and students from all countries which are members of the United Nations, UNESCO or IAEA may attend the School. Participants should hold a university degree in medical physics or related subjects and have some professional experience in medical physics related to radiation therapy. As it will be conducted in English, participants should have an adequate working knowledge of this language.
Although the main purpose of the Centre is to help research workers from developing countries, through a program of training activities within a framework of international cooperation, post-doctoral scientists from developed countries are also welcome to attend.
As a rule, travel and subsistence expenses of the participants should be borne by the home institution. Every effort should be made by candidates to secure support for their fare (or at least half-fare). However, limited funds are available for some participants from developing countries, to be selected by the organizers. There is no registration fee.

HOW TO APPLY FOR PARTICIPATION

The application form can be accessed at the activity website:

http://indico.ictp.it/event/a14234/

Once in the website, comprehensive instructions will guide you on how to fill out and submit the application form.

ACTIVITY SECRETARIAT:
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United Nations Educational, Scientific and Cultural Organization

IAEA
International Atomic Energy Agency

IOMP EFOMP AAPM

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TOPICS

Radiobiology

Dosimetry

Therapy equipment

Dosimetry algorithms

3D conformal, advanced (IMRT, VMAT) treatment delivery and brachytherapy

Treatment planning and its practical implementation

Treatment verification

Quality assurance

Case studies

APPLICATION DEADLINE

5 January 2015

PROFESSIONAL ACTIVITIES

"2ND INTERNATIONAL CONFERENCE ON MEDICAL PHYSICS IN RADIATION ONCOLOGY AND IMAGING (ICMPROI-2014)" IN DHAKA, BANGLADESH

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Abstract – Review of the 2nd International Conference on Medical Physics in Radiation Oncology and Imaging (ICMPROI-2014) in Dhaka, Bangladesh

Keywords – ICMPROI-2014, International conference; Dhaka, Bangladesh

I. INTRODUCTION

Medical Physics is still a new subject in Bangladesh. The importance of Medical Physics in Bangladesh is gaining day by day as cancer treatment is entering a new era from conventional therapy to conformal therapy. *Bangladesh Medical Physics Society (BMPS)* is a non-profit, non-trade registered organization primarily engaged in professional, educational and research activities, public awareness throughout Bangladesh in the field of medical physics including biomedical engineering, especially the application of physics in medical sciences. Also it organizes and or cooperates national, regional and international conferences, meetings or courses.

With that aim, after the 1st International Conference on Medical Physics in Radiation Oncology and Imaging (ICMPROI-2011) in 2011, BMPS has now organized the 2nd International Conference on Medical Physics in Radiation Oncology & Imaging (ICMPROI-2014) jointly with the Association of Medical Physicists of India ***(AMPI)*** and Nepalese Association of Medical Physicists ***(NAMP)*** from 20 to 22 August 2014 at the premier Postgraduate Medical Institution of the country Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka. The ICMPROI-2014 was supported this time by Asia-Oceania Federation of Organizations for Medical Physics (***AFOMP***), Middle East Federation of Organizations of Medical Physics (***MEFOMP***) and The Abdus Salam International Center for Theoretical Physics (***ICTP***). Prof. Dr. Golam Abu Zakaria, Chairmann and Chief Medical Physicist of Gummarsbach Hospital, Academic Teaching Hospital of the University of Colonge, Germany and Dr. Hasin Anupama Azhari, Chairman Department of Medical Physics and Biomedical Engineering of Gono University, Bangladesh & Founder President of Bangladesh Medical Physics Society (BMPS) were the Organizing Chairperson and Organizing Secretary of this conference respectively.

II. PARTICIPANTS

During this conference more than 300 participants (40 foreign participants) including many eminent scientists, young researchers from universities, hospitals and industries of 24 countries (Algeria, Arab Emirates, Australia, Bangladesh, Belgium, Canada, China, Germany, India, Iran, Italy, Japan, Lebanon, Mexico, Nepal, Oman, Pakistan, Poland, Srilanka, South Korea, Sweden, Switzerland, United Kingdom, USA) exchange their knowledge, experience and buildup a network.

We were honoured to have with us President, Asia-Oceania Federation of Organizations for Medical Physics ***(AFOMP)****, Prof. Dr. Yimin Hu*, President of Middle East Federation of Organizations of Medical Physics ***(MEFOMP***), *Dr. Ibrahim Duhaini*, President of Polish Society of Medical Physics ***(PSMP),*** *Prof. Pawel*

Kokolowicz, President of Pakistan Organization of Medical Physics ***(POMP)*** *Syed Mansoor Naqvi*,

Fig: 1 Some of the Distinguished guests, ICMPROI 2104.

President of Nepalese Association of Medical Physicists ***(NAMP***), *Mr. P. P. Chaurasia*, Secretary of Association of Medical Physicists of India ***(AMPI)***, *Dr. Challapalli Srinivas*, President of Bangladesh Medical Society ***(BMPS),*** *Mr. Kumaresh Chandra Paul and* International Atomic Energy Agency ***(IAEA)*** representative *Dr. Ahmed Meghzifene.*

III. Scientific sessions

According to the tradition of the previous ICMPROI meeting the scientific program of the ICMPROI-2014 was composed of Plenary Sessions, Invited Lectures, Oral, Poster and Vendor Presentations which have covered a wide range of issues related to Dosimetry, External Beam Therapy, Brachytherapy, Treatment Planning, Diagnotic Imaging, Nuclear Medicine, Quality Assurance, Radiobiology, Radiation Oncology, Radiation Safety, Biomedical Engineering and also on Education. 105 papers were presented in the different 18 scientific sessions. *On the 1st day* of the conference the Inaugural Ceremony was followed by scientific sessions, a cultural evening and grand dinner**.** *On the second day*, a special session and a workshop has included in the scientific sessions. *On the third day*, there were scientific sessions, poster sessions, award ceremony and finally the closing session.

IV. Inaugural ceremony

The inaugural ceremony of ICMPROI-2014 was held on Wednesday, 20 August 2014 in the Milon Hall of Bangabandhu Sheikh Mujib Medical University (BSMMU). *Hon'ble Minister, Ministry of Foreign Affairs*, Mr. Abul Hassan Mahmood Ali, M.P, was present to grace the occasion as the Chief Guest. *The Charge d' Affaires, German Embassy to Bangladesh*, Dr. Ferdinand von Weyhe and *Director General, Directorate General of Health Services (DGHS)* Prof. Deen Mohd. Noorul Huq were present in this occasion as Special Guests. *President, Asia-Oceania Federation of Organizations for Medical Physics (AFOMP)*, Prof. Dr. Yimin Hu and *President, Bangladesh Academy of Science & Vice-Chancellor, Gono Bishwabidyalay (University)* Prof. Mesbahuddin Ahmad were present in the occasion as Guests of Honour and Prof. Dr. Golam Abu Zakaria was present as *Organizing Chairperson* of the conference. The session was presided over by *Vice Chancellor of BSMMU* and Patron of the Organizing Committee, ICMPROI-2014 Prof. Dr. Pran Gopal Datta (Fig:2).

Fig: 2 Inaugural Ceremony ICMPROI 2104.

V. Cultural evening (Day-1):

A beautiful cultural evening was presented followed by Gala Dinner with Bangladeshi food and sweets. The cultural programme has represented the culture & custom of Bengali Nations by classical and traditional dances
(Fig: 3).

Fig: 3 Cultural Evening ICMPROI 2104.

VI. Special session (Day-2):

In a special video session entitled 'Interdisciplinary workshop on treatment planning and dose delivery for radiation oncologists and medical physicists', the whole chain of the treatment planning and delivery for cancer patients was discussed with experts (Radio-oncologists and Medical Physicists) from different countries.

VII. Poster session (Day-3):

33 posters were displayed. The committee of judges for poster session selected three posters for first, second and third prizes.

The First, Second and Third posters were *"Ranking of 3D Treatment Plan Variants Considering Physical and Biological Parameters in External Beam Therapy"* from **Bangladesh** by Kausar A., Azhari H.A., Chaudhuri S., Bhuiyan M.A., Zakaria G.A., *"Flexible Film Haptic Actuator Made with Cellulose Derivative for Surgical Simulation"* from **South Korea** by Mohiuddin M., Kafy A., Akhter A., Kim Huan-Chan, Jaehwan K. and *Application of Diamond Detector in Radiation Beam Measurements in High Energy Linear Accelerator"* from **Oman** by Ravichandran R., Binukumar J.P., Al Amri I., Davis C.A. respectively.

VIII. Workshop (Day-2):

A workshop entitled 'Advanced Dosimetry and Treatment Planning' followed by a dinner was held at the evening of second day of the conference at Clinical Oncology Department in the Ahsania Mission Cancer and General Hospital (AMGCH).

IX. Closing and award ceremony (Day-3):

Closing speech (Fig:4) was delivered by the Presidents and the Secretaries of different societies/organizations (AFOMP, MEFOMP, PSMP POMP, NAMP, AMPI, BMPS).

Fig: 4 Closing Ceremony ICMPROI-2014

In the award ceremony BMPS has recognized *Prof. Dr. Golam Abu Zakaria* as the founder of Medical Physics in Bangladesh and honored him as "Honorary Member" for his extraordinary contribution for the education and development of medical physics in Bangladesh. We have also honored Prof. Dr. Guenther Hartmann as "Honorary Member" for his great contribution for the medical physics education in Bangladesh (Fig:5).

Fig: 5 Award giving to Prof Zakaria from BMPS President and Prof Hartmann from BMPS Secretary.

Hopefully we expect more contributions and advise from international organizations like IAEA, IOMP, IFOMP, DGMP, AAPM and others for the coming 3rd ICMPROI-2017 in 2017.

Acknowledgement

Our best thanks go to the contributors, abstract reviewers, organizing committee, co-organizers, sponsors and all other peoples, students who make this conference a success.

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10 YEARS OF MEDICAL PHYSICS TRAINING IN GHANA: SUCCESSES, CHALLENGES AND THE WAY FORWARD

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Abstract – Medical Physicists are an important part of Cancer management worldwide. In Ghana, Medical Physics education and training first started in 2004 with 6 students. The Medical Physics Department is currently located in the School of Nuclear and Allied Sciences, University of Ghana – Atomic Campus which was founded by a collaboration between the Ghana Atomic Energy Commission (GAEC) and University of Ghana, with support from IAEA. The training comprises of didactic lectures, clinical practicals and thesis work. The department incorporates the latest developments of imaging and radiotherapy in its training. It has led to graduates who are equipped for their task.

Keywords – medical physicist, clinical training, School of Nuclear and Allied Sciences.

I. INTRODUCTION

In response to the need of adequately trained medical physicist in the health delivery system of Ghana and Africa at large, the M.Phil Medical Physics programme was established in 2004. The programme was initially hosted by the School of Allied Health Science (SAHS), University of Ghana. In 2006, with support from the International Atomic Energy Agency (IAEA), Ghana Atomic Energy Commission (GAEC) in collaboration with University of Ghana (UG) established the Graduate School of Nuclear and Allied Sciences (SNAS) to promote Post Graduate university education and training for preservation and enhancement of nuclear knowledge in Ghana and Africa. A department of Medical Physics was created and the programme was moved from the SAHS to SNAS. In 2008, PhD in Medical Physic was also introduced and currently has a duration of four (4) years.

Over the years, the Medical Physics programme has grown from initially admitting local students to admitting foreign students from across Africa. Governments and the IAEA have also sent students from across Africa to be trained in the programme.

II. FACULTY

The Medical Physics department has a well-resourced faculty comprising of Professors, Associate Professors, Senior Lecturers and Lecturers. In addition to the faculty members from GAEC, UG and Kwame Nkrumah University of Science and Technology (KNUST), adjunct professors, lecturers and scholars have been recruited from partnership institutions and the IAEA Member States to lecture and co-supervise PhD Sandwich programmes of the School.

III. ADMISSION REQUIREMENT

The minimum qualification for this programme is a good first degree (at least a second class lower division) in Physics from any approved University. A candidate who does not satisfy the requirement in an appropriate field of study as above but is otherwise adjudged suitable by virtue of appropriate experience could be considered.

IV. ACADEMIC & PRACTICAL TRAINING

The MPhil programme includes two (2) semesters of didactic academic work followed by one (1) year of research and clinical training. Academic courses pursued in the first year include: Radiation Physics, Research Methodology, Radiobiology, Anatomy and Physiology, Professional and Medical Ethics, Nuclear Medicine, Radiation Dosimetry, Physics of Radiation Oncology, Physics of Imaging and Diagnostic Radiology.

The two year training is followed by a one (1) year clinical internship for local graduates. The internship comprises 6 months radiotherapy, 3 months diagnostic radiology and 3 months nuclear medicine. This arrangement ensures that clinically qualified medical physicists receive minimum of two years clinical training. After internship, interns are certified to practice only after passing an examination of the Allied Health Professions Council [1]. The PhD programme compromises of one (1) taught course and three (3) years of research work.

The training programme is accredited by the National Accreditation Board (NAB) ~~in~~ of Ghana. Assessment by NAB is carried out periodically at a frequency of once in every three years, using the services of international experts and consultants to ensure neutrality. Recommendations provided are scrupulously applied to ensure that international standards are upheld in the programme.

Graduates of the Medical Physics programme have over the years benefitted from further training in the form of IAEA short courses and fellowships, ICTP – College of Medical Physics, ICTP – short courses and workshops and ESTRO training. This has further increased capacity and abilities in the field.

V. ENROLMENT DATA

Table 1. MPhil and PhD enrolment statistics

M.Phil.					PhD		
Year	**No. of Students**	**LOCAL STUDENTS**	**IAEA fellows**	**Other Nationals**	**No. of Students**	**Male**	**Females**
2004	6	6	-	-	-	6	-
2006	4	4	-	-	-	3	1
2008	3	3	-	-	1	3	-
2009	4	4	-	-	-	4	-
2010	4	4	-	-	1	4	1
2011	7	5	2	-	2	9	-
2012	10	6	2	2	-	8	2
2013	13	7	5	1	-	11	2
2014	10	9	-	1	-	9	1

VI. TRAINING FACILITIES

The School collaborates with the following institutions were practical training are undertaken:

- National Centre for Radiotherapy and Nuclear Medicine, Korle-Bu Teaching Hospital, Accra
- Oncology Directorate, Komfo Anokye Hospital, Kumasi
- Sweden Ghana Medical Centre, Accra
- Laboratories of GAEC
- 37 Military Hospital, and other diagnostic facilities throughout the country

With the collaboration of Ghana Society for Medical Physics (GSMP) students are placed on Internships after completion of the programme.

VII. SUCCESSES

Regional Designated Center (RDC): Due to the demand for Medical Physicist across the continent, the School of Nuclear and Allied Science applied to IAEA to be considered for RDC status. By this, the IAEA will be positioned to send fellows from other African countries to be trained in Ghana.

Provision of Human Resource: The programme has and will continue to provide Human Resource for the nation and Africa at large. Graduates from the School find themselves in the field of research, academia and in the clinical environment.

Ghana Society of Medical Physics (GSMP): In 2011, GSMP was establishment to regulate activities of professional medical physicist especially in clinical setting. GSMP collaborated with other health professions and in 2013, medical physics was legally recognized with the passing of “Health Professional Regulatory Bodies Act (Act 857)”. GSMP is affiliated to FAMPO & IOMP. Members of GSMP in IAEA RAF 6044, RAF 6048 & RAF 6017.

Table 2. Classification of Medical Physicists in Ghana

Classification of Members	Number
Clinical	9
Research	6
Academia	13
TOTAL	28

VIII. CHALLENGES

Dedicated clinical training facilities: The School has no dedicated clinical training facilities on school premises. Studies and lecturers must travel to facilities before clinical practicals can be undertaken. This sometimes serves as a disincentive for studies especially those who are self-funding.

Lack of advanced phantoms: Lacking is advanced phantoms especially in diagnostic radiology and radiotherapy for students to undergo practicals in quality control and quality assurance. This limits the scope of practicals to be conducted.

IX. WAY FORWARD

To position the Medical Physics programme as a centre of excellence, IAEA support in terms of equipment for quality control especially in diagnostic radiology is required.

X.CONCLUSION

On this 10th anniversary of the Medical Physics education and training in Ghana, it can be said that there has been a success. Student enrollment has increased with other African nationals and IAEA fellows also going through the programme. Graduates from the training programme are serving as medical physicists in clinical, research and academic institutions across Africa.

ACKNOWLEDGEMENT

The authors will like to express their profound gratitude to the Government of Ghana, International Atomic Energy Commission, Ghana Atomic Energy Commission and the University of Ghana. Our heartfelt appreciation to the Korle – Bu and Komfo Anokye Teaching Hospitals, Sweden Ghana Medical Centre, and all diagnostic centre where our students undergo clinical training.

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INNOVATIONS

RADIATION DOSE OPTIMIZATION TECHNOLOGIES IN MULTIDETECTOR COMPUTED TOMOGRAPHY: A REVIEW

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***Abstract*—Computed tomography (CT) is a well stablished imaging technique that is used worldwide for diagnosis and treatment planning. The purpose of this review is to describe the most notable technological advances in the last decade, with a special focus on their impact in CT dose optimization, that is, achieving the same diagnostic image quality at a reduced radiation dose. The review describes main components of a CT system such as x-ray tubes, detectors, shape filters and collimators; as well as the control of key variables such as the tube current and tube potential. In addition, technological advances in iterative reconstruction and specific applications such as cardiac CT, ultra-fast scanning with dual-source CT, and dual-energy CT, are also presented. While the some topics discussed in this review could be generalized to all modern CT scanners, many features are specific for CT systems manufactured by Siemens Healthcare and thus might not be available through other manufacturers**.

Keywords— **Computed Tomography, radiation dose reduction, image quality, radiation dose optimization.**

I. INTRODUCTION

Since its introduction in the seventies [1], computed tomography (CT) technology has improved tremendously and has become an essential imaging modality for treatment planning and for the diagnosis of different pathologies such as cancer, infectious diseases, trauma, stroke, cardiovascular diseases, among others. Some notable advances over the first three decades after its introduction include the development of spiral (or helical) CT [2], multi-detector CT [3] [4], and the dual-source CT [5]. These technological advances have led to the establishment of CT as an imaging modality that provides isotropic and sub-millimeter spatial resolution, fast acquisition speeds -with typical acquisition times below 10 seconds for whole volumes of data-, and with routine temporal resolution as low as 65 ms [6] [7] for applications such as cardiac imaging. While the technologies aimed to improve acquisition speed, temporal resolution and spatial resolution continue to steadily progress, radiation dose reduction has only recently become a primary driver of the development of new CT technologies. In the last decade, radiation dose from imaging procedures that use ionizing radiation have received increased attention and scrutiny. A report from the National Council on Radiation Protection and Measurements (NCRP) indicated that the average effective dose per capita to the US population had increased from 3.6 mSv in 1980 to about 6.2 mSv in 2006 [8]. The same report identified that radiation from medical procedures was the primary reason for such increase, and that a contribution of about 24% to the effective dose per capita was due to CT alone [8]. These findings reflect the consolidation of CT as an essential imaging modality for diagnosis and treatment in modern medical practice. This consolidation is also supported by the fact that over 70 million CT examinations are performed per year in the US alone [9]. However, the increased utilization of CT and the small potential risk of cancer associated with the use of ionizing radiation [10], require that every CT scan is both clinically justified and performed using the CT technique optimized with respect to radiation dose [11]. In this paper, we will focus on the latter.

While dose reduction is important, acquiring a poor non diagnostic scan for the sake of having ultra-low dose provides no benefit to the patient. Thus to provide good patient care and maximize the benefits to patients, it is crucial to perform exams that reduce radiation dose while maintaining diagnostic image quality. Hence, we will focus on the most recent CT technologies which aim for exam optimization rather than a mere radiation dose reduction. To facilitate the description of newer CT technologies it is convenient to review the CT imaging chain (**Fig. 1**). It starts with the essential components of a CT system that include the x-ray tube (s), shape (bowtie) filters, collimators and detectors (Section II). Next, the CT scanner has various control systems, most notably for the x-ray tube current and tube potential. The control of these parameters have a direct impact both on the radiation dose used during a CT examination and the image quality, particularly regarding image noise and contrast-to-noise ratio (Section III). After the acquisition and prior to image reconstruction, the CT projection data undergoes several preprocessing steps (i.e. beam hardening and scatter correction), usually transparent to the end users of clinical systems. Finally, the image reconstruction takes place using either the traditional filtered backprojection (FBP) or iterative reconstruction (IR) methods (Section IV). In most cases several of the aforementioned technologies can be simultaneously combined to optimize radiation dose and image quality or be adapted for specific applications such as cardiac imaging, ultra-fast acquisition, or dual-energy CT (Section V). Newly introduced features such as dose structured reports, dose notifications and alerts are also discussed (Section VI).

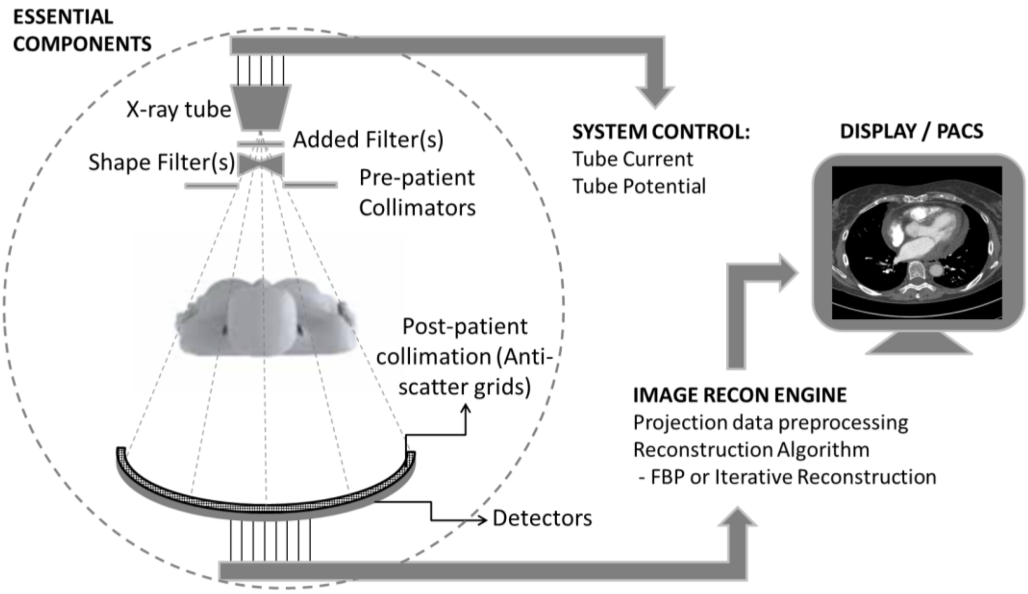

Fig. 1. Block diagram with some of the components of the CT system imaging chain.

II. CT SYSTEM HARDWARE

X-ray tube

An x-ray tube is one of the essential components of a CT system. The key characteristics that define the performance of an x-ray tube include tube power reserve, heat storage capacity, focal spot size, and the range of polychromatic spectra that it provides (i.e. the different kilovoltage values at which it can operate). Modern clinical CT systems typically operate at a peak power of between 50 to 80 kW, with higher end systems able to reach up to 120 kW per x-ray tube. Large power reserves of 80 kW or higher are particularly helpful for ultra-fast scanning modes and for scanning obese patients. In these applications, the x-ray tube must operate near its maximum current. Therefore, unless there's enough tube power, some decrease of the acquisition speed might be needed in order to be able to scan larger patients with sufficient image quality [12]. One solution to increase the overall tube power reserve is to use a dual-source (DS) CT system that can simultaneously and independently operate two perpendicularly arranged x-ray tubes. Such technology can double the power reserve up to 2 x 120 kW in the third generation DS system (SOMATOM Force®, Siemens Healthcare), when operating both tubes at the same kV [13].

A specific approach for the x-ray tube design is the rotating envelope tube (Straton®, Siemens Healthcare), which utilizes convective cooling rather than radiative cooling as in conventional rotating anode disks [14]. This design allows operations at a high-power with high heat dissipation rates of 5,400 kJ/min. Because of the fast cooling ability; rotating envelopes facilitate operation in rapid succession minimizing the need of cooling delays in between scans. Typical peak tube potential values available in modern CT scanners are from 80 to 140 kVp. Most recently, lower tube potential settings at 70 kVp (CARE Child, Siemens Healthcare, Forchheim, Germany) has been introduced and are particularly well suited for scanning children [15] or thinner structures in the body such as the neck [16].

One limitation of the Straton and other x-ray tubes is that it can only reach its maximum power at high tube potentials (e.g. 120 or 140 kV), while at low tube potentials (e.g. 80 and 100 kV) the maximum tube current (hence, power) is significantly smaller than at 120 kV. The newest x-ray tube (Vectron®, Siemens Healthcare) employed by the third generation DS system overcomes this limitation and can achieve a very high tube current up to 1300 mA, even at low tube potential values such as 70, 80 or 90 kV. This is a major advantage for low kV imaging that is often limited by insufficient power reserve [17].

X-ray beam shaping filters

Considering that the cross-section of patients is well approximated by an oval shape, special shape filters like the "bowtie filters" are nowadays common in CT systems for attenuating the beam at the periphery, while keeping the intensity in the central portion of the beam. Further adaptation of these bowtie filters can be considered for specific scanning modes such as pediatric imaging or cardiac imaging. For example, cardiac bowtie filters reduce the exposure outside of the area of the heart leading to lower dose in organs and structures outside of this area. Radiation dose savings due to bowtie filters have been reported to be in the range of 10 to 20% [18].

One of the effects of adding filters to the x-ray beam is that these filters can affect the x-ray spectra. For example, most x-ray tubes in a CT scanner include some added filtration such as aluminum to cut off the lower energy photons that typically do not contribute to image formation. Even shape filters can alter the x-ray spectra by a small percentage [19].

Primak et al. investigated the use of additional (flat) filters for the x-ray tube operating at high tube voltage for dual-source dual-energy CT applications [20]. The added filtration, of materials such as tin, increased the spectra separation between the tubes operating at low and high energies and was demonstrated to reduce image noise in material-specific dual-energy images, which in turn translated to dose reduction for dual-energy CT applications [21]. More recently, with the introduction of the third-generation DSCT (SOMATOM Force®, Siemens Healthcare), two special acquisition modes were included, in which a flat tin filter is added to both x-ray tubes operating at either 100 kVp or 150 kVp. For these modes, instead of achieving spectral separation between the low and high energies, the entire spectrum is shifted to higher energies. It was demonstrated that for non-contrast imaging tasks such as discriminating soft tissue and air that, this hardened spectra can be more dose efficient achieving a high contrast-to-noise ratio between soft tissue and air with less dose than traditional scan modes without the tin filter at typical tube voltages. Applications for the 100 kV with tin acquisition mode have already been demonstrated in phantoms and patients undergoing low-dose non-contrast chest CT with doses as low as 0.07 mSv, while still maintaining the ability to detect lung nodules [22].

Collimators

There are two basic types of collimators in CT: pre-patient and post-patient. Conventional approaches for both types of collimation are reviewed elsewhere [23] [24]. Some of the latest advances in pre-patient collimations are the dynamically adjustable z-axis x-ray beam collimators (e.g. Adaptive Dose Shield, Siemens Healthcare, Forchheim, Germany); which are used in spiral CT to reduce unnecessary dose due to overscanning [25] [26] [27]. In order to acquire sufficient data to reconstruct a particular image slice, it is necessary to acquire enough projection data before and after that slice (required for spiral interpolation). Therefore, a full irradiation of the detector through the slice is needed, although not all acquired data contributes to the final image formation. Dynamically adjustable z-axis collimation is achieved by using fast motion collimator blades that limits this over-scanning. At the beginning and end of each spiral CT scan, the pre-patient collimator asymmetrically opens and closes with the purpose of blocking the portions of the x-ray beam which do not provide the projection data useful for the image reconstruction. The use of this technology has been shown to lead to dose reductions in the range of 5 to 50% while maintaining image quality, with percent reductions strongly dependent on the pitch and scanning range [26]. The higher reductions were observed for scans using high-pitch values (and hence higher overscanning needed) and short scan ranges; as often would be the case in pediatric imaging and cardiac CT [28].

Detectors

Modern CT systems use solid-state detectors which are made of materials such as gadolinium oxide, cadmium tungstate or ultra-fast ceramics (UFC®, Siemens Healthcare) [29]. While the detector itself is the component which transduces absorbed x-rays into light, the whole detector module (or detector cell) is also comprised of a photodiode, which transduces light into an electric signal, and an analog-to-digital converter (ADC) that, as the name suggests, takes the analog electric signal produced by the photodiode and converts it into a digital signal. To improve radiation dose efficiency, advances in the detector material and system electronics are needed. One of those latest advances has been in the detector electronics by integrating the photodiode and ADC into one application-specific integrated circuit (ASIC). The benefit of this integration is that it obviates analog connections of conventional detector electronics, which are a major source of electronic noise. Quantum noise is typically they main contributor to CT image noise and is determined by the number of photons collected by the detector. However, when the detected signal has amplitude which is close to the electronic noise floor, then the contribution of electronic noise to image quality degradation becomes an issue. Such scenarios can happen when doing scans at very low dose levels, which could be the case in exams such as low dose chest CT for lung cancer screening [30] or CT colonography [31] [32]; but also in scenarios when morbidly obese patients are scanned [33] [34], , i.e. causing photon starvation. **Fig. 2** provides an example of the noise reduction achieved with the use of the integrated electronics detector.

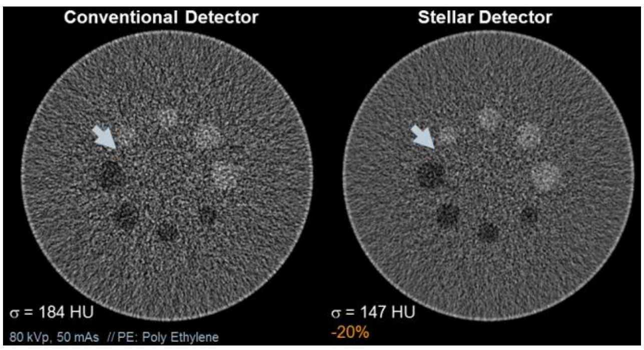

Fig. 2. Poly ethylene phantom scanned with identical CT technique of 80 kVp and 50 mAs using both a (left) conventional CT detector and (right) integrated-electronics detector (Stellar detector) to demonstrate noise reduction.

A commercial implementation of this new integrated detector electronics technology has been recently introduced with the Stellar® and Stellar-Infinity ® detectors (Siemens Healthcare, Forchheim, Germany). Recently published investigations have confirmed the benefits of the integrated detectors for reducing the image noise when scanning obese patients or through the thicker anatomical cross-sections such as the shoulders and pelvis [34].

In addition to better dose efficiency by reducing electronic noise, advances in CT detectors can have a direct influence on spatial resolution by minimizing detector to detector crosstalk and coupling that information with more advanced iterative reconstruction methods which model system parameters such as focal spot blurring and detector themselves. For example, combining use of the Stellar detectors and iterative reconstruction lead to improvements in spatial resolution as demonstrated for applications such as temporal bone imaging [35] or for the depiction of coronary stents in CT angiograms [36], with both types of applications benefiting from the improved ability to depict smaller structures.

III. SYSTEM CONTROL OF CT PARAMETERS: TUBE CURRENT AND TUBE POTENTIAL

Automatic exposure control

The automatic exposure control (AEC) of the tube current in a CT scanner is one of the key features for radiation dose optimization, and it has become a standard feature in all modern CT systems. The AEC modulates the tube current as a response to changes in patient attenuation due to patient size, anatomy and shape [37] [38] [39]. The tube current can be modulated angularly, such that a higher current is applied in view angles with higher attenuation. For example, most patients are thicker (more attenuating) in the lateral direction relative to the anterior-posterior direction; hence a higher tube current is applied laterally relative to anterior-posterior. The tube current can also be modulated longitudinally. For example, patients typically have thicker cross-sections in the shoulders compared to the rest of the thorax that has less tissue because of the air-filled lungs. Hence, the longitudinal tube current modulation will apply a higher current through the shoulders and a lower current through the rest of the chest. One of the strategies used to perform AEC is CAREDose4D (Siemens Healthcare, Forchheim, Germany), which responds directly to attenuation changes from the patient in the angular direction (x-y plane) and also along the patient in the z-direction (**Fig. 3**). Furthermore, CAREDose4D has a built-in "real-time" feedback mechanism to further refine angular tube current modulation during the scan using the patient attenuation profile obtained from the previous 180 degrees of projection data.

Manufacturers use one of three main strategies to control the tube current in AEC systems: reference mAs (Siemens), standard deviation or noise index (Toshiba, General Electric, Hitachi), and reference image (Philips, Neusoft) [40]. For example, CAREDose4D is controlled with the reference effective mAs, with effective mAs defined as:

Eff. mAs = [tube current x rotation time] / pitch (1).

The reference effective mAs is defined as the effective mAs needed to produce the desirable image quality for a given reference attenuation (e.g. 33.9 cm of water for the abdomen (**Fig. 4**). If a patient has lower attenuation than the "reference patient", the effective mAs needed to reach the desired image quality is then lower than the reference effective mAs. On the contrary, larger patients will require an increase in the effective mAs beyond the reference value to warrant adequate image quality..

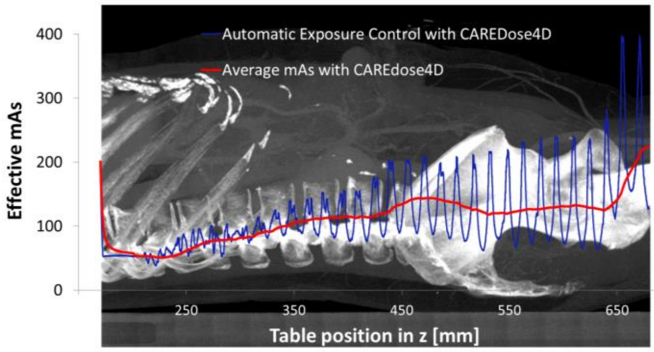

Fig. 3. Automatic exposure control of the tube current using CAREDose4D from a patient undergoing a chest-abdomen-pelvis CT exam. The tube current continuously changes as a function of patient's attenuation; hence it follows changes angularly and longitudinally, in addition to real-time feedback (every half rotation) to fine tune the tube current applied to the patient.

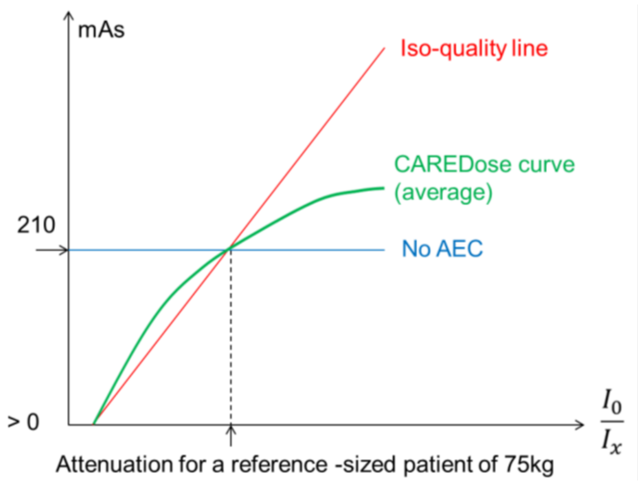

Fig. 4. Tube current-time product (mAs) adaptation as a function of patient attenuation. The example compares the nonlinear function used by CAREDose4D for automatic exposure control (AEC), with a fixed tube current approach (No AEC), and to a the tube current adaptation approach that attempts to deliver constant noise (iso-quality line).

Now, a mathematical function needs to be defined to adapt the effective mAs as a function of patient attenuation. One approach to that mathematical function is to linearly adapt the effective mAs with patient attenuation changes, such that the noise is constant. However, clinical experience suggests that this relationship does not need to be linear, as higher noise can be tolerated in larger patients, due to more body fat that increases tissue contrast. Likewise, in pediatric applications the lack of intrinsic tissue contrast and the small structures may require lower image noise relative to adult patients. CAREDose4D operates under this paradigm, and hence, the relationship between patient's attenuation and applied tube current is nonlinear (**Fig. 4**). Furthermore, CAREDose4D allows the user to adjust the shape of the mathematical function to adapt the tube current to the patient attenuation. In practice, the users can define how aggressively they want to increase (or decrease) the tube current (i.e. effective mAs) in response to the changing patient attenuation.

Organ-based tube current modulation

Organ-based tube current modulation is designed to reduce the radiation exposure to superficial radiosensitive organs such as the breast [41] [42], thyroid [43] or the eye lens [44]. This technique is implemented as X-CARE (Siemens Healthcare, Forchheim, Germany) and operates by decreasing the tube-current when the x-ray tube is passing anteriorly to the patient in an angular range of about 120 degrees (**Fig. 5**). To avoid a compromise in image quality, the tube current is increased for the posterior angular range such that the overall radiation exposure is comparable to a traditional scan without X-CARE. Various investigators have found that organ-based tube current modulation can effectively spare radiation dose to sensitive organs like the breast [41] [45], eye lens [44], and thyroid [43]; while maintaining image quality in terms of image noise and CT number accuracy. An approach previously used to reduced exposure to radiosensitive and superficial organs were the bismuth shields, placed over the radiosensitive organ (e.g. on the breast), but they were found to have issues such as increased image noise and artifacts. The usage of bismuth shields has been controversial [46] [47] but it is now usually discouraged since a global reduction in the tube current or the use of technologies such as X-CARE can achieve the same goal without sacrificing image quality [48].

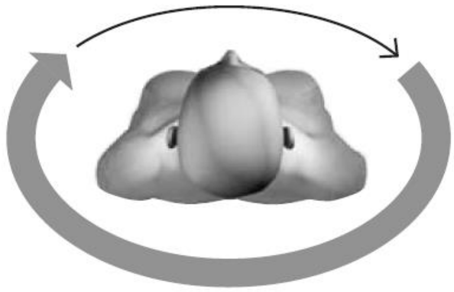

Fig. 5. Illustration of principle of organ-based tube current modulation with X-CARE. With this technology it is possible to reduce the exposure to radiosensitive organs such as the breast, thyroid or eye lens. This is achieved by decreasing the tube current by 75% of the maximum value while the x-ray tube is covering an anterior angular range of 120 degrees (thinner arrow) and then increased for the remaining view angles (thicker arrow).

Automated Tube Potential Selection

The selection of the tube potential in a CT examination has three main consequences. First, the tube potential influences the radiation exposure, with a relationship defined by $[kV_{new}/kV_{old}]^n$, where n is between 2 and 3 (depending on the patient's size). Second, because the tube potential affects the overall radiation exposure, the image noise is also affected; the lower the radiation exposure the higher the image noise. Therefore, the tube current typically has to be adjusted to compensate for an excessive increase in image noise when lowering the tube potential. The third consequence of changing the tube potential is that it directly impacts the image contrast of radiological relevant tissues and materials such as calcium and iodine. For either of those two materials, their contrast relative to soft tissue increases with reduced tube potential.

Various scientific studies have been done investigating the benefits of using lower tube potential, particularly for applications using iodinated contrast agents [49] [50]. One approach attempts to quantify the gain in image quality (i.e. CNR) while at the same time establish the dose efficiency by calculating a figure of merit, based on the square of the CNR and the radiation output, the dose weighted CNR (CNRD):

$$CNRD = \frac{(C_{iodine} - C_{water})^2}{\sigma^2 \cdot CTDI_{vol}}$$

Using the CNRD it is possible to demonstrate that for imaging tasks that use iodine, typically the use of tube potentials below 120 kVp can lead to improved dose efficiency, that is, a higher CNR at a lower dose (**Fig. 6**).

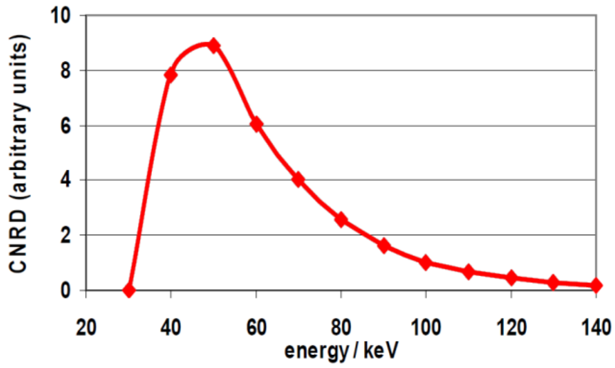

Fig. 6. Dose-weighted contrast to noise ratio (CNRD) as a function of photon energy (keV) for iodine relative to water. Since the mean energy of a polychromatic CT spectrum decreases with kVp, optimal CNRD is often found for lower kVp values (e.g 80 or 100 kVp) when the material's attenuation increases at lower energy values.

One challenge people often face when trying to effectively implement the consistent use of reduced tube potential is how to simultaneously adjust the tube current. Moreover, it is also necessary to consider the patient size, since practical issues such as the tube power limit may prevent the use of reduced tube potential for very large patients [49]. While many hospitals have experience with setting the quality reference mAs for conventional 120 kVp examinations with AEC; this is often not the case when using a reduced tube potential such as 80 or 100 kVp. Therefore, users are more uncertain about which reference mAs should be used to maintain a desired level of image quality. One possible solution is to create comprehensive look-up tables or manual charts. However, this approach could be difficult to implement in a busy clinical environment and it could also be error prone. A more effective approach would be the ability to automatically select the tube potential [51]. One commercially available solution is CARE kV (Siemens Healthcare, Forchheim, Germany) that automatically selects the combination of tube potential and tube current according to patient size and diagnostic task.

The input to CARE kV consists of the patient CT localizer radiograph (i.e. topogram) and the user selection of an optimization setting based on the exam type (e.g. non-contrast, contrast-enhanced or angiography). Based on this input, CARE kV calculates the patient's attenuation and establishes a desired CNR associated with the diagnostic task selected. Then, CARE kV compares all combinations of tube potential and corresponding tube current values that reach the target CNR, and selects the combination that achieves this task at the lowest radiation output (i.e. $CTDI_{vol}$). For smaller patients, the system would typically select lower tube potential values, especially for contrast-enhanced examinations; while for larger patients the value often remains at 120 kVp. Furthermore, for non-contrast examinations in obese patients, CARE kV may suggest to increase the tube potential from 120 to 140 kVp, because the CNR might be slightly improved at 140 kVp due to less image noise at the same contrast.

Various studies using CARE kV have demonstrated substantial dose reductions ranging from 20 to 60% relative to scanning with 120 kVp. These dose reductions were achieved while maintaining or even improving image quality in CT applications such as CT angiography [52], contrast-enhanced body imaging applications [53], cardiac CT [54], and pediatric CT examinations [55].

IV. ITERATIVE RECONSTRUCTION

Iterative reconstruction (IR) has quickly become a standard feature on modern CT scanners, considering that first commercial implementations started to appear by 2009. The goal of using IR is to be able to acquire CT data with lower radiation exposure (e.g. by reducing mAs or kV) while maintaining image quality (e.g. image noise, spatial resolution, low-contrast detectability, etc.) and overall diagnostic performance similar to conventional filtered backprojection (FBP) reconstruction from higher dose CT data. Unlike FBP, IR can incorporate more information in the reconstruction process by modeling the system geometry, imposing smoothing constraints (i.e. regularization), and by incorporating physical effects such as beam hardening or scattering [56] [24] [57]. Implementing these aforementioned aspects of IR can result in very long reconstruction times and make IR of limited use in a busy clinical environment. The first generation IR methods have concentrated only on the regularization aspect (i.e. noise reduction). One of those techniques was Iterative Reconstruction in Image Space (IRIS, Siemens Healthcare, Forchheim, Germany) which incorporates a noise model to preserve spatial resolution and reduce image noise. The second generation IR methods began to improve noise modeling in the image space while also incorporating a feedback loop (i.e. forward projection) in the projection (raw) data domain to reduce artifacts caused by the non-exact (in mathematical sense) nature of FBP. This is the case of Sinogram Affirmed Iterative Reconstruction (SAFIRE, Siemens Healthcare, Forchheim, Germany), which achieves both noise reduction and artifact suppression [58]. SAFIRE has been combined with reduced tube current and reduced tube potential acquisition to increase the dose reduction potential [59] while maintaining image quality (**Fig. 7**).

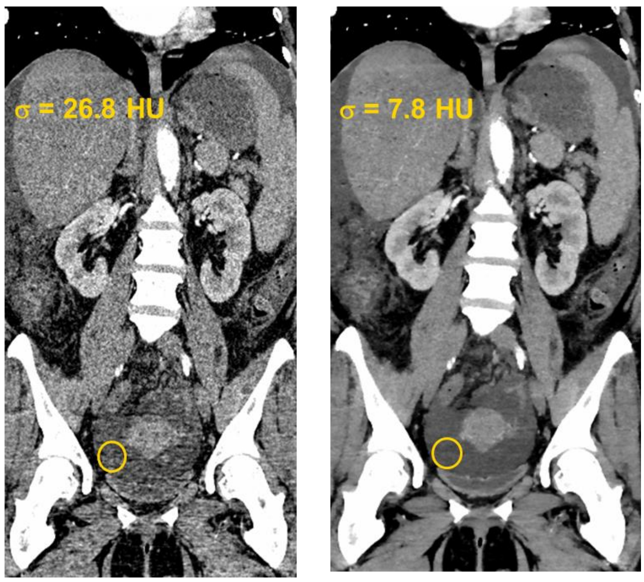

Fig. 7. Example comparing image reconstruction of the same CT dataset using (left) standard filtered back-projection (FBP) and (right) iterative reconstruction with SAFIRE. The dataset corresponds to a abdomen-pelvis examination of an adult patient. The image reconstructed with SAFIRE exhibits a lower noise, better CNR at maintained spatial resolution compared to the same image reconstructed with standard FBP.

Most recently, third generation IR methods have emerged, in which more detailed modeling in the projection data domain results in less noise streaks and better artifact suppression; while the improved three-dimensional regularization process results in better noise reduction in the image domain. An example of the third generation IR is the recently introduced Advance Modeled Iterative Reconstruction (ADMIRE, Siemens Healthcare, Forchheim, Germany). A combination of ADMIRE with other scanner advances has already demonstrated the potential for dramatic dose reductions in applications such as lung cancer screening. For example, a recent phantom study using the SOMATOM Force and ADMIRE showed that image quality and CT number accuracy were maintained using a $CTDI_{vol}$ of only 0.15 mGy, which is comparable to the exposure of two-view chest radiographs [60].

A large number of publications have reported the effectiveness of IR methods to reduce image noise of lower dose acquisitions. This is prevalent across manufacturers who currently offer one or more types of IR approaches. However, due to the nonlinear nature of IR there is a greater awareness that simple metrics of noise reduction or CNR are insufficient to fully characterize these methods. Other effects such as noise power spectra, spatial resolution, and viewer conditions may affect the actual human observer performance. Several research groups have been putting serious efforts in the development of model observers to attempt to better characterize the actual radiation dose reduction potential of IR for various diagnostic tasks, most notably for low-contrast detectability [61] [62] [63] [64].

V. APPLICATION-SPECIFIC TECHNOLOGIES FOR DOSE OPTIMIZATION

Cardiac CT

There exist two major approaches for imaging the heart with CT: retrospective ECG-gating with a spiral CT acquisition and prospective ECG-triggering with a sequential CT acquisition (**Fig. 8**). One standard feature for dose reduction in the retrospective mode is to modulate the tube current to a lower value outside of a predefined cardiac phase of interest [65]. For example, in most cardiac examinations (heart rate ≤ 65 beats per minute) the optimal cardiac phase is around 70% (measured between two R peaks in the ECG signal), coinciding with mid to late diastole, which is when the heart is moving the least. Thus, with this technique the tube current is only maintained at its maximum value near the 70% phase: for example in a temporal window between 60 to 80%, while the tube current can be decreased to a lower value (i.e. 20% of the maximum tube current) outside this 60-80% cardiac phase range. The cardiac phase range corresponding to the maximum tube current window can be narrowed or widened according to the user needs and this will directly impact the total exposure delivered to the patient. One modern approach to this technique is the adaptive ECG-pulsing (Siemens Healthcare, Forchheim, Germany); in which the dose modulation for a cardiac scan is ECG-controlled. The ECG-pulsing algorithm is able to quickly react (by widening the acquisition window) when detecting an arrhythmia or ectopic beats so that image quality is maintained. This technique is recommended for patients with higher and unstable heart rates. On the other hand, a related innovation for this type of cardiac acquisition is to reduce the tube current outside the pre-defined acquisition window to only 4% of its maximum value (MinDose, Siemens Healthcare, Forchheim, Germany). With this type of ECG-based current modulation, it is possible to reduce mean radiation dose by up to 50% [65] relative to the acquisition without tube current modulation.

The prospectively triggered technique typically uses a sequential acquisition instead of spiral. Just like with the retrospective mode, the ECG signal is used to define a desired cardiac phase, but unlike to the retrospective mode, the x-rays are only applied during the cardiac phase of interest. Hence rather than decreasing the tube current to a lower value, the x-rays are turned off during the non-selected cardiac phase range. However, this mode traditionally works best for patients with relatively low and stable heart rates. An implementation of this type of cardiac CT acquisition is available as Adaptive Cardio-Sequence (Siemens Healthcare, Forchheim, Germany). This mode achieves more robust performance in cases with occasional ectopic beats by using an improved arrhythmia detection algorithm. With the use of these technologies, typical effective doses in the range of 1 to 3 mSv have been reported [66].

Fig. 8. Illustration of cardiac CT data acquired using adaptive ECG-pulsing in spiral CT (left) and with the adaptive cardio sequence (right) using a SOMATOM Definition dual-source CT system.

Ultra-fast scanning: Dual-source high-pitch technique for prospectively triggered cardiac CT

This technique is enabled by the use of the dual-source CT in which it is possible to operate the scanner with a high-pitch value of 3.4; which doubles the maximum pitch of 1.5-1.7, traditionally possible in conventional single-source CT system [67]. The basic principle of the high-pitch scan mode is that gaps in the projection data generated from one x-ray source are filled up by the data generated from the second x-ray source which is arranged perpendicularly to the first in a dual-source CT system (**Fig. 9**). Because no redundant data is acquired, this mode can reduce dose even further compared to the prospective sequential mode, while maintaining the image quality [68]. With this technique, it is possible to image the entire heart within one heart beat with excellent temporal resolution and often with less than 1 mSv effective dose when used in combination with lower tube potential such as 100 kVp [69]. The best image quality is achieved in patients with stable heart rates ≤ 60-65 bpm (SOMATOM Definition Flash) and ≤ 70-75 bpm (SOMATOM Force).

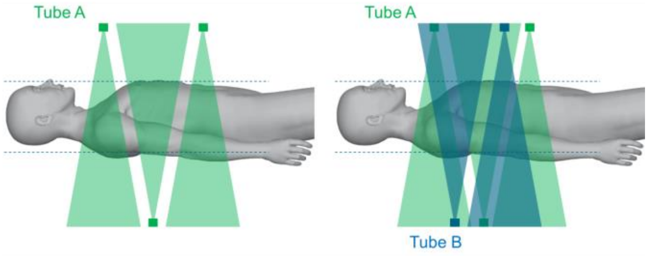

Fig. 9. Principle of high-pitch dual-source CT. A high-pitch value of up to 3.4 can be reached. The projection data gaps generated from projections recorded from exposure with one of the x-ray tubes (Tube A) are filled up with projections acquired from exposure from the second x-ray tube (tube B). Both x-ray tubes are arranged perpendicularly within the CT gantry. Dashed lines indicated the field of view in which image data is reconstructed (e.g. 33 cm in the SOMATOM Definition Flash dual-source CT).

Dual-Energy CT

In dual-energy CT two datasets are simultaneously acquired using two different tube potentials, most commonly 80/140 and 100/140 kVp. An advantage of using dual-energy CT over conventional single-energy CT is that in addition to anatomical imaging, it is possible to discriminate between some materials. Material decomposition with dual-energy CT is primarily based on expressing the attenuation coefficient of a voxel as a linear combination of the attenuation coefficients of two basis materials. This calculation can be done in either projection space or image space [70]. Because material decomposition allows the identification and quantification of materials such as iodine in the CT images, it is also possible to 'virtually' remove the iodine from the images and generate the so-called virtual-non contrast images. In multiple-phase CT studies, such as those commonly performed for imaging the liver or kidneys, virtual-non contrast imaging with dual-energy CT can potentially reduce the radiation exposure by 50 or 33%, in two- or three-phase CT studies. These radiation dose savings are achieved by eliminating the need of the true non-contrast CT images and replacing them with the virtual-non contrast images derived from post-contrast dual-energy CT exam [71] [72].

Another possibility for radiation dose reduction and image quality optimization is the use of virtual monoenergetic (or monochromatic) images calculated from dual-energy CT datasets [70]. Early studies demonstrated that virtual monoenergetic images can provide improved image quality at the same or lower dose when comparing to single-energy CT at 120 kVp [73]. A more recent study, using a new advanced version of monoenergetic imaging (Monoenergetic Plus, Siemens Healthcare), has demonstrated that it can actually provide superior CNR at the same dose compared to scanning with reduced tube potential at 80 kVp; and hence, can potentially reduce radiation dose [74].

VI. STANDARD ATTRIBUTES FOR DOSE OPTIMIZATION AND MANAGEMENT IN CT

In 2013, the national electrical manufacturers association (NEMA) released a set of standards which are expected to become commonplace in all CT scanners [75]. The released standard covers 4 aspects: (1) the use of standard DICOM structured reports to capture post-exam information regarding the radiation exposure such that it can be included in patient records; (2) dose check features that allow the users to set dose notifications and alerts (**Fig. 10**) that are used to inform the user that a predefined 'maximum' radiation output has been reached either for a given scan (dose notification) or the entire exam (dose alert). In case of the dose notification the scanner will inform the user that this maximum has been reached with a message box. In case of the dose alert a warning will also pop up but for the dose alert, the user will have to write down the reason why the dose is exceeded (i.e. clinically justified); (3) existance of reference pediatric and adult protocols stored into the scanner such that they are immediately available after installation; and (4) automatic exposure control needs to be available as one of the essential features for radiation dose optimization.

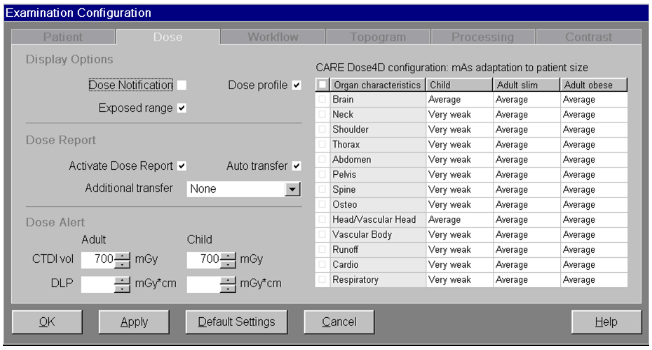

Fig. 10. Screenshot of the dose configuration screen in a Siemens CT system. This page is used to set up dose notifications and dose alerts, among others. When set up values are reached during an examination, the scanner will display the corresponding notifications or alerts to inform the user that a threshold has been reached. In the case of the dose alert, the user will need to write down an explanation why the value has been exceeded (i.e. medical reason) in order to continue the CT examination. In the US, the FDA suggested that the default value for dose alert be set at 1000 mGy.

VII. CONLUSIONS

We reviewed recent technological advances impacting each of the key components of the CT imaging chain starting from its essential hardware components, the systems control of key variables such as tube current and potential, and the image reconstruction engine. These advances help to tailor the CT examination to individual patients but also to different diagnostic tasks. Furthermore, we reviewed how specific technologies are modified to optimize image quality and reduce radiation dose in advanced applications such as cardiac CT, ultra-fast scanning, or dual-energy CT. It is recommended that radiologists, medical physicists, and CT technologists become aware of these newer technologies and make use of them to benefit patients.

These new technologies provide more opportunities for automation in the selection of technique parameters. This becomes increasingly important for consistency in everyday practice, particularly in busy environments. In addition, newer tools such as dose structured reports, dose notifications and alerts (when properly set up) can aid in monitoring radiation exposures and avoiding errors.

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PRACTICAL AND APPLIED MEDICAL PHYSICS

A Website for Teaching Tubestand / Bucky Alignment Principles

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Abstract—**Even in the world of digital imaging, fundamental physics principles still apply. Misalignment of the x-ray tube and image receptor can cause image distortion, grid artifacts, and phototiming errors. A website was developed to illustrate these principles using a multi-modality approach. In addition to explanations of the effects of misalignment, the website also includes videos as well as a simulator demonstrating how stationary radiographic systems achieve alignment.**

Keywords— **Radiography, Grids, Artifacts**

I. INTRODUCTION

Even with the many technical advances is the field of radiographic imaging, fundamental physics principles such as image geometry and grid alignment remain as important as ever. Stationary radiographic systems still hold an advantage over mobile equipment in their ability to provide superior image quality through accurate and consistent alignment of the x-ray tube and image receptor.

Radiology resident physics education at Georgia Regents University begins with a series of hands-on laboratories in an x-ray room. Since they are entering a career in which they are likely to be involved in equipment purchases as well as the supervision of technologists, we felt it important for residents to understand radiographic systems. We also felt it was important to understand the advantages in terms of image quality and consistency provided by stationary equipment, and how the equipment provides these advantages.

The first physics laboratory for new radiology residents consists of an observational tour of an imaging suite. Included in this lab is a demonstration of the tubestand and the way it provides alignment of the x-ray tube to the image receptor. In addition to the obvious radiation safety advantages of imaging in a shielded environment, the image quality advantages of stationary radiographic equipment over mobile units are discussed. The importance of alignment to image quality is emphasized.

In later laboratories, residents make radiation measurements to demonstrate the effects of radiographic technique, automatic exposure control, and changes in absorbers. As part of these later labs, residents are expected to be able to correctly operate the tubestand to satisfy the various system interlocks.

While most textbooks on radiology physics discuss image geometry, distortion, and grid cutoff, there is little on how equipment assists in achieving correct alignment of the x-ray tube to the image receptor. The work described here was an effort to develop a website which illustrates the lessons demonstrated in our physics lab. Websites offer flexibility in the presentation of material not possible in a textbook. In addition to text descriptions and figures, the website offers two additional features. The first was the inclusion of several short video segments showing the use of alignment tools provided by stationary radiographic systems. The second element is a tubestand simulator demonstrating the process of equipment positioning.

II. METHODS

Because radiology residents do not routinely spend much time working with radiographic systems, a web site was developed to not only describe the importance of proper geometry to image quality but also how a stationary radiographic system achieves this geometry. The importance of alignment to image quality is emphasized, as it relates to geometric distortion as seen in figure 1.

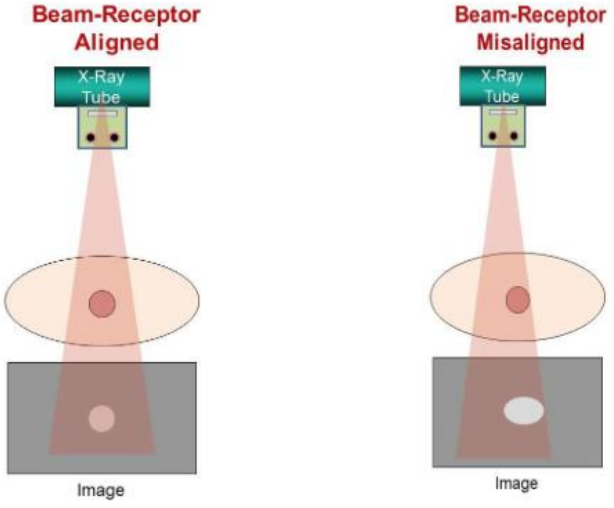

Fig. 1 Image Distortion Caused by Misalignment of the Tube and Receptor

Also described is the importance of alignment with the use of a grid. The various types of grid misalignment and the effect of each on the appearance of the image and on patient dose are described using text and graphics as seen in figure 2.

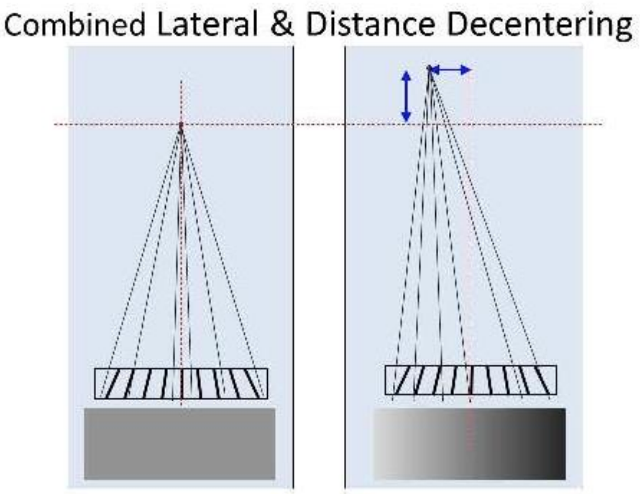

Fig. 2 Graphic Illustrating Grid Misalignment Artifact

Stationary radiographic units incorporate alignment tools not available on mobile systems. Our web site highlights these tools along with photos and videos showing tubestand manipulation. An example is shown in figure 3.

Fig. 3 Embedded Video Showing Tubestand Alignment Process

The site also includes a simulator demonstrating tubestand alignment. Either tabletop or bucky mode can be selected. The user can move the tube in the longitudinal, lateral, and vertical while the bucky can be moved longitudinally. When bucky exposure mode is selected, the user cannot get a "ready" light until the lateral and vertical detents are engaged. As is the case for actual systems, longitudinal alignment is accomplished manually. The simulator is shown in figure 4.

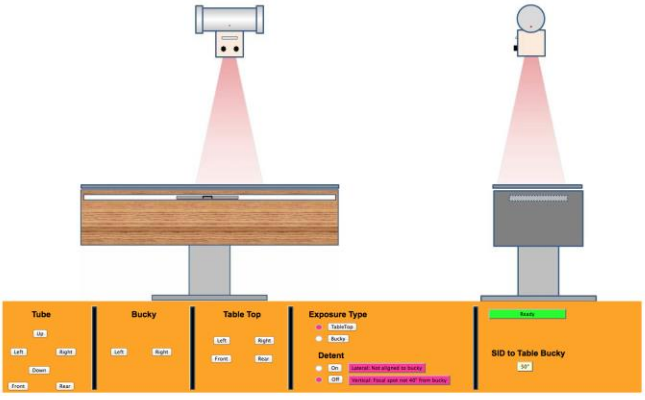

Fig. 4 Tubestand Simulator

III. DISCUSSION

An important aspect of achieving quality is the identification and reduction of variation in a process. Stationary radiographic equipment provides tools allowing the technologist to achieve a consistency in the alignment of the x-ray tube to the image receptor that is impossible using mobile radiographic equipment.

While mobile imaging should only be performed if a patient cannot be transported to stationary equipment for radiation safety or for medical reasons, this is often not the case in practice. It is not uncommon for mobile examinations to be performed because hospitals do not have transport personnel after normal work hours or for other reasons unrelated to the medical condition of the patient.

It is important for radiologists to understand how stationary systems provide positioning consistency and the compromises to image quality and radiation safety associated with mobile examinations. Radiologists need to be able to interact with technologists and administrators to ensure mobile exams are only performed when medically necessary and not for the sake of convenience.

Identification and understanding of the issues associated with mobile examinations are components of the education of radiology residents. At Georgia Regents University, this education begins with a series of laboratories in stationary x-ray rooms where alignment tools can be demonstrated. A web site was developed to illustrate the physics principles associated with misalignment such as distortion and grid effects. The web site uses photographs, videos, and a tubestand simulator to teach alignment principles previously only available in laboratory classes.

The website described here can be accessed at the following link:

http://www.gdavidasp.net/Tubestandsim/Index.html

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HISTORY AND HERITAGE

ROENTGEN'S INVESTIGATION DETERMINING THE CHARACTERISTICS OF X-RADIATION

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Abstract—**Following the discovery of a "new kind of rays," to be named by him as x-radiation, and others as Roentgen's rays, Dr. Roentgen embarked on an intense investigation in a series of innovative experiments to determine its properties and characteristics and how it compared to other known radiations, specifically light and cathode rays. He demonstrated that the radiation produced fluorescence and exposed photographic plates. The revolutionary discovery was that it penetrated normally opaque objects and produced shadow images of things within. It was these characteristics alone that were the foundation of x-ray imaging that soon changed and enhanced the practice of medicine around the world.**

For additional experiments he developed a variety of test devices that continue to be used by physicists for evaluating the performance of x-ray equipment and devices. These included a pinhole camera, step wedge, and an innovative device to become known as a penetrameter. A major focus of his work was investigating the penetration of the radiation through a variety of objects and materials. He demonstrated, and often documented with photographic images, that penetration related to both characteristics of the material (thickness and density) and the x-ray beam itself (pressure within the tube, the associated electrical voltage, and filtration of the beam). Having observed the effect on electrical charges in the vicinity of the x-ray apparatus he developed a series of experiments to demonstrate the direct ionization in air.

Within just a few months of intense research he discovered, evaluated, and documented virtually all of the properties and characteristics of x-radiation as we know them today.

Keywords— **Roentgen, x-rays, discovery, investigate, properties.**

I. INTRODUCTION

It is well known that a "new kind of rays," to be named x-rays or Roentgen's rays, were discovered by Wilhelm Roentgen while experimenting with cathode rays on the evening of November 8, 1895. What is less known and appreciated within the physics community is the extensive investigations he conducted following the discovery to determine and document the properties and characteristics of this radiation.

Through a series of innovative and carefully conducted experiments he demonstrated most of the major properties of x-radiation even as we know it today. The results were published in three articles that are the source of information and references for this article.

Here his observations and findings are quoted along with illustrations added by the author. The illustrations represent the author's understanding of the experiments based on the published descriptions.

Fig.1. An imaginary conversation between Dr. Roentgen and the author

That was actually a question by a writer for a magazine preparing an article on his discovery. His answer is very significant. It illustrates his recognition that it was necessary that he determine the properties and characteristics of this new kind of radiation before publishing or discussing it with others.

II. THE DISCOVERY

Before the time of the discovery physicists in various institutions were experimenting with partially evacuated glass tubes connected to high-voltage sources of electricity. It had been determined that streams of accelerated electrons, or cathode rays, were produced within the tubes. If a tube had a sufficiently thin window, some of the cathode rays penetrated into the surrounding air. Roentgen was experimenting with cathode rays coming from a tube when he made the discovery. Typically the tubes would glow because of the ionization of the air that remained in the tube. This light was interfering with Dr. Roentgen's experiment of observing fluorescence produced by the cathode rays close to the tube. To produce a dark environment he enclosed his glowing tube with an opaque cover. It was in this darkness that he noticed light being emitted from a fluorescent material at some distance from the tube--a distance much greater than the range of cathode rays in air.

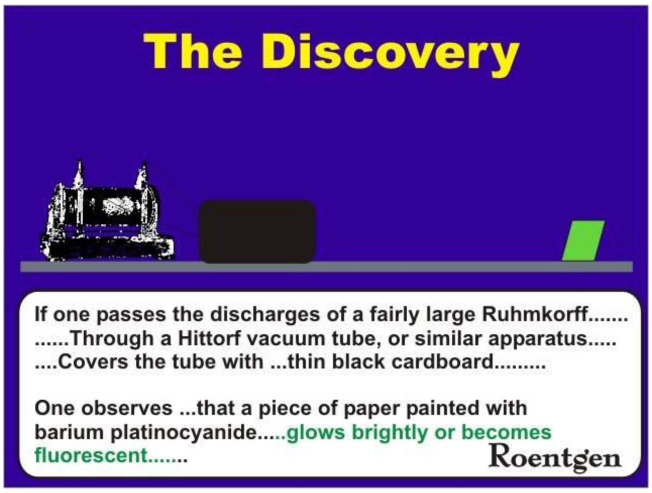

Fig. 2. The equipment that produced the x-radiation leading to the discovery

After associating the fluorescence with an invisible radiation from the tube he determined it would penetrate a variety of normally opaque materials and produce shadows. When holding an object, perhaps a piece of metal, he saw a shadow of the bones within his hand as illustrated below.

Fig. 3 An illustration of what Roentgen saw. Shown here is the author's hand in a recreation.

III. EXPERIMENTS

What followed these initial observations was a period of intense experimentation to investigate and determine the characteristics and properties of the "new kind of rays". Some of the major experiments are now described.

Transparency of objects to the new kind of radiation: This appears to be one of the first characteristics that were investigated with several experiments. One was the penetration of the radiation through a book.

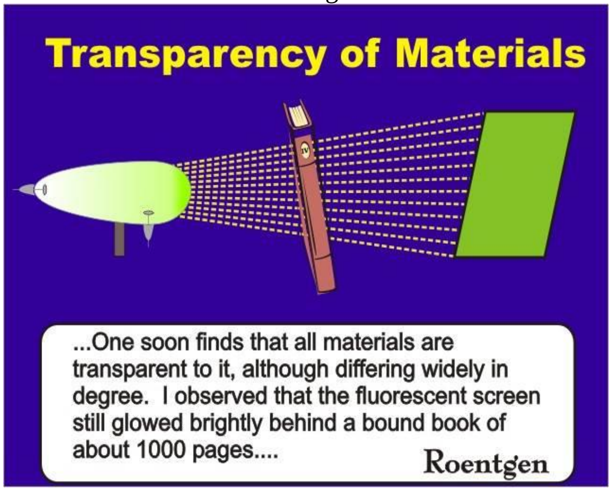

Fig. 4. A thick book was one object that was penetrated by the radiation.

Propagation in straight lines (like light)**:** In the investigation of the characteristics of the new radiation it would have been logical to consider how it compared to other known radiations at that time such as light and cathode rays or electrons. A pinhole camera was used to verify the straight line propagation, demonstrating it shared some properties with light.

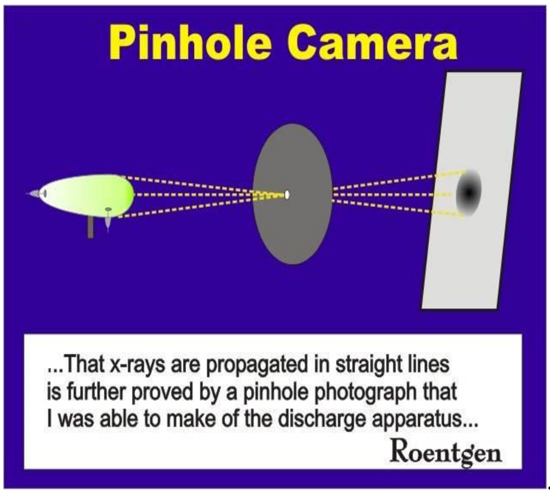

Fig. 5. Using a pinhole camera to compare characteristics to those of light.

The pinhole camera was used in several experiments. It produces an image of the actual x-ray source. This is the technique that has now been used by physicists to determine the actual size and distribution of radiation for x-ray tube focal spots.

Reflection (like light)**:** The question is whether x-rays are reflected from surfaces as light is reflected.

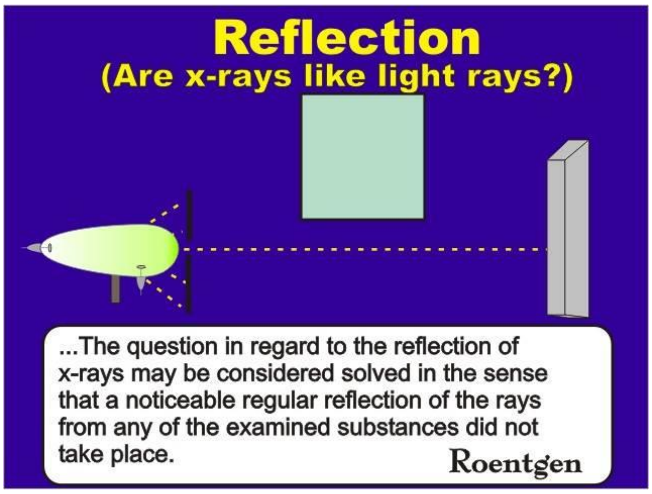

Fig. 6. Reflection of x-rays from a variety of materials was not observed.

Scattering of x-radiation*:* In an interesting experiment described here the observation was reported as reflections from several metals. This appears to be scattering or the production of secondary radiation from within the metal objects and not reflections from the surfaces, as light would be reflected.

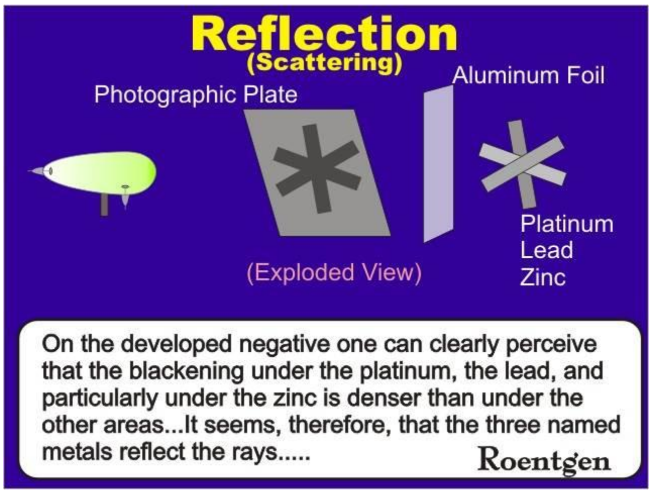

Fig.7. An experiment that apparently demonstrates the formation of a secondary radiation by different metals.

Refraction of x-radiation: A logical investigation was to determine if x-radiation undergoes refraction, a property that would be shared with light.

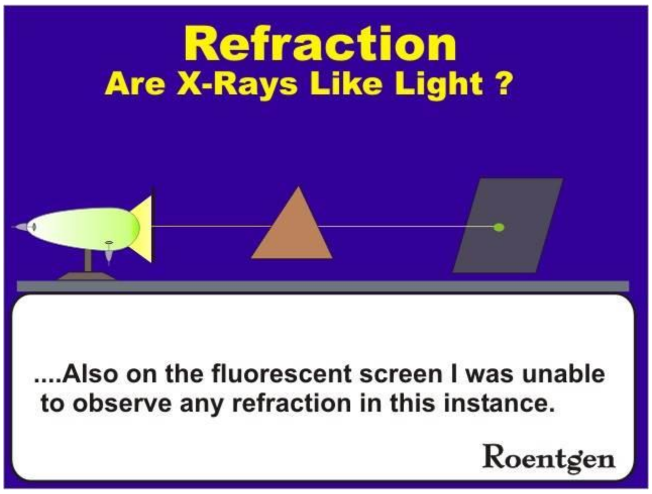

Fig.8. An experiment to investigate the possibility of refraction within a material.

Experiments were conducted using a variety of materials to determine if x-rays refracted, or changed direction, when moving from one material to another. There was no indication of this which suggested that x-rays could not be focused with a lens.

Do x-rays have magnetic properties? This was a continuation of experiments comparing x-radiation to known radiations--in this case, cathode rays.

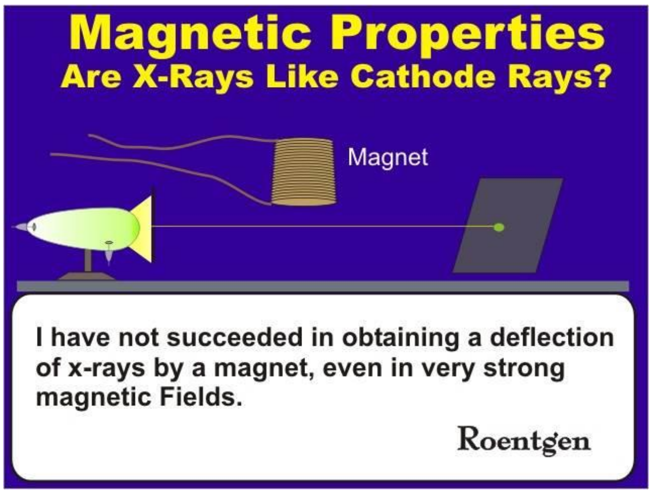

Fig.9. Cathode rays within a tube can be deflected with a magnet, but not x-rays emitted from a tube.

Effect of Object Thickness on Transparency**:** Having already observed that a variety of materials were transparent to x-radiation, attention was turned to investigating the relationship to material characteristics.

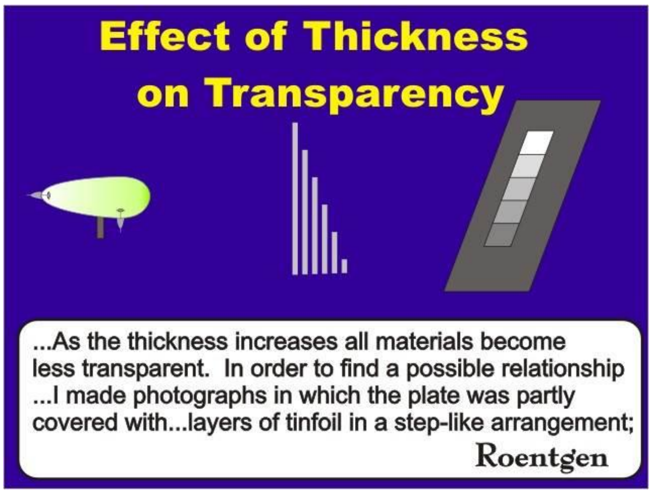

Fig.10. The use of a step wedge to investigate the effect of thickness on transparency.

In other experiments the effect of material density on transparency was studied. It was observed that the product of density and thickness was not the only factor affecting penetration. Various substances had different attenuations even when the product of density and thickness was the same. This third characteristic, in addition to thickness and density, was not specifically identified at that time. Today we know that characteristic is the atomic number (Z) of the material.

It was the ability to penetrate materials that made the x-radiation completely different from any other known radiations. Therefore it was the property studied in many experiments to determine the characteristics of both materials and the radiation that determined penetration.

Characteristics of the radiation that affect penetration. To investigate what we would recognize as the spectral characteristics of the radiation, Roentgen constructed and used a device that was the first of what would become known as a penetrameter.

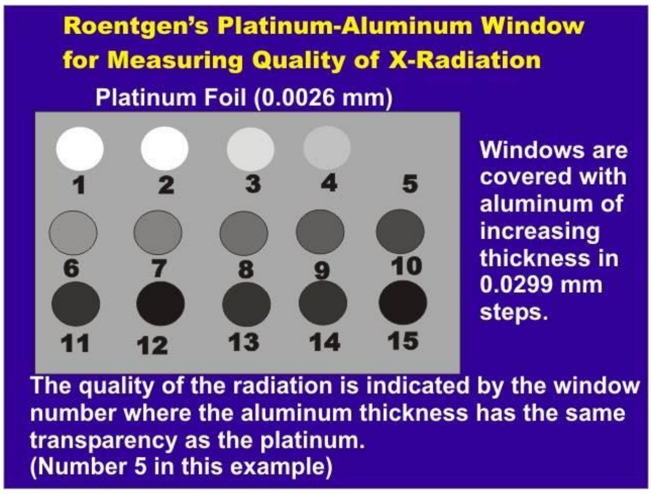

Fig.11. The general design of a device developed to investigate the spectral characteristics or quality of the radiation.

This is based on the principle that would be used years later for measuring the KV of x-ray spectra. It was built into a cassette and was a common test instrument used by physicists until the development of digital electronic KV meters. Similar devices are used in industrial radiography.

Filtration. It was observed by Roentgen that filtration increased penetration and he used his device to measure the effect as illustrated here.

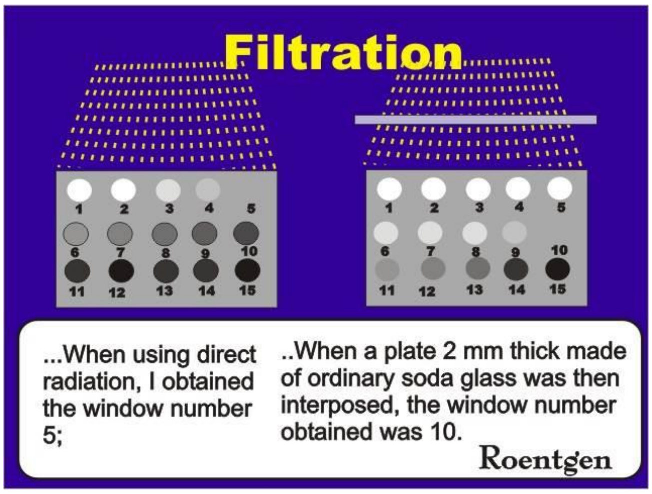

Fig.12. Measuring the effects of filtration on an x-ray beam spectrum.

X-ray tube pressure or "hardness". The pressure, or quality of the vacuum, in these early tubes was highly unstable and varied considerably. The pressure within a tube also was a factor in determining the voltage that developed across the tube. The terms "soft" and "hard" were used to describe the range of pressures and how the tube was operating. The glowing region within a tube varied with the pressure and could sometimes be used to judge its degree of "hardness".

The major significance was that as a tube became "harder" with reduced pressure the radiation became more penetrating. Roentgen observed this effect on the human hand as illustrated below.

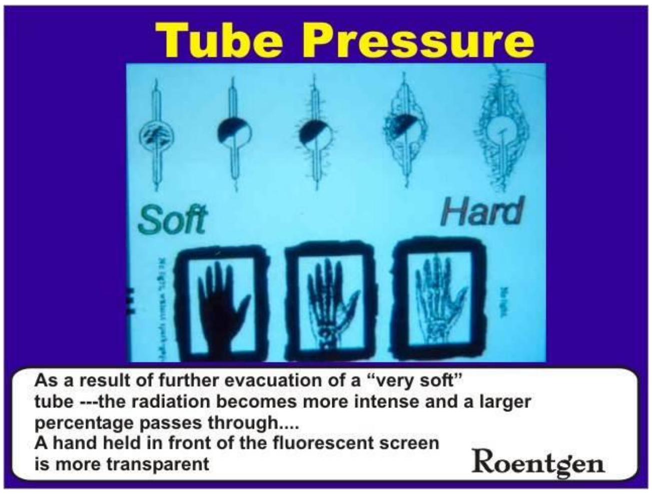

Fig. 13. Roentgen's observation of the effect of tube "hardness" on penetration through a human hand. Also illustrated is the change in the glowing region within a tube with pressure. This particular drawing is thought to be from a source other than Roentgen.

This variation in tube pressure was a considerable problem with the early x-ray tubes. Holding the hand in front of a fluoroscopic screen was a common practice to judge the degree of "hardness" and when the beam was appropriate for an imaging procedure.

This problem, along with some other limitations, was eliminated by the development of the hot-cathode tube.

Effect of anode material on x-ray production. Roentgen used a dual anode tube to demonstrate the effect of anode material on the efficiency of x-ray production. He experimented with several electrode configurations within tubes. His earlier tubes, such as used at the time of the discovery, were obviously not designed as x-ray tubes with anodes arranged for that purpose. As he learned more about how the radiation was being produced he obtained and used tubes that were designed for that purpose.

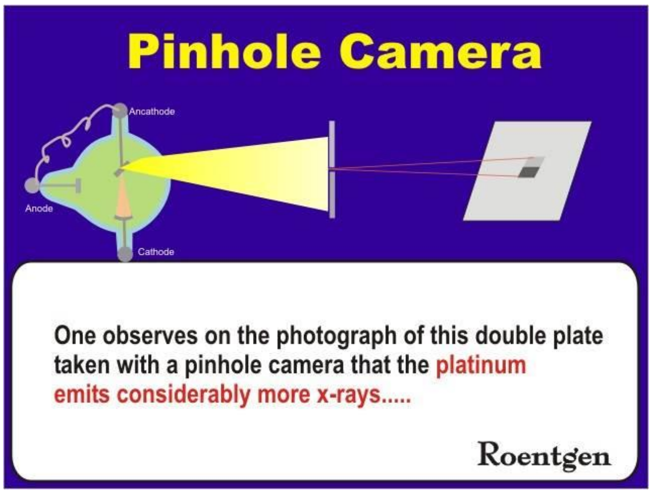

Fig. 14. An experiment to demonstrate the effect of anode materials.

Ionization of air.

Early in his investigations Roentgen had observed that x-rays were able to discharge electrified bodies. Before publishing on this he wanted to verify that the ionization of the air was being produced directly by the x-rays and not the high-voltage fields and discharges around the tubes and electrical apparatus. To isolate his experiments from the electrical fields he conducted them inside a large metal box into which only the x-rays could enter through a small hole.

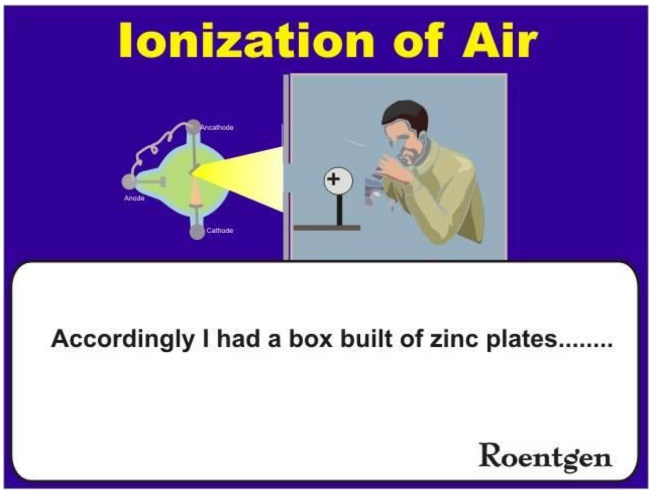

Fig.15. A shielded enclosure to investigate the ionization of air.

One experiment to demonstrate that the ionization was in the air and also remained in the air for some time is illustrated below.

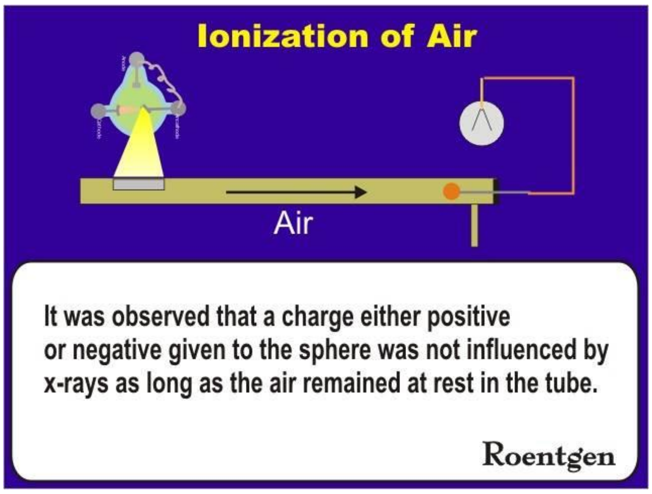

Fig.16. Verifying that the ionization was within the air.

IV. RESULTS AND CONCLUSIONS

During a period of less than three months of very intense experimentation Roentgen discovered, evaluated, and documented essentially every property and characteristic of the new kind of radiation as illustrated below.

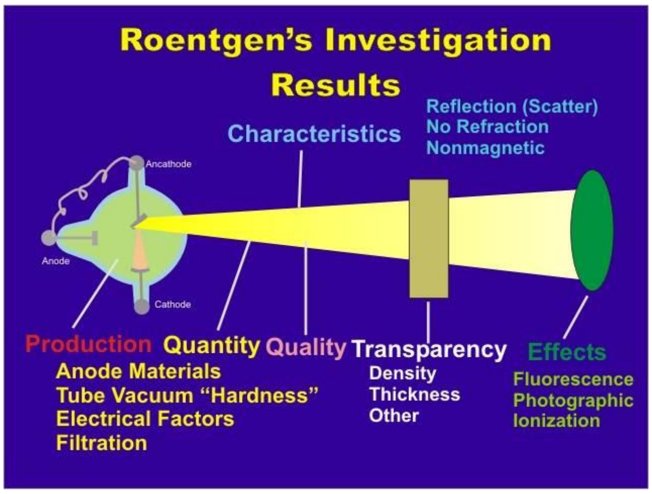

Fig.17. The properties of x-radiation that were investigated by Roentgen along with a summary of the results.

V. THE PRESENTATION

He submitted his first paper (Ref.1) for publication on December 28, 1895, less than two months after the discovery. In addition to submitting it for publication he sent reprints to several colleagues and distinguished scientists at other institutions. It was through this distribution of reprints to persons who understood the significance of his discovery and preliminary investigations that it was introduced to the world.

Following his first paper and announcement Roentgen received invitations from various groups, including the German parliament, the Reichstag, to lecture and describe his work and discovery, which he refused. The invitation that he did accept was from his Wurzburg colleagues and the Wurzburg Physical-Medical Society. This was delivered as shown below to a large audience of professors, high-ranking government officials and military officers, and students.

Fig. 18. Roentgen's public lecture and demonstration of the new kind of radiation.

He began by stating that because of the interest that had developed he believed it was his duty to discuss his work but that the experiments were still in a preliminary stage. He then referred to the work of several others, including Hertz and Lenard, and that this had encouraged him to conduct experiments along the same lines. He then described his observation of fluorescence of the small screen and that the tube was the source. He focused on the penetrating characteristics of the radiation, which he said he discovered by accident, and the use of photography to demonstrate this characteristic. He then demonstrated with several materials and objects.

Perhaps the highlight of the presentation was when he asked His Excellency Albert von Koliker, the famous anatomy professor, for permission to produce an x-ray image of his hand. When the image was developed and shown to the audience it generated tremendous applause. Von Koliker stated that in his many years (almost half a century) of attending medical and scientific meetings, this was the most significant presentation he had experienced. After leading the audience in three cheers for Roentgen he proposed that the new kind of radiation be called "Roentgen's Rays" which was approved by the audience.

References

The references for this paper are the reports published by Roentgen (Ref. 1-3) and the English translations with additional information in the book by Glasser (Ref. 4)

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2. W.C. Roentgen: On a New Kind of Rays. March 9, 1896 (*Continued*)
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4. Otto Glasser: Dr. W. C. Roentgen. Charles C. Thomas-Publisher. First Edition, 1945.

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ANNOUNCEMENTS

PUBLICATION OF DOCTORAL THESIS AND DISSERTATION ABSTRACTS

A special feature of Medical Physics International (on line at www.mpijournal.org) is the publication of thesis and dissertation abstracts for recent graduates, specifically those receiving doctoral degrees in medical physics or closely related fields in 2010 or later. This is an opportunity for recent graduates to inform the global medical physics community about their research and special interests.

Abstracts should be submitted by the author along with a letter/message requesting and giving permission for publication, stating the field of study, the degree that was received, and the date of graduation. The abstracts must be in English and no longer than 2 pages (using the MPI manuscript template) and can include color images and illustrations. The abstract document should contain the thesis title, author's name, and the institution granting the degree.

Complete information on manuscript preparation is available in the INSTRUCTIONS FOR AUTHORS section of the online journal: www.mpijournal.org.

For publication in the next edition abstracts must be submitted not later than /February 1, 2015.

PhD ABSTRACTS

METHODOLOGY TO ASSESS THE CLINICAL AND DOSIMETRIC IMPACTS RESULTING FROM THE CHANGE OF A CALCULATION ALGORITHM IN RADIOTHERAPY

Abdulhamid Chaikh[1,2]

Supervisors: Jean-Yves Giraud[1,2], Jacques Balosso[1,2]

[1] University Joseph Fourier, Grenoble, France
[2]Department of Radiation Oncology and Medical physics, Grenoble University Hospital, France

Introduction: Treatment planning is one of the main steps in radiotherapy. It involves as a final output the calculation of Monitor Units (MUs), which describe the real quantity of ionizing radiation delivered to the patient. As yet, it is unclear when and how to adjust the prescribed dose by the radiation oncologist when changes are introduced in TPS calculations. In this study we proposed a quantitative method to assess changes introduced by a new calculation algorithms in clinical use for radiation therapy. The ultimate goal is to help the clinician to decide when and how to alter his dose prescription.

Method and materials: This original method is based on dosimetric, statistical and global analysis. The dosimetric analysis is based on the comparison of MUs, isodose curves, cumulative and differential dose volume histograms and quality indices such as the conformity index, homogeneity index, PTV conformity index and geometrical index. The goal of the statistical analysis is to provide the radiation oncologists with interpretable results to help them to make a medical decision. Thanks to its operability with small series, the Wilcoxon signed rank test was used to assess the statistical significance of differences. A p-value < 0.05 was considered as statistically significant. The global analysis is based on 2D and 3D gamma index. To compare the dose distribution using the CT-Scan image, two treatment plans were generated: the reference plan (Dr) using the current algorithm and the tested plan (Dt) using the novel algorithm. The DICOM images including the PTV and the OAR for each patient were exported from TPS Eclipse®. The 2D gamma analysis was displayed using a gamma plot and gamma pixel histogram indicating the fraction of pixels with a gamma index equal or below a specific value. A mean value of gamma ≤ 1 indicates agreement between dose distributions. In order to discriminate an over- from an under-estimated dose using 3D gamma, a sign was attributed to absolute values of γ, i.e. $Dt \geq Dr$ had a positive sign and $Dt < Dr$ had a negative sign. The 3D γ maps and the cumulative Gamma Voxels Histograms (GVH) were generated. The GVH show each voxel according to its gamma value and provided a visual representation of the proportion of voxels which respect the conventional tolerance (3mm, 3%). For this study, the gamma criterion was set at 3% for the dose and 3 mm for the distance to agreement. We considered that the dose distribution using the tested algorithm agreed with the dose distribution, calculated with the reference algorithm, if 95% of the pixels or voxels had gamma ≤ 1.

Clinical application: We applied this method for the change of dose calculation algorithms and the change of irradiation techniques (breast cancer) and we also evaluated the impact of the modification of CT-Scan calibration curve on dose using density correction methods. For clinical comparison, 4 cancer sites were compared including chest cancers, head and neck cancers, brain cancers and prostate cancers.

Results and discussion: The comparison between Clarkson and Pencil Beam Convolution PBC algorithms without density correction showed that the difference for monitor unites was 1.2% for lung and less than 1% for head and neck, brain and prostate ($p>0.05$). The dosimetric parameters derived from dose volume histograms were higher for organs at risks using Clarkson compared to PBC inviting clinicians to make "safer" prescriptions [1].
The density correction methods such as Batho power low, Batho modified and ETAR produced a lower number of MUs than PBC algorithm by an average of 5% for chest cancer including 6 patients. The Wilcoxon test showed a significant difference between PBC and density correction methods ($p<0.001$). Dosimetric parameters derived from the DVH were higher for the planning target volumes and organs at risks using density correction methods when compared to PBC [2]. The quantitative analysis, of dose distribution based on 2D and 3D gamma, confirms the under dosage observed with density correction methods using MUs comparison, for chest cancer when the density correction was done [3]. This means that the risks related to the modification from the homogeneity plan to the heterogeneity plan were the reduction of delivered dose to the PTV and the increase of the dose to the organs at risk, as shown in **figure 1**. For chest tumors, according to this study, the prescribed dose had to be increased by 5% when moving from PBC algorithm to density correction methods in order to obtain the same clinical results.

Conclusion: Our method enables clinicians and physicists to understand treatment modifications associated with any changes in dose calculation procedure: software or irradiation techniques. According to this study the concept of 3D gamma index and the non-parametric statistical test (Wilcoxon) were validated to evaluate and compare the difference of dose in irradiation therapy.

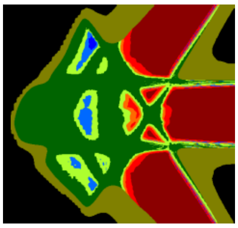
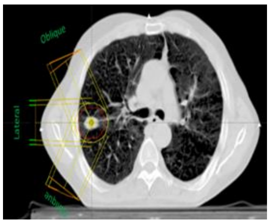
a)  b) 

Figure 1.a. shows a sample of 3D γ maps to compare PBC with modified Batho algorithms. The red and blue colorings indicate that gamma is outside the tolerance criteria showing respectively over- and under-estimated doses for OAR and PTV. Graph 1.b. shows the corresponding treatment planning picture for the parenchyma site.

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2. Abdulhamid Chaikh, Jean-Yves Giraud, Jacques Balosso. A method to quantify and assess the dosimetric and clinical impact resulting from the heterogeneity correction in radiotherapy for lung cancer. Int J Cancer Ther Oncol 2014; 2(1):020110.
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Conflict of Interest : None

ANNEX

50 Medical physicists

who have made an outstanding contribution

to the advancement of medical physics

over the last 50 years

Outstanding Contributions Over the Last 50 Years

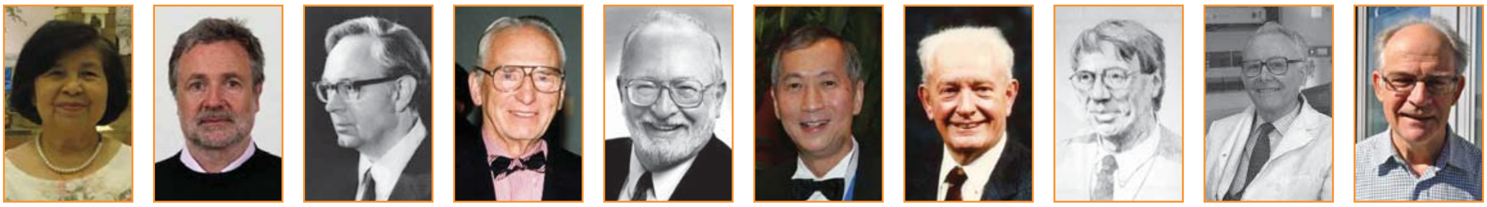
1963- 50 Years of IOMP -2013

Medical physicists who have made an outstanding contribution to the advancement of medical physics over the last 50 years.

To mark the 50th Anniversary of the IOMP, national and regional medical physics organizations were invited to nominate medical physicists, and other closely related professionals, who have made an outstanding contribution to the advancement of medical physics and healthcare through research, clinical developments, education and training activities, service development, and to professional matters over the last 50 years. Whilst in most cases the contribution is of international importance, some of those selected have made such a significant contribution nationally or regionally that the international selection panel considered that they should be recognized.

Barry Allen | Penelope Allisy-Roberts | Carlos E. de Almeida | Peter R. Almond | F. Herbert Attix | Keith Boddy | Caridad Borrás | Anders Brahme | John R. Cameron | John R. Cunningham

Aaron Fenster | Maryellen L. Giger | Dietrich Harder | William R. Hendee | Yimin Hu | Godfrey Hounsfield | Willi Kalender | Constantin Kappas | Kiyomitsu Kawachi | Valeriy Kostylev



Anchali Krisanachinda | Tomas Kron | Lawrence H. Lanzl | John S. Laughlin | Paul C. Lauterbur | C. Clifton Ling | John Mallard | Jim Malone | Peter Mansfield | Sören Mattsson

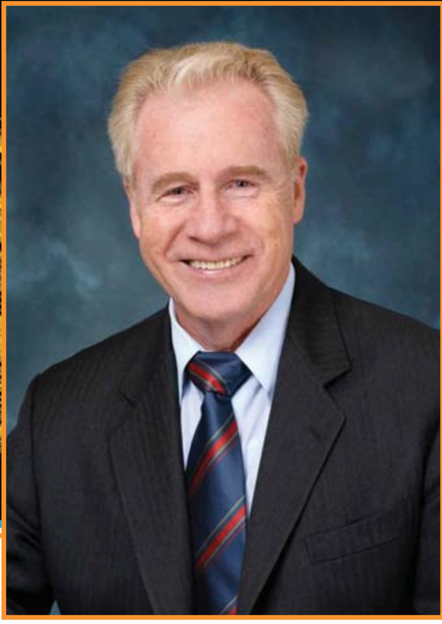
Charles A. Mistretta | Kwan-Hoong Ng | Fridtj of Nüsslin | Colin G. Orton | Jose Perez-Calatuyud | Ervin B. Podgorsak | Ambika Sahai Pradhan | Madan M. Rehani | David W.O. Rogers | Jean-Claude Rosenwald

Wolfgang Schlegel | Tae Suk Suh | Hans Svensson | Eiichi Tanaka | David Thwaites | Giampiero Tosi | David W. Townsend | Jacob Van Dyk | Steve Webb | Peter Wells

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

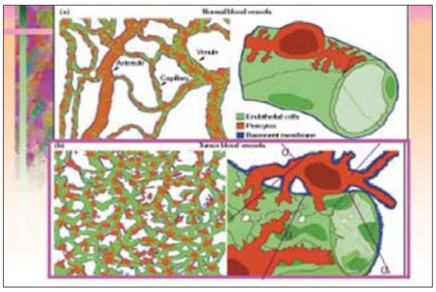


Barry J Allen

Barry Allen PhD DSc is a Professorial Fellow at four Sydney Universities. Previously, he worked at the Australian Nuclear Science and Technology Organisation (ANSTO) as a Chief Research Scientist and more recently as a Principal Medical Physicist Specialist in the Cancer Care Centre and Clinical School at St George Hospital in Sydney.

In the early 1980's Barry Allen began R&D programs in Boron Neutron Capture Therapy (BNCT) for cancer and In Vivo Body Composition (IVBC) for medicine. He designed the in vivo nude mouse irradiation facility at the Moata reactor at Lucas Heights, demonstrating the induction of double strand breaks in DNA arising from neutron capture induced auger emission. Barry went on to become President of the International Society for Neutron Capture Therapy and to convene the Fourth International Symposium in Sydney in 1990.

Barry Allen designed the first human body protein monitor (BPM) in Australia at Lucas Heights, which was installed at Royal North Shore Hospital where it continues to operate today in collaborative clinical studies with most Sydney hospitals. The BPM was an important research tool in studying the efficacy of management of many paediatric and adult diseases and treatments, including cystic fibrosis, renal disease, AIDs, cancer and surgery.



The hierarchy of normal tissue blood vessels is shown in Fig a. The chaotic and leaky tumour capillaries are shown in in fig b, which allow the extravasation of the alpha immune-conjugate to target antigens on pericytes and perivascular cancer cells. Emitted alphas kill the endothelial cells, shutting down the capillaries and starving the tumour.

The Targeted Alpha Therapy (TAT) project, begun in 1994, was successful in developing new agents for the treatment of melanoma and leukaemia, breast, prostate, pancreatic and colorectal cancers. Barry was Study Director of two world first trials of intralesional and systemic targeted alpha therapy for metastatic melanoma, with 51 patients treated in these Phase I trials. Barry developed the tumour anti-vascular alpha therapy (TAVAT) concept to account for regression of solid tumours by alpha therapy, since confirmed by Monte Carlo calculations.

A further development was the biological dosimeter for systemic radiotherapy, based on the formation of micronuclei in lymphocytes. Barry Allen has published over 320 papers in neutron and biomedical physics. Research topics include neutron capture gamma rays, resonance cross sections, stellar nucleosynthesis, clinical in vivo body composition, neutron capture therapy, macro and micro-dosimetry, microbeams, biological dosimetry and preclinical and clinical targeted alpha therapy. He is a co-author of the text book "Biomedical Physics in Radiotherapy for Cancer" (2011).

Professor Allen achieved Fellowship in the AIP (1972), the APS (1981), the ACPSEM (1992) and the Institute of Physics (1999). He was elected President of ACPSEM in 1998, AFOMP in 2003, IOMP in 2006 and IUPESM in 2009, introducing many new initiatives in these organisations, including the Health Technology Task Group for developing countries. He convened the 2003 World congress on Medical Physics and Biomedical Engineering in Sydney.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

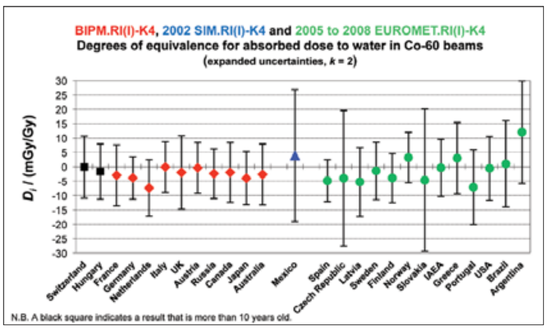
1963-2013

Penelope Allisy-Roberts

Dr Penelope Allisy-Roberts OBE, FInstP, FIPEM, FSRP is known for her work in the field of radiation protection, for which she was awarded an OBE in 1999. Whilst working for the International Bureau of Weights and Measures (BIPM) she oversaw significant developments in the field of ionizing radiation metrology. She has also made a major contribution to the teaching, organisation and professionalism of this discipline.

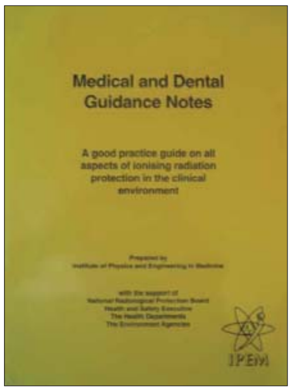
Dr Roberts became a medical physicist in 1971 and first held posts at the Queen Elizabeth Medical Centre in Birmingham, UK, based in the Regional Radiation Physics and Protection Service, of which she became Consultant Physicist and Head in 1988. In 1990, she was appointed Director of Medical Physics and Engineering at Southampton University Hospital. In these posts, she expanded the physics services, training and provision to other hospital departments.

In 1994, she became a radiation metrologist at the Bureau International des Poids et Mesures (BIPM). As Director of the Ionizing Radiation Department there, she was responsible for assuring the metrological equivalence of national standards in radiation dosimetry for x-ray and gamma radiation beams. Under her direction, the range of international standards was expanded to cover dosimetry in radiotherapy accelerator x-ray beams, mammography x-ray beams and high dose-rate brachytherapy with ^{192}Ir . She also assured radionuclide activity metrology standards for some 65 different radionuclides and promoted the development of a transfer instrument for activity measurements of short-lived radionuclides. Her work ensured the future viability of the International System for Radionuclide activity measurements (SIR) at the BIPM. She retired in 2012.



International equivalence of national dosimetry standards assured by the BIPM.

Dr Allisy-Roberts has made a significant contribution to a wide range of organisations serving this field. She has been active in the Institute of Physics and Engineering in Medicine (IPEM) since 1971, becoming its first female President in 1990. She has served on national committees for the Department of Health, Department for Business, Innovation & Skills and the Health and Safety Executive. Internationally, she has served on committees of: the European Council, the International Commission on Radiological Protection, the International Commission on Radiation Units and Measurements, the International Atomic Energy Agency and World Health Organization Network of Secondary Standards Dosimetry Laboratories (SSDL) and the European Federation of Organisations for Medical Physics. She is currently the Secretary of the EU Training and Education in Radiation Protection (EUTERP) Foundation. Her committee work has resulted in several collaborative publications, including the Medical and Dental Guidance Notes and the SSDL Network Charter.



Example of a cooperative effort in medical radiation protection.

ICMP 2013

The International Conference on Medical Physics

50 years of IOMP

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Carlos E. de Almeida

Carlos E. de Almeida, a Brazilian medical physicist, received his MSc and PhD at M.D. Anderson Hospital – University of Texas. He is known for his pioneering work to establish the primary standards for air-kerma for Co-60, medium-energy X-rays and the absorbed-dose standard for HDR Ir-192 sources in Brazil.

Carlos de Almeida's career is marked by his work at the Brazilian National Calibration Laboratory and later on the staff of the National Cancer Institute until 1995. At the NCI, he was the mentor of a markedly successful program, the National Quality Assurance Program in Radiation Oncology, which involved physicists, radiation oncologists and technologists from 32 institutions. He is recognized for his persistence to create and improve educational programs, to enhance awareness of the necessity of well-designed quality assurance programs and to promote the creation and organization of local Medical Physics Societies in the region.

As a consultant to PAHO and IAEA, he has taken several missions in many countries in LA for site evaluation or to teach courses on Medical Physics.

In 1993, he became the first Full Professor in Medical Physics at Rio de Janeiro University, the first Medical Physics Chair in the country and Chairman of the Radiological Sciences Laboratory. Since then, he has combined his academic role at the university with an active role at the hospital. His academic role has resulted in the education of more than 50 graduate students, 18 among whom are from Latin American countries.

His leadership in promoting the quality of medical physics and radiation oncology has been recognized by the Radiation Oncology and Medical Physics Societies. As result, in 2001, he received full recognition by the Latin American Medical Physics Society and in the same year became a Fellow of the AAPM. He was a Visiting Scientist at the BIPM, Institut Gustave Roussy and Institut Curie. He has served as president of the Brazilian Association of Medical Physics. He is a diplomat of the American Board of Radiology and the American Board of Medical Physics.

He has authored or co-authored over 100 scientific articles and several chapters in radiotherapy textbooks.

In 2008, he was awarded the Gold Medal by the Radiation Oncology Society. In 2010, the Academie Francaise de Languedoc awarded him the Becquerel Prize.

In conjunction with IOMP, in 1994, he was the President of the World Congress in Rio de Janeiro, the Chairman of the Education Committee for two terms and a member of the Science and Awards Committees.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Peter R. Almond

Dr. Almond received his undergraduate honors degree in physics from Nottingham University and his training in medical physics from Bristol University, in the United Kingdom. In 1959 he moved to the United States as a fellow in Medical Physics at the University of Texas M.D. Anderson Hospital and Tumor Institute earning his master's and doctoral degrees in nuclear physics from Rice University in Houston in 1960 and 1965 respectively. From 1964 to 1985 he worked at The University of Texas M.D. Anderson Cancer Center in Houston in the Physics Department, where he served as the head of the Radiation Physics section and director of the Cyclotron Unit and Professor of Biophysics. He was a member The University of Texas Graduate School of Biomedical Sciences from1966-1985 and from 1999 to the 2012 as a Distinguished Senior Lecturer. From 1985-1998 he was Vice-Chairman of the Department of Radiation Oncology at the University of Louisville.

Illustration: Dr. Almond was the founding editor and Editor-in-Chief of the electronic Journal of Applied Clinical Medical Physics.

Dr Almond helped develop cancer treatments with various forms of radiation, including high-energy photons, electrons and neutrons. He has been instrumental in developing basic measurement techniques for these radiations, writing calibration protocols for the United States, the IAEA and ICRU. He helped found the journal, Medical Physics, and has served as the North American Editor for Physics in Medicine and Biology. He has served on numerous national and international committees and councils including the NCRP, the NRC and on the Radiation Study Section of the NIH, serving as chairman for two years. He worked on the dosimetry for the atomic bomb survivors for the NAS/NRC.

Academically, Dr. Almond has supervised over 25 masters and doctoral students in medical physics. He has authored or co-authored over 100 scientific articles and numerous chapters in radiotherapy textbooks. He has served as president of the American Association of Physicists in Medicine and as chairman of the Board of Chancellors of the American College of Medical Physics. Dr. Almond is a fellow of the AAPM, ACMP, ACR and the IOP. He is diplomat of the American Board of Radiology and the American Board of Medical Physics. He is licensed as a Professional Medical Physicist in the state of Texas and a Chartered Physicist (C Phys) in the United Kingdom. He has received the Coolidge Award and the Marvin M.D. Williams Professional Achievement Award from the AAPM and the ACMP respectively. He has twice received the Farrington Daniel Award for the best scientific paper on Radiation Dosimetry in Medical Physics. Now retired, he works on the history of medical physics. Springer has just published his book *"Cobalt Blues The Story of Leonard Grimmett, the Man Behind the First Cobalt -60 Unit in the United States."*

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

F. Herbert Attix

There is both great depth and breadth to Professor Attix's scientific achievements in radiological physics. Few medical or health physicists can perform their daily tasks without using some result or experiment ultimately traceable to Herb Attix. These efforts spanned a career of almost 40 years divided roughly into three periods: the National Bureau of Standards (NBS), the Naval Research Laboratory (NRL), and the University of Wisconsin in Madison.

Herb Attix graduated from the University of California with A.B. (cum laude) in Physics and soon joined the NBS. At the Bureau, he had a unique collaboration with L.V. Spencer which resulted in the well known Spencer-Attix cavity theory of ionization. Their cavity theory still stands as the most comprehensive approach to electron-photon cavity response. Much of this research was included in Attix's M.S. thesis from the University of Maryland. Attix was also a major contributor in the development of the free-air ionization chamber for precise and accurate x-ray measurements at the Bureau.

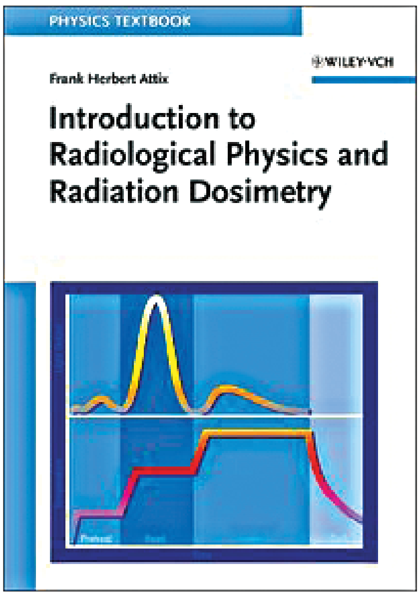


Illustration: Professor Attix published 'Introduction to Radiological Physics and Radiation Dosimetry'.

Attix joined the NRL in 1958 as head of the dosimetry branch and led the way with comprehensive investigations of thermoluminescent dosimeters: TLD response to photons, electrons and neutrons. These efforts led to a new type of TLD adopted by the US Navy, several patents and publications, and the organization of the first international conferences on luminescence dosimetry. With National Cancer Institute sponsorship, Attix led the dosimetry effort in neutron radiation therapy at the NRL. He became a spokesman for fast neutron dosimetry, and chaired the task group of the AAPM responsible for neutron dosimetry in the US radiotherapy program.

When Attix joined the faculty of the University of Wisconsin in 1976 as a Professor of Radiology in the Medical Physics Section, he continued research in dosimetry with publications in fast neutron cavity theory, the invention of A-150-plastic gas, and clarification of several dosimetric quantities. He worked with John Cameron to found the Department of Medical Physics at Wisconsin and served as its Chair for the last two years before his retirement in 1987. He died in 1997.

Professor Attix received the Distinguished Scientific Achievement Award of the Health Physics Society in 1987 and the Coolidge Award of the AAPM in 1994. He had approximately 80 referred articles, 80 invited lectures and 20 books and reports.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Keith Boddy

The career of Professor Keith Boddy CBE started in radiation safety, an interest that continued for the rest of his life, but his work developed to encompass many other areas. During his 20 years leading medical physics in Newcastle, UK, he built up his group to be one of the leading such departments in the country. He was also a major figure in developing the profession nationally and internationally.

After graduating from Liverpool University in 1959, he was appointed Radiation Protection Officer and Head of Health Physics at the Aldermaston Court Research Laboratory where he was the first to report radioactivity in rainfall following Russian nuclear weapons testing. In 1963, he became a lecturer at the Scottish Universities' Research and Reactor Centre where he developed the first high sensitivity shadow-shield and mobile whole-body radioactivity counters. These and other research contributions earned him a PhD and a DSc.

The mobile whole body counter used to measure uptake of radioactivity in the population of UK following the Chernobyl accident. Professor Boddy led the project.

In 1978, he returned his native North East, on appointment as both Head of the Regional Medical Physics Department of the (then) Northern Regional Health Authority and Professor and Head of the Department of Medical Physics, Newcastle University. He succeeded in transforming a department on just two hospital sites in Newcastle into a truly regional and comprehensive medical physics service with over 270 staff in hospitals or centres across the North East of England.

He served on many committees, including the Committee on Medical Aspects of Radiation in the Environment (COMARE) of the UK Department of Health and the Radioactive Waste Management Advisory Committee (RWMAC) of the Department of the Environment.

Professor Boddy was elected President of the UK Hospital Physicists' Association and UK Institute of Physical Sciences in Medicine in1986. He was President of the International Organisation for Medical Physics (IOMP) from 1994 to 1997. One of his many contributions as President of IOMP was to initiate and actively promote the inclusion of medical physicist as a profession in the International Standard Classification of Occupations of the International Labour Organisation of the UN . In 1997, he became President of the International Union for Physical and Engineering Sciences in Medicine (IUPESM) and through his tireless efforts IUPESM achieved full membership of the International Council of Scientific Unions (ICSU).

Professor Boddy was awarded the CBE on his retirement in 1998. He died in 2010.

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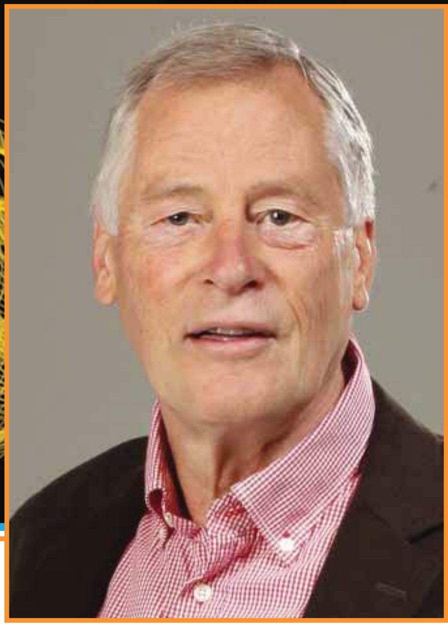

Anders Brahme

Anders Brahme has, as a scientist and entrepreneur, contributed to the development of radiation therapy physics for more than 40 years. His visionary ideas have improved radiation therapy worldwide and are presently used routinely in clinical practice. We include here some of his major contributions to the field of radiotherapy spanning over a wide area from planning, delivering and adapting the treatment.

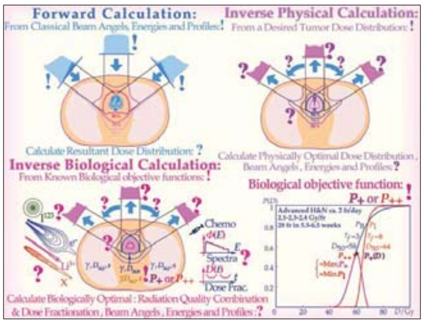

Figure 1: The development from classical forward "trial and error" treatment planning to inverse physical calculation (IMRT) and inverse biological calculation with biological objective functions.

Treatment gantries – Anders Brahme's first important contributions to radiation therapy were in optimization of treatment heads and gantries. He developed methods to construct scattering foils and applicators for optimizing clinical electron beams, as well as flattening filters and other methods such as scanned beams and multileaf collimators for optimizing clinical photon beams. These ideas are still applied in modern units for radiation therapy.

IMRT – (Intensity modulated radiotherapy) – Inverse treatment planning and IMRT is recognized today by the scientific community as being initiated and conceptually invented by Anders Brahme and his group. In the paper by Brahme et al 1982, a new way of approaching radiation therapy was proposed which is today used as a standard method worldwide. IMRT as it is performed today is, of course, the result of a long chain of gradual developments in which the mathematical approach for inverse planning went hand in hand with technological achievements but they are all based on Anders Brahme's idea of modulating the fluence in order to achieve a higher degree of spatial conformality of the resulting dose distribution with the tumor target volume (Brahme 1988). The initial idea was pursued and further developed by Anders Brahme and his co-workers and it made a more than substantial contribution to the development of inverse treatment planning for IMRT.

Biologically Optimized Treatment Planning – The optimization of the dose distribution based on physical objectives was further developed by the research group of Anders Brahme. Biological objectives were included in the treatment planning accounting for the radiobiological response of the tumors and the organs at risk. Biological optimization is considered today state-of-the-art in treatment planning.

Light ions in radiotherapy – Anders Brahme has also made a major contribution to the use of light ions in radiotherapy with a special focus on the radiobiological aspects on the optimal radiation quality.

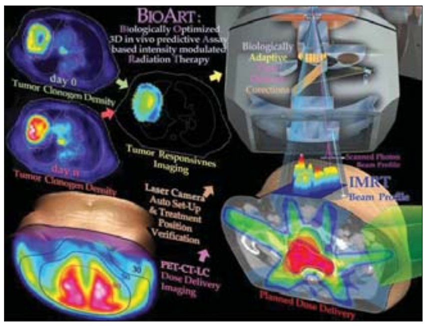

Figure 2: Schematic view of the concept of Biologically Optimized 3D in vivo predictive Assay based intensity modulated Radiation Therapy (BioArt) where PET/CT derived responsiveness information is extracted and used to optimize and adapt the treatment.

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Caridad Borrás

After obtaining her "Licenciatura en Ciencias Físicas" (M.S. equivalent) from the University of Barcelona, Spain in 1964, Dr. Borrás worked for two years as a Hospital Physicist in the Department of Oncology and Nuclear Medicine, Hospital Santa Creu i Sant Pau, Barcelona. Then, with the aid of a Fulbright Scholarship, she moved to the USA where she began graduate research at Thomas Jefferson University, Philadelphia, PA for which she earned a Doctorate of Science degree from the University of Barcelona in 1974. During this period she worked as an Assistant Physicist in the Department of Radiology, Thomas Jefferson University Hospital, Philadelphia, PA. In 1974 Dr. Borrás moved to the West Coast Cancer Foundation, San Francisco, CA as a Radiological Physicist and, from 1985-1986 she also acted as Associate Director of the Western Center for Radiological Physics.

In 1988 Dr. Borrás was appointed Regional Adviser in Radiological Health, Pan American Health Organization / World Health Organization (PAHO/WHO), Washington, DC, which propelled her into the international arena where she has spent the most recent years of her illustrious career. Since then she has served as Coordinator of the PAHO/WHO Program on Essential Drugs and Technology, Washington, DC; Senior Scientist, Director of Special Programs, The Institute for Radiological Image Sciences, Inc., Frederick, MD; Radiological Physics Consultant, Pan American Health and Education Foundation; Los Alamos National Laboratory; PAHO & the IAEA, Vienna, Austria; Consultant on Medical Physics, Radiation Safety and Health Services, Washington, DC; and Guest Researcher / Visiting Professor, DOIN/DEN/UFPE, Recife, Pernambuco, Brazil. During this period she has worked on the preparation of over 100 publications and reports for PAHO, WHO, and IAEA, including reports of investigations of several radiation accidents and radiotherapy overexposures, and has organized and/or participated in more than 200 international courses, workshops and symposia. She has played very active roles in several national and international societies including, for the IOMP and the IUPESM, Chair of the IOMP Science Committee (for nine years) and Chair of the IUPESM Health and Technology Task Group. She currently serves as Chair of the AAPM Work Group on Implementation of Cooperative Agreements between the AAPM and other National and International Medical Physics Organizations.

In recognition of her outstanding contributions, Dr. Borrás has been honored by receipt of the IUPESM Award of Merit, the AAPM Edith Quimby Lifetime Achievement Award, and the Gold Medal of the Sociedad Española de Física Médica.

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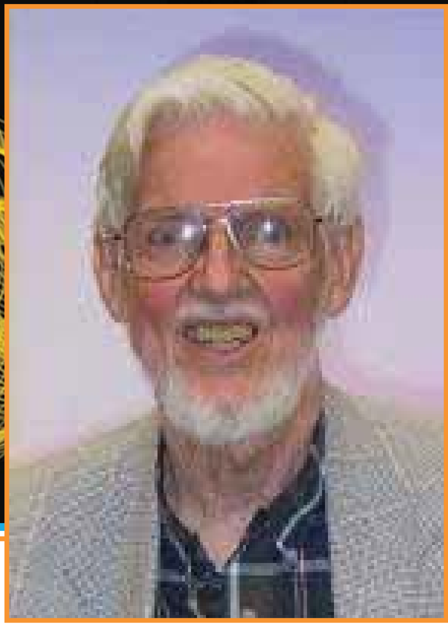

John R. Cameron

John experienced first-hand the hardships of the Depression years. His education was interrupted by service in the U.S. Army Signal Corps from 1941–1946. After the war, he enrolled at the University of Chicago, where he received his B.S. degree in mathematics in 1947. He received his Ph.D. in physics in 1952 from the University of Wisconsin [UW]-Madison. For the next two years, he was an Assistant Professor at the Universidad de São Paulo in Brazil. He became an Assistant Professor at the University of Pittsburgh from 1956–1958. In 1958 was appointed physicist in the Department of Radiology at Madison and accepted an Assistant Professor position with a joint appointment in the Department of Physics.

Over the next three decades, the UW Medical Physics program grew from a "one physicist" operation to become one of the largest and most productive departments in the world. Over the years approximately 350 individuals have graduated from the program since its founding. The program was awarded departmental status in 1981, and John served as departmental chairman until his retirement in 1986.

John Cameron investigated and advanced the use of thermoluminescence for dosimetry, writing one of the first books on this topic with Suntharalingam and Kenney in 1960. At about the same time, he also invented bone densitometry, to determine the mineral content of bone. Subsequently, many useful clinical applications of highly accurate bone densitometry became evident and a number of companies developed bone densitometers.

John also worked to develop simple quality assurance tools and techniques to measure radiation and to evaluate the quality of x-ray images. Based upon this work, he founded Radiation Measurements Inc. (RMI), a not-for-profit pioneer manufacturer in quality assurance measurements, materials and devices. He also founded Medical Physics Publishing, a non-profit corporation whose initial objectives were primarily to provide reprints of useful books. That company now publishes a wide spectrum of original books and is a major source of material relating to medical physics.

Over the years, John was involved in numerous professional activities, serving many organizations as an officer, board member or committee member, and in advisory roles. He also retained a lifelong interest in supporting medical physics activities in developing countries, especially in Central and Latin American countries. John received the Coolidge Award from the AAPM in 1980. In 1995, he was one of four who received the first (and only) Roentgen Centennial Award from RSNA. The IOMP awarded him the Madame Curie Award for his activities in Medical Physics education in developing countries. He died in 2005.

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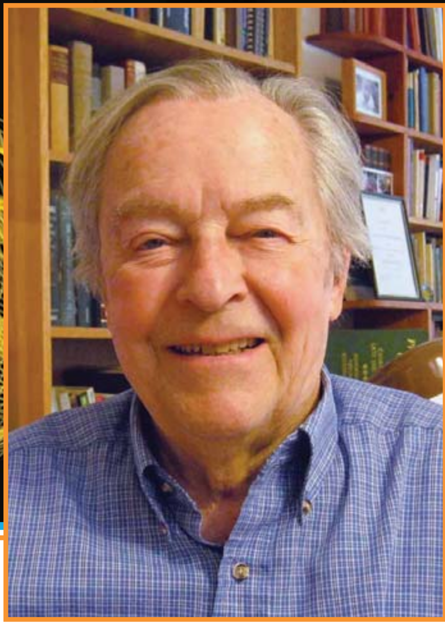

John R. (Jack) Cunningham

Dr. John Robert Cunningham PhD, FCCMP, FCOMP (known universally as "Jack") received his B.Eng. in Engineering Physics in 1950 and the following year his M.Sc. in Radiation Physics (under Dr. H. E. Johns), from the University of Saskatchewan in Saskatoon. He received his Ph.D. in Physics from the University of Toronto in 1955. After working at the Defense Research Board, he joined the staff of the Ontario Cancer Institute / Princess Margaret Hospital (OCI/PMH) in Toronto as a Medical Radiation Physicist in 1958. He became Chief Clinical Physicist in 1965.

Dr. Cunningham experienced and contributed to the genesis of Canadian medical physics and his achievements in radiotherapy planning software are well-known. During his career Dr. Cunningham published more than 70 scientific papers, proceedings and book chapters, and co-authored, with Dr. H. E. Johns, the textbook The Physics of Radiology. His major contributions to Medical Physics have been clinical dose calculation and treatment planning algorithms for radiation therapy. The methods he has developed can be found in many commercial as well as non-commercial treatment planning computer systems throughout the world.

Dr. Cunningham has also been very active in the national medical physics scene in Canada. He served twice as the Chair of the Division of Medical and Biological Physics of the Canadian Association of Physicists (the forerunner of COMP). Internationally, Dr. Cunningham served as the Canadian representative to the International Organization for Medical Physics (IOMP) and as the President of the IOMP. Although Dr. Cunningham retired from the OCI/PMH in 1988, he still remains active in the field.

COMP established the J.R. Cunningham Young Investigator Awards to recognize Dr. Cunningham's contributions. The awards are presented to the top three speakers in the Young Investigators' Symposium held during the annual meeting of the Canadian Organization of Medical Physics. The Symposium is widely recognised as one of the highlights of the annual meeting, with presentations that are of international calibre.

In 2006, Dr. Cunningham was awarded the inaugural Gold Medal of the Canadian Organization of Medical Physicists (COMP), COMP's highest honour. His career has been marked by other important awards including the Kirkby Award of the Canadian Association of Physicists, the Coolidge Award of the American Association of Physicists in Medicine and the international IUPESM Award. This lifetime of contributions culminated in being named Officer of the Order of Canada in 2005. He continues to serve unofficially as the friendly international diplomat of Canadian medical physics.

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David W Townsend

David W. Townsend, PhD, FRCR (Hon), DSc (Hon) is currently Professor of Radiology at the National University of Singapore and Director of the A*STAR-NUS Clinical Imaging Research Centre. He is best known as the co-inventor, with Dr Ronald Nutt, of the first combined Positron Emission Tomography / Computed Tomography (PET/CT) scanner while he was professor of radiology at the University of Pittsburgh in 1998. The prototype PET/CT was built in collaboration with CTI PET Systems of Knoxville, Tennessee and funded by a grant from the National Institutes of Health. The first PET/CT images were acquired in 1998 and in 1999 the work received the Image of the Year Award at the annual Society of Nuclear Medicine Meeting in Los Angeles, California. In 2000, TIME Magazine recognized the PET/CT as the Medical Invention of the Year. The first commercial PET/CT scanners appeared in 2001 and within three years all PET scanners sold worldwide incorporated CT. To date, there are over 6000 PET/CT scanners operational in medical institutions throughout the world, primarily for the diagnosis and staging of malignant disease, and for monitoring response to therapy.

Figure 1. The first prototype combined PET/CT scanner installed at the University of Pittsburgh Medical Center in 1998.

David Townsend obtained a PhD in Particle Physics from the University of London and became a staff member at the European Centre for Nuclear Research (CERN) in Geneva. He moved to the University Hospital of Geneva to apply technology developed at CERN to medical imaging applications and specifically to PET. In collaboration with colleagues at the MRC Cyclotron Unit, Hammersmith Hospital, London and the Free University in Brussels he worked on making PET a fully 3D imaging modality. In 1990 he was the Principal Investigator on a grant to develop a low-cost rotating PET scanner, funded by the Swiss government. In 1993, he moved to the University of Pittsburgh where he was Principal Investigator for the design and development of the PET/CT scanner. In 2003, after ten years at the University of Pittsburgh, Dr Townsend became Professor of Medicine and Radiology at the University of Tennessee, Knoxville and Director of the Molecular Imaging and Translational Research Program. He moved to the National University of Singapore in 2009.

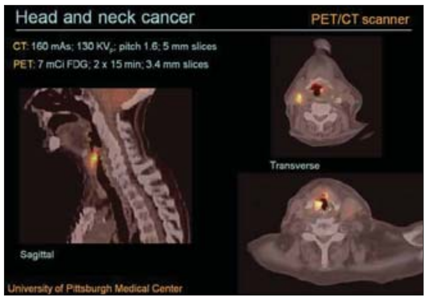

Figure 2. A combined PET/CT scan of a patient with head and neck cancer that was awarded the Image of the Year at the Society of Nuclear Medicine Meeting, Los Angeles, 1999.

In 2004, David Townsend received the Academy of Molecular Imaging Peter Valk Distinguished Scientist Award. In 2006 he was elected a Fellow of the IEEE and in 2008 he received the Distinguished Pioneer Award from the Austrian Society of Nuclear Medicine. In 2010 he shared, with Dr Ronald Nutt, the IEEE Medal for Innovations in Healthcare Technology. In 2012 he was elected an Honorary Fellow of the Royal College of Radiologists and he has received honorary doctorates from the University of the Mediterranean in Marseille (2009), and the University of Bristol (2013).

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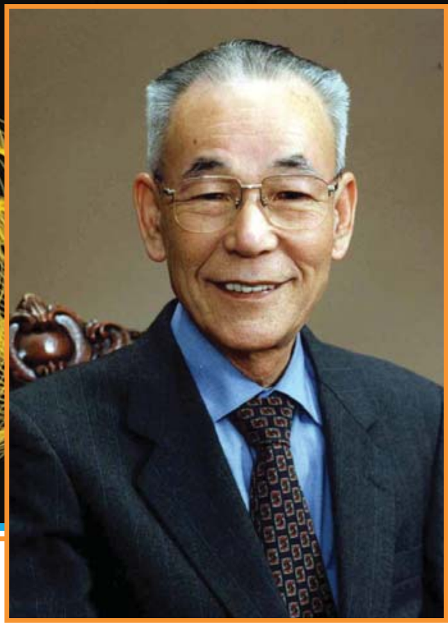

1963-2013

Dr. Eiichi Tanaka

Dr. Eiichi Tanaka is one of the leading authorities of Positron Emission Tomography (PET) scanner research and development. After he led the development of the first-ever PET scanner in Japan, he went on to lead internationally cutting-edge research and development on the PET physics and technology. He graduated from the Physics Department of Kyoto University in 1950. He was affiliated with National Institute of Radiological Sciences beginning in 1957 and has served at Hamamatsu Photonics K.K. since 1988 as an Advisor and Director. He has a doctorate degree in the sciences. Between 1986 and 1989 he served as the president of Japanese Association of Radiological Physicists, the antecedent organization of JSMP. In addition to being awarded the Purple Ribbon Medal (National Honoring for Science, Technology and Culture), Dr. Tanaka has also received numerous academic awards, among them the Shimadzu Prize, the Science and Technology Agency Director-General's Award, the Mainichi Industrial Technology Award, the Eto Memorial Award, and others.

Figure 1. The jumbo gamma camera (1972).

Figure 2 The first PET scanner, Positologica-I, in Japan (1979).

The group led by Dr. Tanaka at National Institute of Radiological Sciences pursued the research and development of the delay-line position encoding scheme from the end of the 1960s to the beginning of the 1970s and, through a joint development project with Toshiba, led the world in successful commercialization of a gamma camera with a large 35 cm field of view (Fig. 1). During the latter part of the 1970s, Dr. Tanaka developed the first PET scanner in Japan, the Positologica-I (Fig. 2) jointly with the Hitachi Group. This pioneering equipment adopted the BGO crystal, which quickly became the standard, achieving the highest spatial resolution in the world. The group developed the Positologica-II and III by the early 1980s, again incorporating detector technologies ahead of the rest of the world and paving the way to the development of the Positologica-IV, the first PET scanner in the world for small animals.

Dr. Tanaka also pursued research on image reconstruction methods for SPECT imaging since before the invention of the computed tomography (CT), devised a unique method for three-dimensional image reconstruction, and clarified the frequency characteristics of the Fourier rebinning method, which is effective for practical image reconstruction of three-dimensional PET scanning. He also contributed iterative image reconstruction methods for PET. Dr. Tanaka's research achievements in the image-engineering field are rare and lasting, thereby making significant contributions to establishing the foundation for the advanced image reconstruction technology to be used in clinical settings.

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Aaron Fenster

Dr. Aaron Fenster PhD, FCCMP, FCOMP received his PhD in 1976 from the University of Toronto's Department of Medical Biophysics under the supervision of Dr. H. E. Johns. He then began his first academic appointment at the Department of Radiology and Medical Biophysics at the University of Toronto.

In 1987 he became the founding Director of the Imaging Research Laboratories at the Robarts Research Institute and Professor at the University of Western Ontario in Radiology and Medical Biophysics in London, Ontario. He is a Professor in the Department of Radiation Oncology and an adjunct Professor in Physics and Astronomy and Biomedical Engineering. Dr. Fenster has built the Robarts Imaging Laboratories into an internationally recognized group which includes 16 scientists and approximately 90 graduate students. He has a unique leadership style that encourages collaboration, clinical involvement and entrepreneurship.

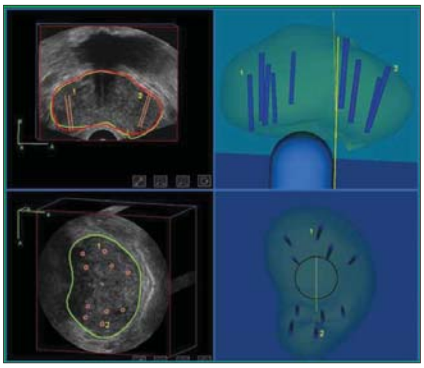

Figure 1. Images showing result of a 3D ultrasound guided prostate biopsy using a system developed in Fenster's laboratory. The panels show view sof the biopsy cores superimposed on the 3D ultrasound images and a graphical representations of the segmented prostate and the core locations.

Dr. Fenster was the founder and is the current Associate Director of the Graduate Program in Biomedical Engineering at Western, combining the strengths of basic scientists, engineers and clinician scientists in 3 faculties (Medicine & Dentistry, Engineering and Health Sciences). He is Chair of the Basic Science Division of the Department of Medical Imaging at Western which combines the strengths in imaging research across London's Institutions to make the London medical imaging research community one of the largest in the world, with over 350 staff and students and $100M in research equipment. He is also the Director of the Biomedical Imaging Research Centre at Western University and the Centre Director for the Centre for Imaging Technology Commercialization (CIMTEC), a Canadian federally funded Centre of Excellence for Commercialization and Research. Currently, he holds a Canada Research Chair-Tier 1. He is the first recipient of the Premier's (Ontario) Discovery Award for Innovation and Leadership (2007), the Hellmuth Prize for Achievement in Research at the Western (2008). In 2011 he was inducted into the Canadian Academy of Health Sciences.

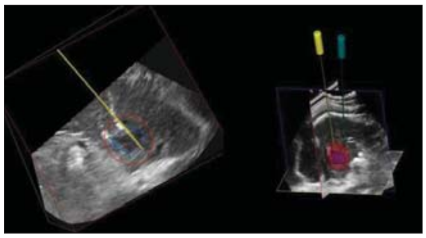

Figure 2. Images showing images obtained during a 3D ultrasound guided focal liver RF ablation procedure. The images show the trajectory of the RF applicator, the segmented tumour (blue) and the ablation region (red).

Following his PhD, Dr. Fenster worked for many years in basic X-ray imaging physics and continues this work at Robarts, becoming a co-founder of Enhanced Vision Systems (EVS), a successful micro-CT company that was eventually sold to GE Healthcare. GE set up its manufacturing base in London ON. For the past 15 years, Dr. Fenster's group has focused on the development of 3D ultrasound imaging with diagnostic and surgical/therapeutic cancer applications in humans and mouse research models. With his team, he developed the world's firsts in 3D ultrasound imaging of the prostate, 3D ultrasound guided prostate cryosurgery and brachytherapy, 3D ultrasound guided prostate and breast biopsy for early diagnosis of cancer and 3D ultrasound images of mouse tumours and their vasculature.

Dr. Fenster's research has resulted in over 25 patents and the formation of three companies (Life Imaging Systems Inc., Enhanced Vision Systems Inc. and Enable Technologies). He has trained over 60 graduate students and fellows, many of whom are well known as leaders in the Canadian medical physics community, and is a prolific publisher, with over 250 peer-reviewed papers and 450 conference proceedings. He is regularly in demand as a keynote speaker around the globe.

Dr. Fenster served as Chair of the Canadian Organization of Medical Physicists (COMP) in 1993 and 1994 and in 2010 was awarded the COMP Gold medal, COMP's highest award.

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Maryellen L. Giger

Maryellen L. Giger earned her Ph.D. in medical physics in 1985 from the University of Chicago, and is presently Professor of Radiology, the Committee on Medical Physics, and the College at the University of Chicago, Chicago, Illinois, USA. She also serves as Vice-Chair of Radiology for Basic Science Research and Director of the Imaging Research Institute, and is the immediate past Director of the Graduate Programs in Medical Physics and Chair of the Ph.D. degree-granting Committee on Medical Physics at the University.

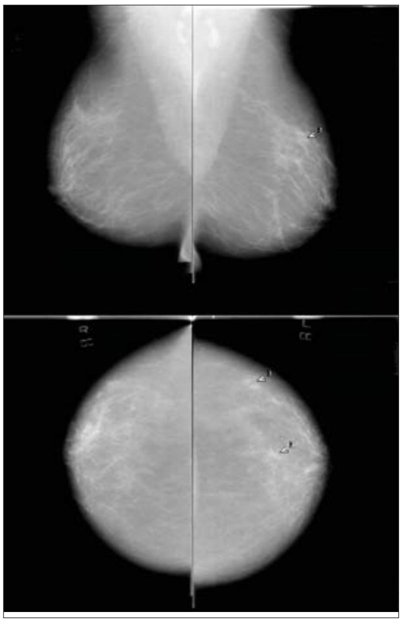

Figure 1. Output from the first prototype CADe system for screening mammography, developed at the University of Chicago (circa 1994).

Maryellen Giger is considered one of the pioneers in the development of CAD (computer-aided diagnosis), and has also extended aspects of CAD to quantitative image analysis and image-based phenotyping with genomics. For over 25 years, she has directed and managed her NIH-funded University of Chicago research lab and have advised over 100 medical physics graduate students, post-docs, undergraduates, and others – many who have gone on to their own successful careers in academic, industrial, or clinical medical physics research.

In addition to her academic career, she has served AAPM since 1987, first as a member (and later chair) of the AAPM Commission on Accreditation of Educational Programs for Medical Physicists and as an annual meeting abstract reviewer; then as annual meeting scientific program director, elected Board Member, elected Treasurer, and ultimately as elected President and Chair of the Board. She has also served SPIE as symposium chair for Medical Imaging and as an elected Board Member.

Maryellen Giger is a member of the National Academy of Engineering (NAE) of the National Academies, an elected fellow of the American Institute for Medical and Biological Engineering (AIMBE) and the American Association of Physicists in Medicine (AAPM), and is a Senior Member of IEEE. She has authored or co-authored more than 300 scientific manuscripts (including 175 peer-reviewed journal articles), is inventor/co-inventor on approximately 35 patents, and serves as a reviewer for various national and international granting agencies, including the NIH and the U.S. Army (DOD).

The Giger lab focuses on the development of multimodality CAD (computer-aided diagnosis) and quantitative image analysis methods. Her research interests include digital medical imaging, computer-aided diagnosis, quantitative image analysis, and data-mining in breast imaging, chest/CT imaging, cardiac imaging, and bone radiography. The long-term goals of her research are to investigate, develop, and translate multi-modality computerized image analysis techniques, which yield image-based tumor signatures and phenotypes, for improved diagnosis, prognosis, and patient care as well as for advanced discovery.

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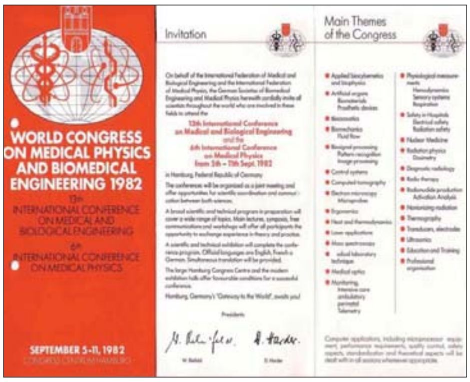
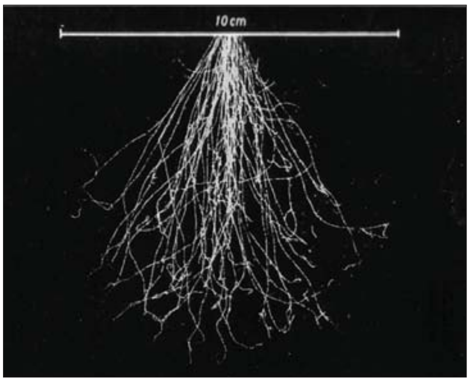
Dietrich Harder

For the postdoc in Rajewsky's Max-Planck-Institute of Biophysics in Frankfurt/Main (1953 - 1960), the 35 MeV betatron group leader at Röntgen's former Institute of Physics in Würzburg (1960-1974), and the director of the Institute of Medical Physics and Biophysics at Göttingen University (1974 - 1999), physics applied to medicine and biology has been the challenge of his life - Dietrich Harder, now emeritus professor of Medical Physics and Biophysics, Göttingen, Germany



Invitation World Congress on Medical Physics and Biomedical Engineering, Hamburg 1982.

In medical radiation physics, the laws governing the passage of high-energy electrons though thick layers of matter and their visualization in the bubble chamber, the formulation of tissue substitutes, the art of imaging and deconvolution, including portal, ultrasound and photothermal imaging, and the principles of probe-type dosimetry have been the milestones.

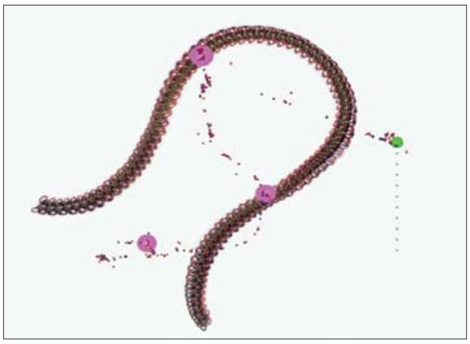


Bubble chamber picture, 7.7 MeV electrons in liquid propane.

In radiation biophysics, the recovery of an enzyme system after large pulses of radiation, the chromatin loop deletion as the primary lesion initiating the formation of radiation-induced chromosome aberrations, and the anti-inflammatory reaction of the immune system to low doses of alpha radiation as the molecular mechanism underlying Radon therapy of rheumatic diseases were his achievements.

In radiation protection, national defense measures against the Chernobyl fallout, leukemia clusters near nuclear power stations and the setup of radiation weigthing factors required his commitment.

The world-wide family of peers was his objective as co-president of the World Congress for Medical Physics and Biomedical Engineering in Hamburg 1982, president of the rejoining meeting of East and West German medical physicists 1990, founder of the journal "Zeitschrift für Medizinische Physik" and member and chairman of the dosimetry committees of DIN, ICRU and ICNIRP as well as the German Radiation Protection Commission. Born 1930 in Stettin (DE), now Szczecin (PL), the honour probably closest to his heart is the honorary membership of the Polish Society of Medical Physics.



Induction of chromatin loop deletions, the primary lesions for exchange-type chromosome aberrations, by correlated groups of high local energy concentrations along particle tracks.

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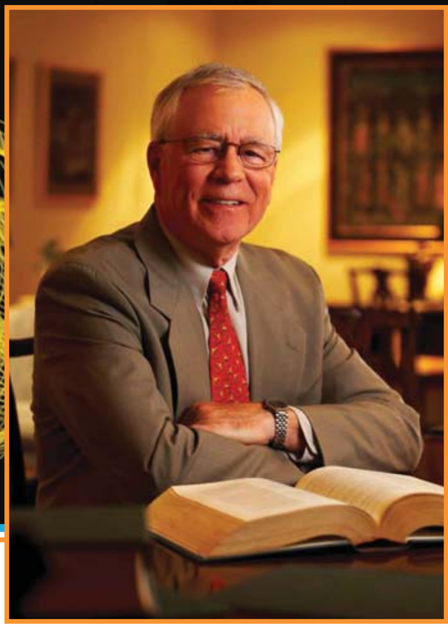

William R. Hendee

William R. (Bill) Hendee Ph.D. is Distinguished Professor of Radiology, Radiation Oncology, Biophysics, and Bioethics at the Medical College of Wisconsin (MCW). He is also Professor of Biomedical Engineering at Marquette University, Adjunct Professor of Electrical Engineering at the University of Wisconsin – Milwaukee, and Adjunct Professor of Radiology at the University of New Mexico, University of Colorado, and Mayo Clinic. Before his retirement from MCW administrative positions in 2006, Dr. Hendee was President of the MCW Research Foundation, Senior Associate Dean for Research, Dean of the Graduate School of Biomedical Sciences, Vice Chair of Radiology, and Interim Dean of the Medical School. Over this period the Graduate School grew from 102 to 562 students, and the College's extramural research funding expanded from $26.5M to $140M. In 2005, he received MCW's Distinguished Service Award.

Prior to joining the Medical College of Wisconsin, Dr. Hendee was Vice President for Science, Technology and Public Health at the American Medical Association (AMA) and Executive Secretary of the AMA Council of Scientific Affairs. Preceding his AMA appointment were 20 years spent at the University of Colorado, including nine years as Professor and Chair of the Department of Radiology.

Dr. Hendee has authored or edited more than thirty books on topics ranging from the physics of imaging and radiation therapy to texts entitled The Perception of Visual Information and The Health of Adolescents. His books Medical Imaging Physics - 4th edition and Radiation Therapy Physics - 3rd edition –, are widely used textbooks in medical physics. His two-volume Biomedical Uses of Radiation (1999) is a standard reference text, and his The Health of Adolescents (1991) was a pioneering work.

Dr. Hendee has published more than 450 peer-reviewed papers focused principally on the physics of medical imaging and radiation therapy, but also on topics such as education and certification in radiology; health physics; patient safety; healthcare quality; research ethics; medical informatics; biotechnology; technology assessment; medical administration and reimbursement; adolescent health; technologies for persons with disabilities; HIV infection and AIDS; and physical fitness. In 1984 Dr. Hendee was awarded the Yearbook Medal for Distinguished Contributions to the Medical Literature.

Dr. Hendee has been president of the American Association of Physicists in Medicine, Society of Nuclear Medicine, American Institute of Medical and Biological Engineering, and American Board of Radiology. He has served as associate editor for many scientific journals, and has been the Editor-in-Chief of Medical Physics since 2005.

Dr. Hendee has received many awards and honors, including the Coolidge Award of the AAPM, Gold Medal of the Radiological Society of North America, Gold Medal of the Roentgen Ray Society, and Gold Medal of the American College of Radiology.

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Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Godfrey Hounsfield

Sir Godfrey Newbold Hounsfield CBE, FRS was an electrical engineer, who was awarded the Nobel Prize for Physiology or Medicine for developing X-ray computed tomography (CT). Its introduction was a fundamental advance of the greatest importance to diagnostic medicine. His name is immortalised in the Hounsfield scale, a measure of electron density which is used in evaluating CT scans.

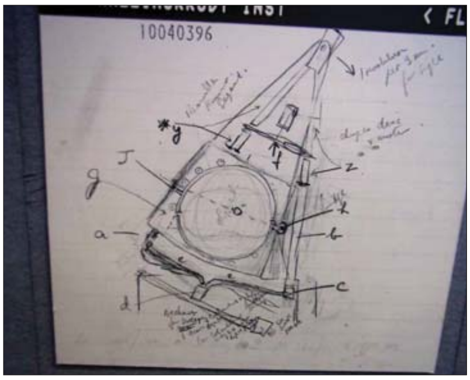

Figure1. Hounsfield's sketch for a CT scanner.

In September 1939, Hounsfield joined the RAF as a volunteer reservist and worked as a radar mechanic instructor during the war. After the war he obtained a grant to study electrical and mechanical engineering at Faraday House in London and then joined the research staff of Electric and Musical Instruments (EMI) at their Central Research Laboratories to work on radar and guided weapons. He became interested in computers and led the team that built the UK's first all-transistor computer: the EMIDEC 1100. In those days, transistors were much slower than valves. Hounsfield overcame this problem by using a magnetic core to drive the transistor. This led to transistors being used in computing earlier than would otherwise have been possible.

Shortly after this, he began working on pattern recognition and became interested in developing a computer that could take measurements from X-rays at various angles to build up a three-dimensional picture of an object. Hounsfield's first experimental system successfully scanned a pig's brain in 1968. The scanning process took nine days and required two and a half hours to process the resulting 28,000 measurements on a high-speed computer. Replacing the gamma ray source with an X-ray tube reduced the scanning time to 9 hours. In 1968, EMI patented the invention. His idea was applied to medicine and became the EMI-Scanner. On 1 October 1971, CT head scanning was introduced into medical practice with a successful scan on a cerebral cyst patient at Atkinson Morley Hospital in Wimbledon, London, United Kingdom. The EMI scanner, costing about £100,000, was announced in 1972. It could perform a scan in four minutes and render a computerised image in three seconds. In the following years he developed a whole-body scanner and announced it in 1975.

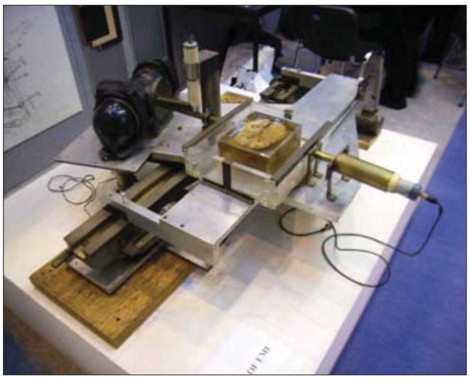

Figure 2. The experimental CT scanner.

His contribution was recognised with many honours and shared with Allan Cormack, who had published theoretical studies on the mathematics needed for the CT scanner, the Nobel Prize for Physiology or Medicine in 1979. He was also awarded the CBE and FRS and was knighted in 1981. He died in 2004.

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Yimin Hu

Yimin Hu was the leading pioneer of medical physics in China and is now acknowledged as one of the profession's most significant contributors. Today, after a career spanning almost 50 years, Yimin Hu has earned the reputation as the father of medical radiation physics in China.

Yimin Hu is the chair professor at the Cancer Institute & Hospital, Chinese Academy Medical Science and Peking Union Medical College. He is chairman of CSMP, president of AFOMP, the AC member of IUPESM and a council member of IOMP. He is a visiting professor at Tsinghua University and University of Science and Technology of China.

Professor Hu has been engaged in both clinical practice and research in medical radiation physics, specializing in radiation oncology physics in China. He designed and supervised the manufacture of the first manual-controlled multi-leaf-collimators for Co-60 unit and for Betatron electron beams in 1960s. In the1970s he established China's first clinical dosimetry system and proposed "four dosimetric principles" of guiding the treatment planning for radiation oncologist and radiation physicist. Since 1980s, he has focused on establishing and promoting quality assurance and quality control programs as well as the adoption of contemporary techniques. In the early 1990s he pioneered linac-based X-ray stereotactic irradiation using implanted gold-markers for image guiding. He designed the CREAT X-ray Stereotactic System including associated treatment planning system. He also designed planning software for the first generation China-made rotational γ- knife.

Professor Hu was appointed as the chair in medical physics in China and has trained numerous students, many of whom later became leaders in their respective clinics world-wide. Since 1980s he has been pursuing the exchange ideas and innovations in the field by developing medical radiation physicist joint training, academic exchange programs and by chairing multiple national and international conferences. He is the chief editor of various textbooks, "Radiation Oncology Physics", "Radiation Oncology Technology", "Radiation Therapy Treatment Planning" and is the co-editor in chief of "Radiation Oncology" as well as the associated editor of various international journals.

Currently Professor Hu is focusing on completing the next generation of IMRT system, which features three heads delivering three cross-firing-beams. This design integrates the clinical functions of various existing systems: C-arm based Linear Accelerators, TomoTherapy unit, X-ray SRS/SBRT systems, Elekta γ-knife, Cyber knife and Vero unit. This system is capable of doing coplanar and non-coplanar real-time imaging- and dose-guided IMRT/SBRT.

Professor Hu has had enormous influence on the development of radiation physics in China, and on the global physics community as well, that encourages not only sound clinical practices and the adoption of modern techniques, but also ensures that his passion is passed down to a new generation of professionals.

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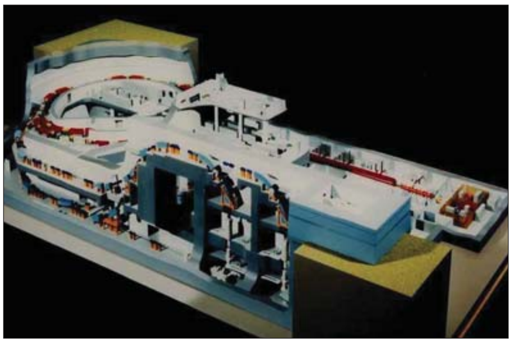
Kiyomitsu Kawachi

Kiyomitsu Kawachi graduated from the Applied Physics Department of Tokai University in 1963, when he joined National Institute of Radiological Sciences (NIRS), and was affiliated with Division of Physics. Although he did the most of research works at NIRS, between 1969 and 1974, he spent at the National Cancer Center of Japan, and the University of Chicago. In the meantime, he developed the well known the electron beam calculation model for treatment planning. He got a doctorate degree in medical sciences from Tohoku University in 1977. At NIRS, he contributed to the developing of various particle therapy systems, such as fast neutrons, protons and heavy ions. He developed three dimensional scanning techniques for proton therapy at NIRS cyclotron in his early days. He also compared potential of charged particles including protons, carbon ions and the other heavy ions for cancer therapy, and concluded that carbon beam was the most suitable for deep seated tumor therapy.



With regards to heavy ion therapy in Japan, Kawachi led the project from the beginning. In 1984 NIRS started a well known HIMAC (Heavy Ion Medical Accelerator in Chiba) project and Division of Heavy Ion Research was established in 1987. He managed the progress of the project as a Section Head and later the Division Director in 1993. HIMAC was completed in 1993 and carbon ion therapy, which was selected at NIRS according to his analysis, started in 1994. Kawachi was appointed Deputy Director General of NIRS in 1999.

HIMAC has been very reliable and efficient during 20 years operation, and so far more than 7,000 patients were treated with carbon ion beam. Now, carbon beam facilities are being constructed or planned not only in Japan, but also all over the world. Therefore, the contributions of Kawachi to carbon ion beam therapy are significant and may be lasting to the future. Kawachi was recommended an Honorary Member of PTCOG (Particle Therapy Cooperative Group) in 2001.

He served as the president of Japanese Association of Radiological Physicist (JARP) between 1998 and 2000, and the president of Japan Society of Medical Physics (JSMP) during 2001. It was during his presidency that JARP developed to JSMP, an academic organization truly independent and to open to all experts in the fields related to medical physics. After JSMP establishment, the number of ordinary members of JSMP increased rapidly and has become three times compared to that of JARP.

Although Kawachi initiated the HIMAC project and played a definitive role, its success was the result of cooperation of many people including administration staffs. Especially Drs. Yasuo Hirao, Satoru Yamada, Tatsuaki Kanai and Masahiro Endo at NIRS were acknowledged for their essential contributions.

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Constantin Kappas

Constantin Kappas is Professor on Medical Physics and Head of Medical Physics Department, Medical School, University of Thessaly and University Hospital of Larissa, Hellas. He was born in Athens in 1954 and his studies include BSc in Physics (University of Patras, Hellas), MSc in Medical Physics (D.E.A. - C.P.A.T. Université Paul Sabatier, Toulouse), Doctorat de Spécialité and Doctorat d'État ès Sciences (Institut Curie, Paris). He has studied with Basil Proimos and Jean-Claude Rosenwald.

UN – IAEA Mission in Zaria General Hospital, Nigeria.

For the last 30 years Constantin Kappas has successfully combined a highly regarded academic work with quality medical physics service at the hospital. His research was mainly focused to the Radiotherapy Physics and he is known in particular for his work in inhomogeneity corrections in radiotherapy treatment planning and in the development of a new non-invasive stereotactic unit (K. Theodorou & C. Kappas), which was also the first installed in his country. He and his colleagues are also actively involved in Treatment Planning Algorithms, Networks & Integration Procedures in Radiotherapy, Monte Carlo Methods in Radiotherapy, High Field MR Imaging, Quantitative MR Imaging and MR Spectroscopy.

Constantin Kappas is also very active in the education process; he teaches a broad spectrum of medical physics subjects to under and post graduate students, to medical doctors, to radiation physicists and to general public as well as being an author to several scientific books.

First Stereotactic Unit in Greece, designed and developed by Patras team.

For this work he has been awarded on several occasions by different academic bodies and organizations. He is also actively involved in ethical matters (writing and participating in respective committees) concerning scientific misconduct and medical malpractice.

Finally, Constantin Kappas is actively involved in social work at national and international level. He participated in several UN – IAEA and other Organizations' scientific missions in developing countries for commissioning of radiotherapy units, gives lectures and supports local clinical projects. Moreover he is the founder of the National Institute for Documentation, Information and Research on Cancer named "G. N. Papanikolaou" as well as he is the founder of the National Institute Against Narcotics named "I.KA.N.O.". Both the Institutes do not only have a positive social impact but they also attract and actively involve medical students, health scientists and academic staff.

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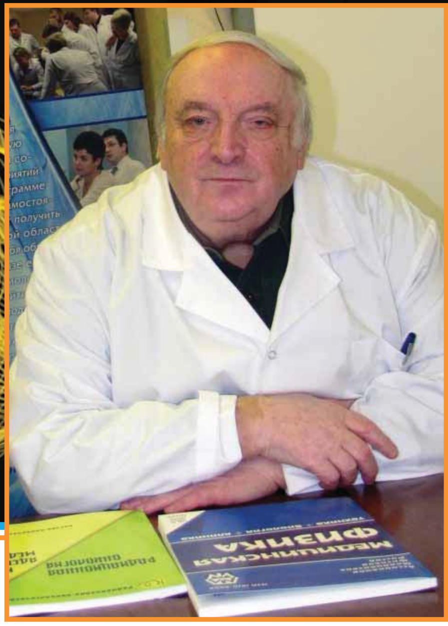

Valeriy Kostylev

Valeriy Kostylev graduated from the faculty of experimental and theoretical physics of the Moscow Engineering Physics Institute (MEPhI) in 1968. Since then he has been working for more than 40 years in the N.N.Blokhin Russian Cancer Research Center (N.N.Blokhin RCRC) and in 1972 received his PhD and in 1985 he earned the Doctoral degree in physics and mathematics. The theses were devoted to the scintigraphic images measurement and processing optimization. The last 12 years he was the head of medical physics department.

In 1993 Valeriy Kostylev organized the Association of Medical Physicists in Russia (AMPR) and became its president. Now AMPR represents about 400 professionals working in the field of fundamental and applied medical physics, engineering, high medical radiation technologies, education and publishing. In 1995 he was the founder and Editor-in-chief of the Journal "Meditsinskaya Fizika" which is an official journal of the Association of Medical Physicists in Russia (AMPR).

In 2004 he organized the Institute of Medical Physics and Engineering for efficient scientific and educational activities in the field of research and education projects and became its director.

Valeriy Kostylev was the founder (2011) and co-chair of the Radiation Oncology Society which counts 868 individual members from Russia and other CIS countries today. The same year he founded and served as Co-chair of the Editorial Board of the Journal "Radiation Oncology and Nuclear Medicine". A year later he was the founding rector of the International Educational Center on medical physics, radiation oncology and nuclear medicine which provides postgraduate education in medical physics for the Russian speaking specialists in the CIS region.

Professor Kostylev is a leading specialist in the medical radiation physics, radiation therapy and nuclear medicine. He's the author of 250 scientific publications in this field. He has acted as scientific advisor and consultant for 60 projects on the development and implementation of domestic medical radiation devices and technologies for radiation therapy and nuclear medicine in clinical practice, including clinical dosimeter with diamond detector, 3D treatment planning system "Amphora" for external beam radiation therapy and treatment planning system "Contact" for intracavitary and interstitial brachytherapy. He is one of the founders of the Russian radiation medical physics school and mentor and guide of several generations of qualified medical physicists in the N.N.Blokhin RCRC, MEPhI. He has also organized many Eurasian and National congresses, conferences, symposia and schools on medical physics and radiation oncology.

Valeriy Kostylev is a member of Expert Councils under the Ministry of Industry and Trade, the State Atomic Energy Corporation ROSATOM, the Federal Antimonopoly Service of Russian Federation. He is chair of the International working group "Modernization and Development of Radiation Therapy and Nuclear Medicine" of the CIS Commission on the use of atomic energy for peaceful purposes. He is an IAEA expert assisting Member States in the upgrading of radiation oncology facilities.

Professor Kostylev has received international recognition for promoting medical physics in Russia and the CIS region.

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Anchali Krisanachinda

Professor Krisanachinda, the Founding President of the Thai Medical Physicist Society, was the President of SEA-FOMP from 2005 through 2012, one of the Founders of AFOMP and has been the AFOMP Treasurer since 2001. She was a member of the IOMP ETC and IAB for Asia (2003-2006), became the Chair of ETC (2006-2009) and joined the Validation and Accreditation Committee of ETC (2009-2012). She was a member of the Awards and Honors Committee (2003-2012), a member of the Finance Committee (2009-2012) and is currently the IOMP Hon-orary Treasurer.

She started her career in medical nuclear physics in 1970 and became an IAEA national coordinator for the project Quality Control of Nuclear Medicine Instrumentation in 1984. She travelled to 20 nuclear medicine centers to es-tablish the quality control procedures for nuclear medicine equipment from 1985 to 1990 and became an IAEA Ex-pert to Malaysia and Vietnam in 1989-1991. She was involved in the publication of the IAEA technical document "Quality Control Atlas for Scintillation Camera Systems".

Since 1999 she has been the national coordinator of the IAEA Project on Distance Assisted Training in Nuclear Medicine for Thailand in which most nuclear medicine technologists participated. She has also trained IAEA fel-lows from Myanmar, Malaysia and Vietnam.

In 2002, she pioneered the graduate program in diagnostic radiology medical physics education, with IAEA sup-port, at Chulalongkorn University. She is also a National Project Coordinator (NPC) of the IAEA Regional Coopera-tive Agreement RAS 6038 project: Strengthening of Medical Physics through Education and Training in Asia and the Pacific.

She supervised the integration, of the IAEA training modules, to the clinical residency training programs in radia-tion oncology medical physics (ROMP) in 2007, diagnostic radiology medical physics (DRMP) in 2010 and nuclear medicine medical physics (NMMP) in 2011. Fifteen clinically trained ROMP and DRMP medical physicists have graduated from the pilot. A second group of residents are currently enrolled in the ROMP training program. Chu-lalongkorn University is the only University that recognizes the IAEA structured clinical program as an academic program, offering a post-graduate degree since 2010.

As a consultant in radiation protection of patients she has contributed to the IAEA Technical Document on Optimi-zation of Patient Dose and Image Quality in General Radiology, Computed Tomography and Interventional Radiol-ogy, by way of a national project.

Dr. Krisanachinda has been dedicated to the promotion of medical physics, both nationally and internationally, serving a lifetime to the advancement of the science from the university to the United Nations.

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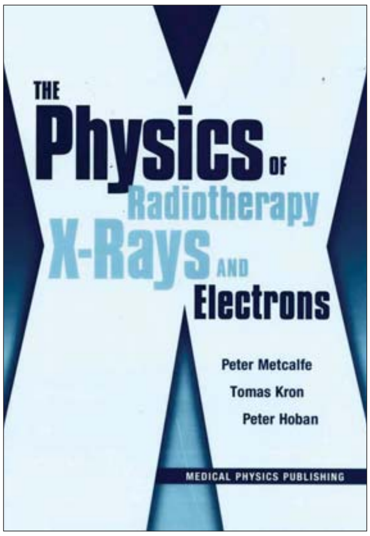
Tomas Kron

Tomas was born and educated in Germany. After being awarded his doctorate in biophysics for work on tracer kinetic studies at the University of Frankfurt in 1989 he migrated to Australia working as a clinical medical physicist in Sydney, Wollongong and Newcastle where he was chief physicist. From 2001 to 2004 Tomas worked in Canada at the London Regional Cancer Centre commissioning one of the first helical tomotherapy units. Since 2005 he is Principal Research Physicist at the Peter MacCallum Cancer Centre in Melbourne, Australia and holds professorial appointments at Melbourne, Monash, RMIT and Wollongong universities.



Tomas has research interests in radiation dosimetry and imaging for radiation oncology documented in more than 50 invited conference presentations, 175 peer-reviewed publications and authorship of textbooks and book chapters. Tomas has particular interest in clinical trials and is trial co-chair of two multicentre trials with the aim to demonstrate the value of new technology in clinical practice. This focus on the impact of technology and techniques on cancer patients and society has led to his involvement in two projects funded by the Australian government that bring together all professions involved in the delivery of radiation oncology services: The writing practice standards for radiation oncology in Australia and the development of a framework to for the Assessment of New Radiation Oncology Technologies and Treatments.

Tomas was president of the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) in 2008 and 2009 and is a member of the IOMP executive where he chairs the Awards and Honours committee. He has been convenor of several conferences most recently the International Conference on the Use of Computers in Radiation Therapy (ICCR) in Melbourne 2013.

Tomas with a 'friend' in 2000 after being awarded a grant from the John Hunter Children's Hospital Research Foundation to study dose distributions in children undergoing radiotherapy.

Tomas has a long standing interest in education and training of medical professionals. This has led to his involvement in many national and international workshops and consultancies for the International Atomic Energy Agency (IAEA) for which he also has designed two series of teaching presentations (Radiation Protection in Radiation Oncology and Training for QUATRO). Tomas is on the editorial board of several international journals including clinical journals such as Clinical Oncology and Radiotherapy and Oncology. He has supervised many postgraduate students, an activity he enjoys very much.

Tomas believes that physical sciences are essential ingredients in health care. His work is aimed at optimising and publicising this impact with the ultimate aim to improve the lot of patients.

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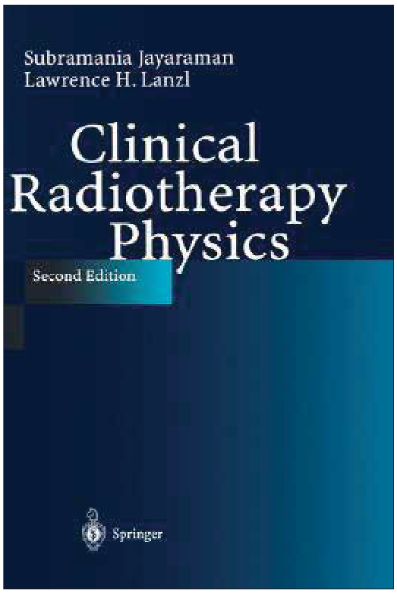
Lawrence H. Lanzl

Lawrence H. Lanzl majored in physics at Northwestern University. After graduation, he joined the Manhattan Project, working first in Chicago and then at Los Alamos. He returned for graduate study in physics at the University of Illinois where he became involved in the development of the betatron for radiotherapy. Dr. Lanzl was on the faculty of the University of Chicago for many years, and much later, at Rush-Presbyterian St. Luke's Medical Center. He worked on the development of Co-60 and linear accelerator teletherapy, and did pioneering work in such topics as bone densitometry, anthropomorphic phantoms for and the handling of radiation accidents. It was during the 1950s and 1960s that he became interested in organizational medical physics, and made several important contributions regarding the professional aspects of medical physics, including education and training, remuneration, and staffing requirements.

Dr. Lanzl, with Dr. Lester Skaggs and Donald Davidson, with a cobalt-60 rotational therapy machine.

Dr. Lanzl was instrumental in the formation of graduate medical physics programs at both the University of Chicago and Rush-Presbyterian St. Luke's Medical Center. He also worked a year for the International Atomic Energy Agency, and was active in the World Health Organization and ultimately, the International Organization for Medical Physics (IOMP). He spearheaded the establishment of the IOMP bulletin, Medical Physics World, and was its first Editor. He assisted medical physicists in development of their profession in numerous countries worldwide. He also served as a consultant on medical physics in various countries and as President of the AAPM and the IOMP.



"Clinical Radiotherapy Physics" a textbook Dr. Lanzl wrote with Subramania Jayarman

Among many honors bestowed upon him was the William D. Coolidge Award from the AAPM in 1978. The Lanzl Institute in Seattle, a medical physics research institution, was established and named in his honor. After becoming a professor emeritus at the University of Chicago, he continued to be active, heading the medical physics program at Rush-Presbyterian-St. Luke's for some time. However, if you had asked him what he considered to be his greatest professional achievement, he would most likely have responded as he did when he received the Coolidge Award " to improve people's health, and establish the profession of medical physics, and by doing these things, to make the world a little more civilized."

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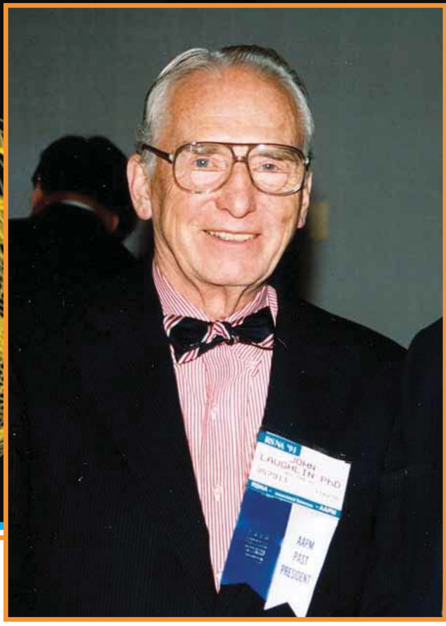
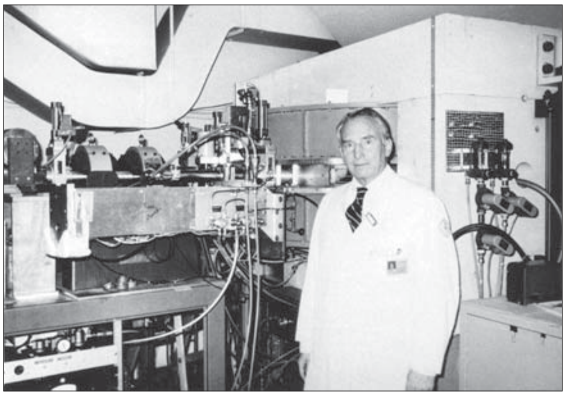


John S. Laughlin

He received his Ph.D. in Nuclear Physics from the University of Illinois in 1947 where he performed research on particle accelerators, in particular on early cyclotrons with Prof. P.G. Kruger and Prof. D. Kerst, who was awarded the Nobel Prize for his invention of the betatron. These years culminated in the first use of high energy electrons produced by a betatron dedicated to the purpose of radiation therapy. In 1952, John Laughlin became the chairman of Medical Physics at Memorial Sloan-Kettering, a position which he held until 1990. He is possibly best know for his pioneering efforts in developing clinical uses of high-energy electrons and the development of dosimetric and calorimetric methods for measuring the energy flux of electrons. During his career, he pioneered developments in every area of diagnostic and therapeutic radiological physics. Recognizing the potential of short-lived positron-emitting nuclides, particularly 11C, 13N, 15O, and 18F, in 1968, he installed the first medical cyclotron in a hospital (and in the heart of New York City), which remained operational until 2000.



Dr. Laughlin and the first medical cyclotron in a hospital (and in the heart of New York City), which remained operational until 2000.

In the 1960s, high energy optimized whole body rectilinear scanners were built as well as a large-field dual head coincidence gamma camera for dynamic studies. These devices pioneered digital data acquisition and computer processing for digital display and quantitation. In addition to being Chairman of the Department of Medical Physics of Memorial Hospital and Professor of Radiology at Cornell University Medical College, John also served as vice president of the Sloan Kettering Institute [1966-72] and chief of the Institute's Laboratory of Biophysics from 1955 to 1989. He was elected President of the: AAPM [1964-65]; Radiation Research Society [1970-71]; International Organization of Medical Physics [1969-72]; Health Physics Society [1960-61]; and served as Vice-President of the Radiological Society of North America [1992]. For many years, he served on the physics panel of the American Board of Radiology. He was awarded by the American Association of Physicists in Medicine, an organization of which he was a founder, it most prestigious prize, the William D. Coolidge Award in 1974. He also received the Distinguished Scientific Achievement Award of the Health Physics Society in 1982, the Aebersold Award of the Society of Nuclear Medicine in 1984, the gold medal of the American College of Radiology in 1988, and the gold medal of the American Society for Therapeutic Radiology and Oncology in 1993. He died in 2004.

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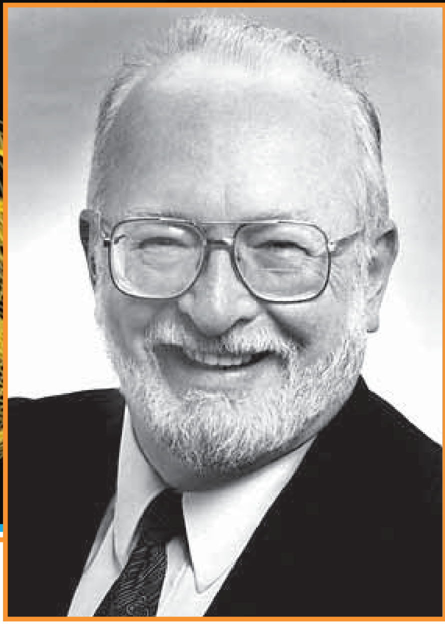
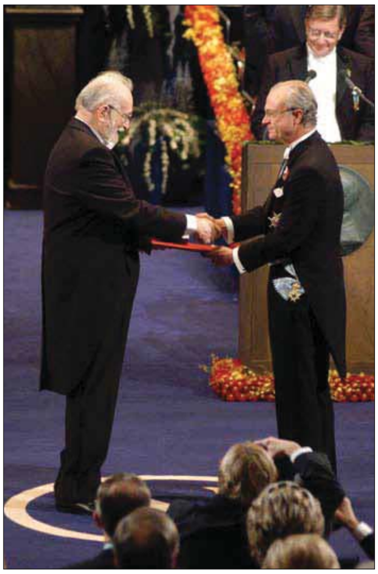


Paul C. Lauterbur

Paul Lauterbur was an American chemist who shared the Nobel Prize in Physiology and Medicine in 2003 with Peter Mansfield for work on the development of magnetic resonance imaging (MRI).

He was born In 1929 in Sidney, OH and did his undergraduate work at Case Institute of Technology in Cleveland. He then worked at the Mellon Institute laboratories of the Dow Corning Corp. with a two year break to serve at the Army Chemical Center in Maryland. While working at Mellon, he also studied at the University of Pittsburgh, graduating with a Ph.D. in 1962. He then became Associate Professor at the State University of NY at Stony Brook. During 1969-70, he worked in the Chemistry Department at Stanford University doing nuclear magnetic resonance research. He returned to Stony Brook and continued there until 1985, when he moved to the University of Illinois at Urbana.



Paul C. Lauterbur receiving his Nobel Prize from His Majesty King Carl XVI Gustaf of Sweden at the Stockholm Concert Hall, 10 December 2003. Copyright © The Nobel Foundation 2003 Photo: Hans Mehlin

While Block and Purcell received the Nobel Prize in Physics 1952 for the development of NMR, it was not until the 1970's that NMR could be used for imaging of the human body due to the work of Lauterbur and Mansfield. Lauterbur used the idea of Gabillard of introducing gradients in the magnetic field which allowed for determining the origin of the radio waves emitted from the nuclei of the objects of study. This spatial information allows two-dimensional pictures to be produced.

The best NMR machine at Stony Brook at that time was in the Chemistry Department, which Lauterbur would have to visit at night to use it for his experiments. Some of the first images that he took were those of a clam, green peppers, and two test tubes of heavy water within a beaker of ordinary water; no other imaging technique at that time could distinguish between the two kinds of water.

When Lauterbur first submitted a paper with his discoveries to Nature, the paper was rejected by the editors because the images were too fuzzy. He requested a second review and the paper was published. At the time of his initial rejection, Lauterbur stated "You could write the entire history of science in the last 50 years in terms of papers rejected by Science and Nature." While Lauterbur was unable to persuade SUNY to file patents on his work to commercialize the discovery, the University of Nottingham did file patents which later made Mansfield a wealthy man. He died in 2007.

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C. Clifton Ling

C. Clifton Ling was born in China, grew up in Hong Kong and received his primary and secondary education from La Salle College. He obtained his Ph.D. degree in nuclear physics from the University of Washington, Seattle, in 1971. He then was a research fellow in radiation biophysics at the Sloan-Kettering Institute. He has held academic appointments at the Massachusetts General Hospital, Harvard Medical School, George Washington University and the University of California, San Francisco. In 1989, he returned to Memorial Sloan-Kettering as the Enid Haupt Professor and Chair of the Department of Medical Physics and Professor of Radiology [Physics] at Cornell University Medical College. In 2007, he stepped down as Chair to join Varian Medical Systems as Director of Advanced Clinical Research and maintained his research at MSKCC.

Dr. Ling's research interests range from the fundamentals of cancer radiation biology to optimized radiation treatment planning and delivery, and more recently biological imaging as applied to cancer management. He has contributed to brachytherapy dosimetry, particularly of I-125 seeds. In collaboration with other scientists and clinicians, he has participated in the development of 3D-CRT and IMRT, and ushered in the widespread use of these advanced techniques. In biological research, Dr. Ling has studied oxygen effect, dose rate effects and the repair of sublethal damage, hypoxic cell radiosensitization, radiation induced carcinogenesis and apoptosis, and the effects of oncogenes on radiosensitivity. Subsequently, his laboratory focused on the biological basis of molecular and functional imaging. His published papers number over 300.

Dr. Ling actively participated in many societies such as the AAPM, Radiation Research, ASTRO, and served on the USA and Canadian NCI panels, and the Nuclear/Radiation Studies Board of the USA National Academies.

Dr. Ling has received numerous honors and awards, including the Ray Bush Visiting Professorship at Princess Margaret Hospital, the Suntharalingam Lectureship of Thomas Jefferson University, Speaker at the Royal College of Physicians and Surgeons of Canada, the Ira Spiro Visiting Professor of Harvard Medical School, the Franz Buschke Lecturer of the UCSF, and the James Purdy Lecturer of the Washington University, St. Louis. He received the ESTRO Honorary Member in 1998, the AAPM Coolidge Award in 2004, the Gold Medal from ASTRO in 2006, the Lifetime Achievement and Contribution Award, Radiation Oncology Society, Republic of China, 2007, and was the 50th Failla Lecturer of Radiation and Medical Physics Society and NY Health Physics Society in 2012.

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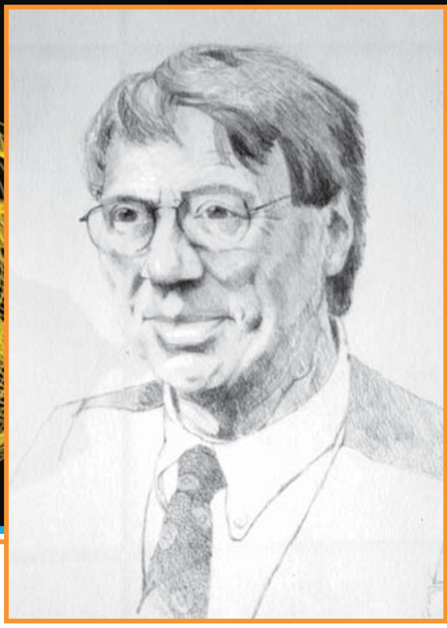

Professor Jim Malone

Professor Jim Malone PhD, MA, FIPEM, FFR(RCSI) is synonymous with Medical Physics in Ireland. He is the Robert Boyle Professor (Emeritus) of Medical Physics at Trinity College Dublin and is well known to colleagues in the international community, having co-coordinated or been closely involved with about 30 EC funded research projects. These resulted in significant contributions to thyroid radiobiology and dosimetry, diagnostic radiology physics and justification of diagnostic medical exposures. He established the first and largest Medical Physics and Bioengineering Department in Ireland at St. James's Hospital, Dublin. Over 140 medical physicists, clinical engineers and technicians have been educated, trained and mentored through the framework he created, many of whom have gone on to become leaders in the profession. Much Irish service and academic output in the area can be traced to Jim's initiatives.

John Synge's "Schrodinger in the hand of God". Jim et al. rescued this fine picture, for posterity. It was loaned for an exhibition and subsequently lost. Schrodinger lived in Dublin 1939-1956.

Jim brings a curiosity about everything to his thinking on the role of the sciences in medicine and society. Once a candidate for Franciscan life, he reconsidered and chose medical physics. He retained a deep interest in the humanities, particularly in literature, the visual arts, spirituality, history and philosophy. In recent years he took an MA on personal spiritualties, which unexpectedly led him to explore ethical issues in radiation protection from medical exposures, a topic to which he now contributes professionally. His broad view contributed to his appointment as the first non-medical Dean, since 1711, of the School of Medicine and Faculty of Health Sciences in Trinity College. Jim has an ongoing interest in the career of Robert Boyle, seventeenth century scientist and polymath, and excellent model for those striving to bring more science, including physics, into medicine.

Procession, Front Square, Trinity College for opening of new Medical School Building (1994). Jim 4th row from front.

Jim has made many national and international contributions. He has been a Consultant with the International Atomic Energy Agency (IAEA) in Vienna since 2006 and is a regular contributor to the European School of Medical Physics in Geneva. He is Chairman of the IEC's (International Electrotechnical Commission) Medical Imaging Committee and has been a Board member of 10 institutions. He has over 300 publications and was awarded an Honorary Fellowship in Radiology from the Royal College of Surgeons in Ireland.

Jim directed two Merriman Summer Schools, a prestigious, incisive and sometimes irreverent annual think in celebrating and dissecting Irish Life and Culture. He is an accomplished set dancer with a preference for Clare Reels and a regular at theatres and concerts.

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Outstanding Contributions Over the Last 50 Years

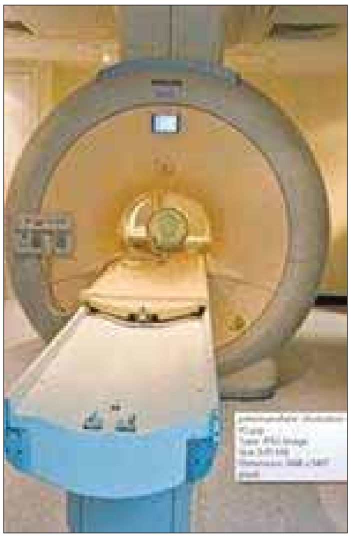
50 Years of IOMP

1963-2013

Peter Mansfield

Sir Peter Mansfield FRS was awarded the 2003 Nobel Prize in Physiology or Medicine for his work in developing magnetic resonance imaging (MRI). Mansfield provided the mathematics needed to produce a useful image from MRI radio signals. He also developed echo-planar imaging, a technique which made functional MRI (fMRI) possible.

He was born in 1933 and left school at fifteen, after being told by a careers teacher that science wasn't for him. However, he later went on to study physics at Queen Mary College, London gaining a PhD in 1962. This was followed by a post-doctoral period in the USA. In 1964, he joined the Department of Physics at the University of Nottingham as a Lecturer where he continued his studies in multiple-pulse NMR. He was successively appointed Senior Lecturer in 1968 and Reader in 1970.



MRI scanner. Copyright. The Wellcome Trust.

By the early 1970s, he was working on the application of Nuclear Magnetic Resonance (NMR) to imaging, research that led directly to the development of MRI. Sir Peter's first paper on MRI was presented at the first Specialised Colloque Ampere in 1973. The first image of a living object was performed in 1974. The only thing Sir Peter and his team could squeeze into the tiny scanner was the finger of one of his students Andrew Maudsley. In 1978 Sir Peter offered himself as the first whole-body human volunteer. He subsequently showed how fast imaging could be possible by developing the MRI protocol called echo-planar imaging, leading to functional MRI (fMRI).

He was made Professor of the Department of Physics in 1990, a post he held until his retirement in 1994.

For his work in the development of MRI, Mansfield was awarded a Nobel Prize in 2003, which he shared with Paul Lauterbur of the United States. His work has also been recognised with a knighthood and a fellowship of the Royal Society (FRS). In 2009, the British Prime Minister, Gordon Brown, presented him with a Lifetime Achievement Award. He continues to work on the safety and acoustic screening of MRI.

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Outstanding Contributions Over the Last 50 Years

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1963-2013

Sören Mattsson

Sören Mattsson started his career studying radiation physics at Lund University in the early 1960s. Already then he showed an outstanding curiosity and determination to formulate strategies to solve problems and to find answers. His formal studies ended up with a PhD in 1972, based on a thesis about transfer of radionuclides in the food-chain lichen-reindeer-man. His professional career started as a medical physicist in Malmö, and in 1983 he became professor and head of Radiation Physics in Gothenburg. His administrative capacity resulted in setting up research groups in all fields of medical physics, raise the necessary funds and fill the groups with enthusiastic students. This was repeated and even more successful when he returned to Lund University at Malmö in 1988 as professor and head of a new department of radiation physics. He stayed there until his retirement in 2010 and since then he has been Senior Professor there.

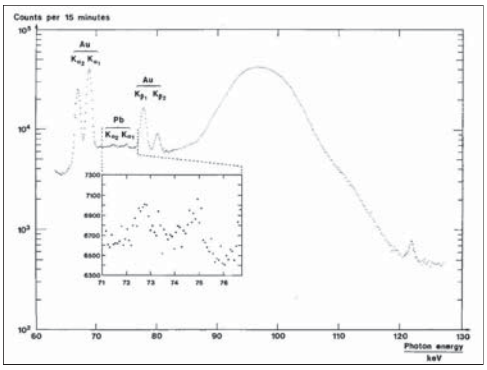

Figure 1. Pulse height distribution recorded at the world's first in vivo x-ray fluorescence study of lead in a retired worker from a metal industry. The lead concentration in the left forefinger bone was estimated to around 50 µg/g [Scand. J. Work, Env. & Health, 1976; 2(2):82-86].

He is known for his and his colleagues' work in the development of various areas of medical physics, including radionuclide imaging and tracer studies, x-ray imaging, in vivo body composition studies, heavy metal research, radiation therapy, radiation dosimetry, radiation protection and environmental radiology.

Figure 2. Some of the students that Sören has supervised towards their PhD degree. The photograph is from the dinner of the symposium in honor of his career.

Sören Mattsson's career span more than 40 years, during which advances in medical imaging, radioanalytical techniques and radiation therapy facilitated huge improvements in the diagnosis and management of disease. He has contributed to the development of in vivo x-ray fluorescence analysis of heavy metals, new nuclear medicine methods and dosimetry, x-ray tomosynthesis as well as retrospective dosimetry and dose estimations. He was active in the planning of a national Swedish proton therapy and has established a very active cooperation between Swedish colleagues and colleagues in the Nordic countries, in Lithuania, UK, Germany, Russia and many other countries. His leadership of the Departments in Gothenburg and Malmö combined an academic role in the university with an active role as chief of the clinical departments there. He was honored with prices and awards from the Swedish Society of Medicine, the Nordic Society for Radiation Protection, the Swedish Society for Radiation Physics, and the Swedish Society for Radiation Biology as well as the St. Petersburg Research Institute of Radiation Hygiene. He was appointed as honorary doctor at Kaunas University of Technology in 2008. In the period 1985 to 2013 he was an active member of ICRP Committee 3.

Outstanding Contributions Over the Last 50 Years

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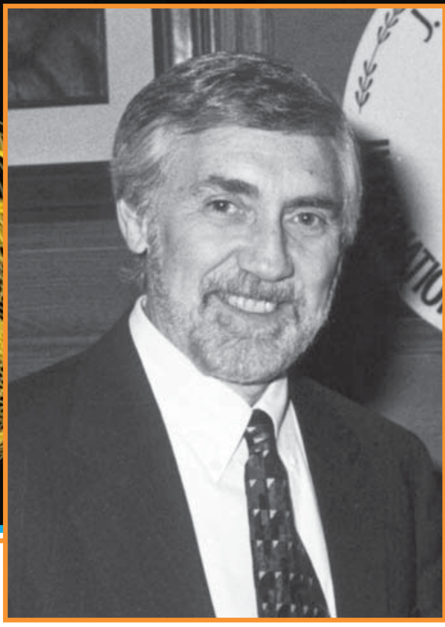

Charles A. Mistretta

Charles A. Mistretta received his Ph.D. from Harvard in 1968 and in 1971, encouraged by John Cameron, began his career in Medical Physics at the University of Wisconsin. Dr. Mistretta became a full professor in the Department of Radiology in 1978 and in 1986 was designated as the John R. Cameron Professor in the Departments of Medical Physics, Radiology, and Biomedical Engineering.

Mistretta has been involved in numerous research areas related to the development of modern time-resolved angiography. This began with the development of digital subtraction angiography (1980). The development of fast angiographic techniques was then extended to magnetic resonance angiography where the development of highly undersampled acquisition such as VIPR and the introduction of constrained reconstruction techniques like HYPR permitted violations of the Nyquist theorem by factors as large as 1000. These principles were extended to X-ray angiography in the form of 4D digital subtraction angiography [DSA] that provides time-resolved 3D volumes 200 times faster than traditional rotational 3D DSA techniques. 4D DSA is combined with 4D Fluoroscopy that provides fluoroscopic viewing from arbitrary views without gantry rotation. These techniques complete a thirty-year circle of angiographic development that permitted improved, less invasive diagnosis and safer interventions.

Dr. Mistretta has trained some of the most prominent investigators in medical imaging and has greatly benefitted from his association with these individuals. He has mentored 33 Ph.D. students and 25 postdoctoral fellows. Among them are Willi Kalender, primary developer of spiral CT; Robert Kruger, co-inventor of DSA and thermoacoustic CT; Stephen Riederer, inventor of MR Fluoroscopy and fast MRI methods; Orhan Nalcioglu, developer of contrast enhanced MRI methods for breast cancer; Bruce Hasegawa, for dual-modality SPECT/CT imaging; James Dobbins III, dual energy tomosynthetic chest radiography; and Yi Wang, fast vascular MRI and quantitative susceptibility methods.

Chuck presently holds 43 issued and 9 pending US patents and their foreign counterparts. He is a Fellow of the American Association of Physicists in Medicine and of the American Institute for Medical and Biological Engineering. He has received the Edith Quimby Award for Lifetime Achievement from the AAPM, and has been awarded the J. Allyn Taylor International Prize in Medicine, and an MIT Technology Achievement Award. He was the RSNA Outstanding Researcher for 2010 and was recently selected by the International Organization of Medical Physics as the recipient of the 2012 Marie Curie Skłodowska Award.

Outstanding Contributions Over the Last 50 Years

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1963-2013

Kwan-Hoong Ng

Professor Kwan-Hoong Ng PhD, FIPM, MIPEM, ABMP, CSci, FinstP, AMM is a professor at the Department of Biomedical Imaging, University of Malaya and a Consultant of the University of Malaya Medical Centre, Kuala Lumpur, Malaysia.

He received his M.Sc. (Medical Physics) from University of Aberdeen and Ph.D. (Medical Physics) from University of Malaya. He is American Board of Medical Physics certified. His main research contributions are in radiological protection, radiation dosimetry, risk communication, biophysical characterization of breast diseases and quantification of breast density.

Illustration 1. Professor Ng with Professor John Cameron. Professor Ng delivered the the Second John Cameron Memorial Lecture at Seacomp'07, Manila, in 2007.

Prof Ng's research effort has led to the publication in a recent Lancet Oncology paper calling for standardization of breast density measurement that will have significant impact on improving the predictability of breast cancer risk.

Prof Ng also established the Master of Medical Physics program at the University of Malaya, Kuala Lumpur in 1998 which was awarded the Institute of Physics and Engineering (IPEM) accreditation in 2004. At present, this is the only such accredited program outside the British Isles.

A prolific writer, Prof. Ng has authored/coauthored over 200 papers in peer-reviewed journals, 80 conference proceedings papers, and 20 book chapters, as well as edited four books. He has also organized and directed several local/international workshops on radiology quality assurance, radiation protection, digital imaging and scientific writing.

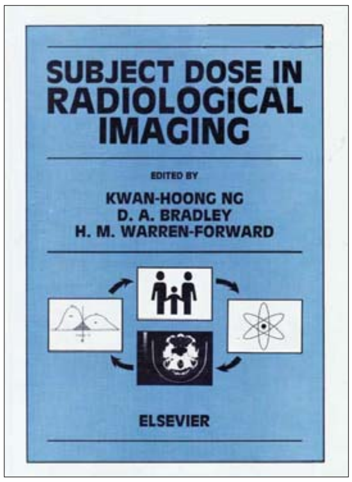

Illustration 2. One of the books edited by Professor Ng.

As the co-founder and co-editor in chief of the open-access e-journal Biomedical Imaging and Intervention Journal (www.biij.org), Prof Ng is passionate about encouraging academic publishing. Prof. Ng is also in the editorial board and advisory board of several journals, including European Journal of Medical Physics, Singapore Medical Journal, Journal of Mechanics in Medicine and Biology, International Journal of Medical Physics, Clinical Engineering and Radiation Oncology, and World Journal of Radiology.

Prof. Ng is an IAEA expert/consultant and has served in this capacity in the drafting committee for several IAEA publications. He is also a member of International Advisory Committee (EMF) of the World Health Organization and has served as a consulting expert for the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

Prof. Ng is actively involved in regional and international professional organisations, including as the Founding President of the South East Asian Federation of Medical Physics (2000-2006) and the Immediate Past President of the Asia-Oceania Federation of Organizations for Medical Physics (2010-2012). He was Chairman, International Advisory Board of the International Organization of Medical Physics 2003-2006. In this role he encouraged and stimulated the formation of two new IOMP regional chapters.
He also served as Chairman, IOMP Publication Committee 2003-2006.

Outstanding Contributions Over the Last 50 Years

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1963-2013

Fridtjof Nüsslin

Growing up in nuclear physics Fridtjof Nüsslin changed to medical physics in 1972 when he was appointed as physicist in the radiotherapy clinic at the newly established Medical School in Hannover. In 1988 he was appointed Chair of the Department for Medical Physics at the University of Tübingen. He retired in 2004 and moved to the Technische Universität München where he was invited to work as Visiting Professor for Biomedical Physics at the Department for Radiooncology. In 2008 he was awarded Distinguished Affiliated Professor of the Technische Universität München and Fellow of the Institute of Advanced Study.

Hyperion – a novel Monte-Carlo IMRT treatment planning program based on isoeffect dose optimization. (F.Nüsslin, M Alber, M.Birkner, M.Fippel: World Congress on Medical Physics & Biomedical Engineering, 2003, Sydney).

One of his major scientific interests was to bridge imaging and radiotherapy technologies to optimize diagnosis and treatment of cancer. Examples are his pioneering work in the early CT-era up to the recent achievements of his working group in the application of molecular imaging in radiotherapy treatment optimization. His group was the first to develop an algorithm for a combined physical and biological dose planning optimization (HYPERION). Since its launch in 2007 Nüsslin has played an active role in the research cluster Munich Advanced Photonics (MAP) to investigate the application of laser technologies to be utilized for imaging and particle beam radiotherapy. Most recently, he is promoting the new field of small animal high precision image guided irradiation.

Nüsslin is an enthusiastic teacher in medical physics. Through his worldwide lecturing activities he contributed significantly to the development of medical physics as an academic discipline. Under the auspices of the German Research Foundation (DFG) he initiated the Academy of Young Scientists. He is the co-founder of the European School for Medical Physics in Archamps. Under the EU 5th Framework Programme he successfully applied for the first Marie-Curie Training Site for Medical Physics in Europe. Furthermore, he was involved in the IOMP sponsored project of e-Learning in Medical Engineering and Physics.

Additionally to his scientific and educational activities, Nüsslin took over leadership positions in many national and international medical physics organizations. He served as president of the Deutsche Gesellschaft für Medizinische Physik (DGMP), as president of the European Federation of Organizations for Medical Physics (EFOMP) and from 2009 till 2012 as president of the International Organization for Medical Physics (IOMP). As one of the most important achievements under his term of office in IOMP the occupation of the Medical Physicist has been explicitly included in the International Standard Classification of Occupations ISCO-08 of the International Labour Organization. Furthermore, he promoted a stronger cooperation of the IOMP with major international bodies, e.g. WHO, IAEA, IUPAP, IRPA and BIPM. The focus of his international activities is promotion of medical physics in developing countries, in particular in Africa and Latin America.

From 2009 till 2012 Nüsslin served as editor of the European Journal of Medical Physics.

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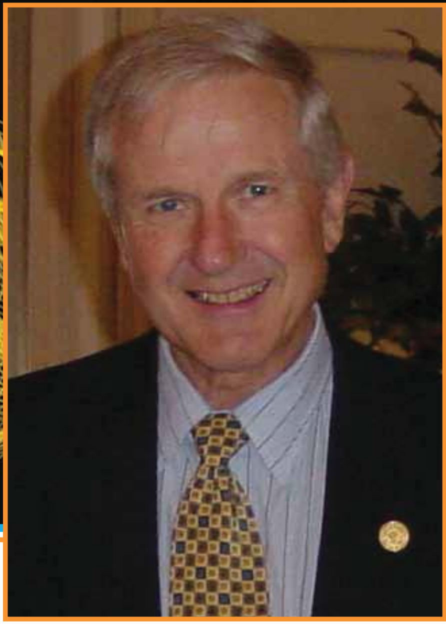

Colin G. Orton

Colin G. Orton, Ph.D., FAAPM, FACMP, FACR, FInstP, started his career in Medical Physics at St. Bartholomew's Hospital Medical College, London University, as an Instructor teaching physics to pre-medical students and radiation oncologists while working on his M.Sc. and Ph.D. degrees in Radiation Physics under the guidance of Professor Joseph Rotblat. In 1966 he moved to the USA as Chief Physicist/Assistant Professor at NYU Medical Center, where he stayed until 1975. On his 1st day at work, the radiobiologist in the department came to his office and asked him if he'd be willing to teach radiobiology to the residents because he preferred to be in the lab and didn't like to "waste time" teaching. This was a seminal moment in Dr. Orton's career since he continued to teach radiobiology to residents, therapists and physicists every year for the next four decades. This also led to his lifelong research interest in biological aspects of radiotherapy. It was during this period in New York that he became involved in AAPM activities, including President of RAMPS and Editor of the Quarterly Bulletin of the AAPM. Whilst Editor, he initiated a series of "Mind Benders" and one of these involved solving a relatively simple NSD problem, which he also sent to about 30 experts worldwide. Over 50% of the responders submitted the wrong answer. This led Dr. Orton to devise the Time Dose Factor (TDF) in order to simplify the NSD.

1973, *British Journal of Radiology*, 46, 529-537

A simplification in the use of the NSD concept in practical radiotherapy

By C. G. Orton, Ph.D., M.Sc. and F. Ellis, M.A., M.Sc., M.D., F.R.C.P., F.F.R.

$$\mathrm{TDF} = n.d^{1\cdot538}.\ x^{-0\cdot169}.\ 10^{-3}$$

Dr. Orton devised the Time Dose Factor (TDF).

Dr. Orton was editor of Medical Physics for eight years.

In 1975 Dr. Orton was recruited to work as Chief Physicist and Associate Professor of Radiation Medicine at Rhode Island Hospital, Brown University and, in 1981 as Chief Physicist/Professor at the Radiation Oncology Center/Wayne State University, Detroit, where he stayed until his retirement in 2003. While at Wayne State he was elected President of the AAPM, Chairman of the ACMP, President of the American Brachytherapy Society, Editor of the new Medical Physics World, IOMP Secretary-General and President, and President of the IUPESM. In 1997 he became Editor of Medical Physics, a position he held for eight years. At Wayne State he directed the medical physics graduate program for over 20 years, with close to 200 M.S. and Ph.D. graduates.

During his career Dr. Orton has published over 200 papers, 50 book chapters, and 19 books, and has received numerous honors including the AAPM Coolidge Award, the ACMP Marvin M. D. Williams Award, and the IUPESM Award of Merit.

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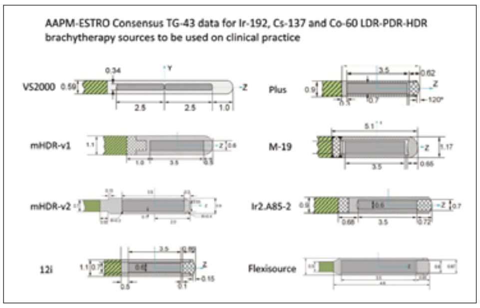
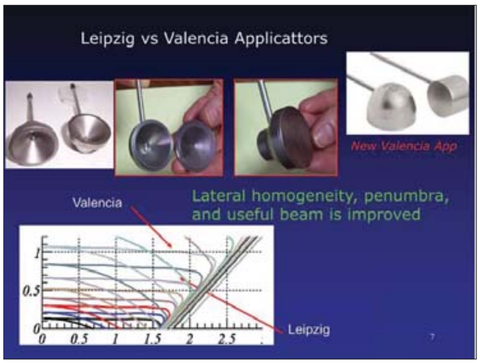
Jose Perez-Calatayud

Jose Perez-Calatayud graduated in Physics in 1981 at Valencia University. He obtained his PhD at the Zaragoza University. He started in Medical Physics in 1985 dedicated to Radiotherapy Medical Physics and subsequently was Associate Professor of the Valencia University (1998-2006). Since 1989 he is the Head of the Radiotherapy Physics Department at the Hospital La Fe in Valencia (Spain) and a member of the Medical Physics Department at Clinica Benidorm (Alicante).

His main research field is Brachytherapy, as part of a Research Group of The Valencia University. The main goals of the group have been the Monte Carlo characterization of a numerous number of brachytherapy sources, the development of the Valencia applicators and last but not least treatment planning aspects on MR based gynecological brachytherapy with the development of dummies compatible with MR.



He is currently or recently been chairman of the Spanish Society of Medical Physics (SEFM) brachytherapy group, Spanish delegate at the GEC-ESTRO BRAPHYQS working group, chair of the AAPM/ESTRO HEBD (High-Energy Brachytherapy Source Dosimetry) Working Group, member of the AAPM Brachytherapy Subcommittee, member of the AAPM TG-143 (Task group on dosimetry for elongated brachytherapy sources), member of the GEC-ESTRO Committee, member of the Physics Committee of the American Brachytherapy Society (ABS) and member of the Brachytherapy Clinical Applications Working Group (BCA-WG) of the AAPM.



Being one of the figureheads of the Valencia Brachytherapy group, he is responsible for an impressive list of high-quality publications in the brachytherapy field. He has contributed to the development and application of the Monte Carlo code to brachytherapy source calculations and consequently a whole set of treatment sources have been characterized.

As member or chair at the main international brachytherapy working groups, he has contributed to establish an international common framework in brachytherapy quality control that it's now referenced all over the world. He has been involved in the process of drawing up the recommendations (AAPM-GEC-ESTRO) for enhancing the quality of treatments and training in brachytherapy.

Finally, as has to be properly mentioned, a worldwide recognized researcher has behind him an outstanding working group, and in this case a grateful recognition has to be included in this poster to: F. Ballester, D. Granero, J. Vijande, M. Rivard, F. LLiso, V. Carmona, M.C. Pujades, T. García, J. Richart, J. Venselaar, R. van der Laarse, F.A. Siebert, S. Rodriguez, M. Santos y A. Tormo (University of Valencia, Hospital La Fe, Cinica Benidorm, AAPM working groups, and BRAPHYQS-ESTRO group).

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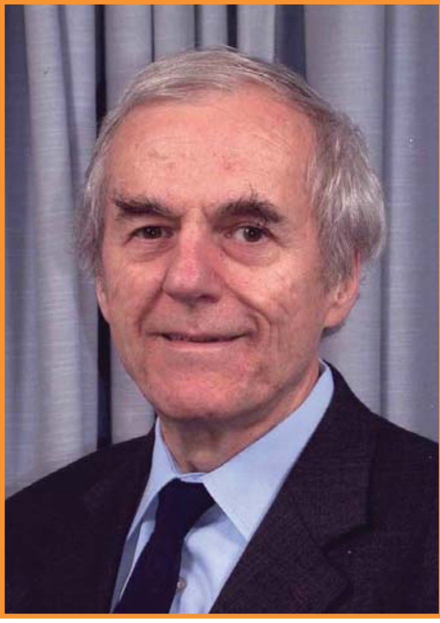

Ervin B. Podgorsak

Dr. Ervin B Podgorsak PhD, FCCMP, FCOMP grew up in Slovenia, where he earned his Dipl. Ing. degree from the University of Ljubljana. He pursued graduate work in medical physics at the University of Wisconsin, receiving his Ph.D. in 1973. Following an invitation by Dr. Harold Johns, he moved to Toronto as a post-doctoral fellow at the University of Toronto and then worked as clinical physicist at the Ontario Cancer Institute. In 1975 Dr. Podgorsak joined McGill University in Montreal and remained there until his retirement in 2010.

As Director of the McGill University Medical Physics Unit from 1991 until 2009, Dr. Podgorsak headed a leading clinical service and an academic program. He built a strong research team at McGill and led the McGill medical physics graduate program and the clinical residency program which were the first Canadian programs to be accredited by CAMPEP.

The author of 157 peer reviewed publications, 3 textbooks, 18 invited book chapters, 70 conference proceedings, and some 360 invited and proffered presentations, Dr. Podgorsak has been involved in medical physics research, such as solid-state dosimetry and linac target design, as well as the development of numerous innovative cancer therapy techniques, most notably dynamic stereotactic radiosurgery.

He has been active within the Canadian College of Physicists in Medicine (CCPM) serving as President from 1987-1989, the American Association of Physicists in Medicine (AAPM), the American College of Medical Physics (ACMP) and the Commission on Accreditation of Medical Physics Educational Programs (CAMPEP). Dr. Podgorsak was also the Chair of the Joint AAPM-COMP Annual Meeting in Montreal in 2002. He has served on the International Stereotactic Radiological Society and on several committees of the International Atomic Energy Agency and is often called upon by international granting agencies for his expertise and ability to function in several languages.

Throughout his career, Dr. Podgorsak worked to improve health care in Quebec and Canada. His long service to the CCPM improved health services by setting standards for education and certification of the medical physicists active in patient care. As the physics leader of one of the larger radiation oncology treatment services in Quebec, Dr. Podgorsak was able to trigger significant improvements in funding for cancer centres in the province.

Dr. Ervin Podgorsak is an outstanding leader and champion of professionalism for clinical medical physicists. In 2006 he received the William Coolidge Award, AAPM's highest honour and in 2009 the Gold Medal, COMP's highest honour. In 2011, the Canadian Association of Physicists (CAP) and COMP awarded Dr. Podgorsak the 2011 CAP-COMP Peter Kirkby Memorial Medal for Outstanding Service to Canadian Physics. This award recognized his leadership in developing and enhancing the Medical Physics profession at the national and international level.

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1963-2013

Ambika Sahai Pradhan

Dr. Ambika Sahai Pradhan is the Editor-in-Chief of Journal of Medical Physics (JMP), an official publication of Association of Medical Physicists of India (AMPI), published by Wolters Kulwer Health and Medknow Publications, online since 2006. The journal caters to the academic need of disseminations of outcome of the newer research in all areas of medical physics. The journal with its international membership of the Editorial Board and the transparent peer review system has attained wide recognition and attracted researchers and readers to opt this journal.

Dr. Pradhan joined Bhabha Atomic Research Centre (BARC), India (a premier research institute of high international repute) in 1969 after his MSc Physics and earned his PhD titled "Thermoluminescence in Radiation Dosimetry" at the University of Bombay in 1981. His early work on indigenous development of thermoluminescence dosimetry (TLD) found wide applications, viz. the TLD badge system continues to be used for countrywide personnel monitoring in India for all occupational workers including those in diagnostic and radiation therapy institutions. His post-doctoral work (including that during fellowship of Alexander von Humboldt (AvH) Foundation of Germany) on in-phantom point dosimetry and measurement of doses due to low and high LET radiation has also found wide application and citation. His current research focuses on on-line dosimetry, imaging and dose mapping using optically stimulated luminescence, radioluminescence and scintillation techniques. He has published 250 research papers (146 in peer reviewed journals) and edited 4 books / conference proceedings

Dr. Pradhan has been a research guide to medical physicists at University of Mumbai and several of them are leading medical physicists both in India and aboard. AMPI conferred on him its award 'Ramaiah Naidu Memorial Oration Award- 2010'. He was also awarded 'KG Vohra Memorial Oration Award -2010' by Indian Association for Radiation Protection (IARP), India. He is a Fellow of Maharashtra Academy of Sciences and is an active member of several other professional bodies in addition to AMPI. He had been a member of Committee-2 of the International Commission on Radiological Protection (ICRP) and continues to be a member of editorial board and book-review-editor of Radiation Protection Dosimetry (RPD) journal of Oxford Universiy Press UK and a member of Safety Review Committee for Applications of Radiation (SARCAR) of Atomic Energy Regulatory Board (AERB) of India.
His dedication to human health care continues unabated.

Outstanding Contributions Over the Last 50 Years

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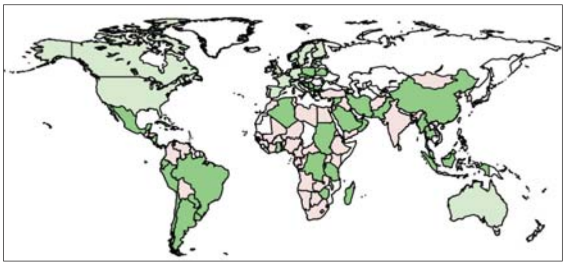
1963-2013

Madan M. Rehani

Dr. Madan M. Rehani has raised patient dosimetry skills of medical physicists in over 70 less resourced countries and brought them to the level of publishing their work in international journals with high impact factor. As a Radiation Safety Specialist at the IAEA he has demonstrated improvement of patient protection in radiology in many countries through his training and research actions. The training material developed by IAEA under his direction has been made freely downloadable and is used extensively by medical physicists in more than 100 countries. He has organised more than 100 training courses in Africa, Asia, Eastern Europe and Latin America and has created the website on radiation protection of patients of the IAEA which is currently a prime resource for radiation protection information in the world. Moreover, he has been serving IOMP as Secretary-General since September 2009.



Countries in dark green where difference was made through projects and documented by publications and light green by use of information provided by him through website

Dr Rehani was earlier Professor & Head, Medical Physics Unit in the Cancer Hospital of the All India Institute of Medical Sciences (AIIMS), New Delhi, India and also Head of the Collaborating Centre of the World Health Organization (WHO) on Imaging Technology & Radiation Protection which he established. He is currently Director of Radiation Protection of European Society of Radiology after retiring from IAEA on 31st Jan 2013.

Awards: He has been awarded the Honorary Membership of the Society of Pediatric Radiology in 2011; The Harold Johns Medal by the IOMP in 2009; the most prestigious award of India in nuclear sciences - Homi Bhabha Memorial Oration by Society of Nuclear Medicine India in 1999; Dr.K.M. Rai Oration by Indian Radiological & Imaging Association 2001.
He was founding President, UPDEL Chapter of the Association of Medical Physicists of India (AMPI) during 1990-94; President, Society of Nuclear Medicine, India, 2001.

Publications: He has edited 5 books, responsible for 15 IAEA publications, published more than 130 papers in journals and contributed Editorials in International Journal of Cardiology, British Medical Journal, Indian Journal of Radiology & Imaging. He has published papers in The Lancet, Catheterization & Cardiovascular Interventions, Semin Ultrasound CT MR, Radiother Oncol, J Nuclear Medicine, Radiation Research, Clin Radiol, Am J Roentgenology, Radiology, Rad Prot Dosimetry etc. Under his chairmanship, 3 Annals of ICRP have been published and another 4 with him as member of TG.

He is Associate Editor of Medical Physics and of BJR and Asstt Editor of AJR.

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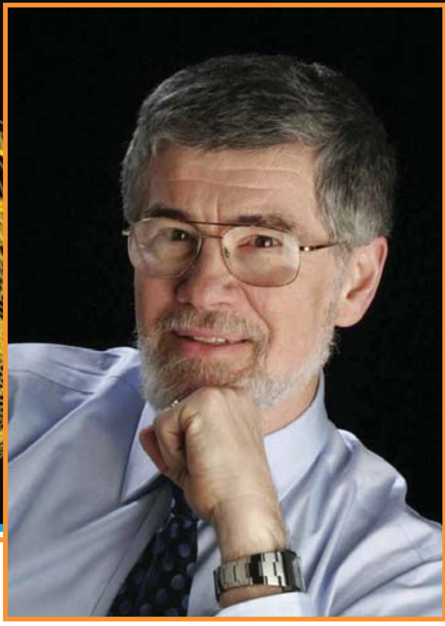


David W.O. Rogers

Dr. David Rogers PhD, FCOMP earned his PhD in experimental nuclear physics from the University of Toronto in 1972. Following a post-doctorate at Oxford, he joined the National Research Council's Ionizing Radiation Standards (IRS) Group that provides Canada's national calibration service for instruments that measure ionizing radiation. He became group leader in 1984 and held that position until 2003. During his tenure, the IRS Group became one of the most respected radiation standards groups in the world. While there he became almost synonymous with the Electron Gamma Shower (EGS) Monte Carlo simulation code. The BEAM code and ESGnrc systems are used often in radiotherapy research and development. At many medical physics meetings, a significant number of the talks on Monte Carlo simulation acknowledge using Dr. Rogers' group's BEAM code.

Dr. Rogers currently holds a prestigious Canada Research Chair at Carleton University's Physics Department. He and his academic team continue to improve, document, instruct and use the EGS Monte Carlo code and solve problems in radiation science.

Professor Rogers emphasizes careful comparison of experimental data to simulations to help improve both. Because of the quality, productivity and importance of his work to the field of medical physics, his collective works are cited extensively.

Professor Rogers is not only an outstanding research scientist but also an accomplished teacher and mentor for students. He has given innumerable EGSnrc/BEAMnrc workshops in Ottawa and around the world. Many of the trainees he has mentored have gone on to leadership roles throughout the North American medical physics community and in various ionizing radiation standards labs in Europe. With Dr. Joanna Cygler, he was the Scientific Co-director and Proceedings Co-editor of the AAPM Summer School in 2009. He has attracted post-doctoral fellows from around the world for his unique mix of Monte Carlo simulation and precise dosimetry metrology knowledge.

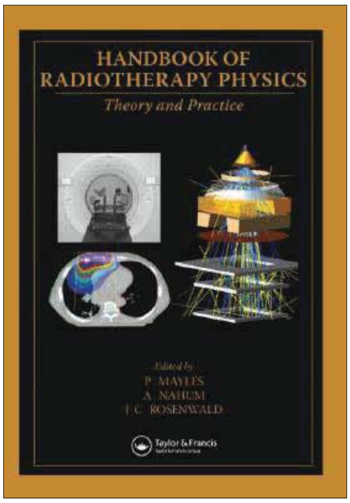
David has been actively involved in COMP since its beginnings and has played a major role in shaping the direction of the organization. In addition to his service to COMP, Dr. Rogers also works tirelessly for international medical physics organizations. He has been on the Editorial Board for Medical Physics for decades and Deputy Editor for Radiotherapy for 9 years. In 2010 he won the AAPM's highest award, the Coolidge Award. Dr. Rogers was awarded the COMP Gold Medal in 2012, COMP's highest honour.

Outstanding Contributions Over the Last 50 Years

Jean-Claude Rosenwald

Jean-Claude Rosenwald was born in 1945 in Neuilly, close to Paris. After earning an engineering degree in electronics, nuclear physics and computing sciences obtained in Nancy in 1967, he began his career as a computer scientist developing dose calculation programs for brachytherapy at the Institut Gustave Roussy in Villejuif, under the supervision of Andrée Dutreix. He obtained his PhD on this subject in 1976.

He was appointed medical physicist at the Institut Gustave Roussy from 1971–1975 and then, after a short stay in Milwaukee (USA) to help for the implementation of computerized treatment planning, he moved in 1976 to the Institut Curie in Paris, as head of the Medical Physics Department. Altogether, 17 PhD and more than 60 master's students have undertaken research programmes under his supervision. His name is cited in more than 100 publications in journals or books and he has made more than 150 communications in national or international meetings.



Dr. Rosenwald was one of the co-authors of the Handbook of Radiotherapy Physics published in 2007.

Dr. Rosenwald has always had a particular interest in the use of computers in radiation therapy and to the related quality control procedures. He participated in several international conferences, has been a co-author of several reports on this subject (ICRU, IAEA, ESTRO, ICRP). He was involved in the development of commercial solutions for treatment planning both for external-beam radiotherapy and brachytherapy (the ISIS software, now superseded by the ISOgray software from the DOSIsoft company). He also promoted the use of proton beams in radiotherapy and played a major role in the development of the Centre de Protonthérapie d'Orsay, now part of the Institut Curie.

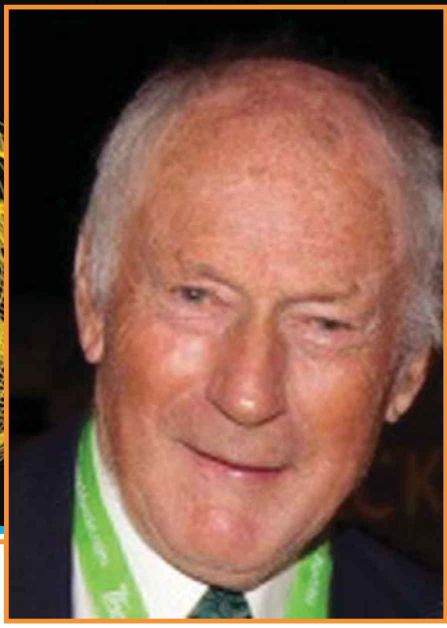
He participated to the education and training of many medical physicists as lecturer for the Master Degrees in Medical Physics and for the French MP Qualification degree. He favoured the creation of the medical physics master degree, at Paris-Sud University in 2004. He was one of the co-authors of the Handbook of Radiotherapy Physics published in 2007.

He served as president of the French Society for Medical Physics (SFPM) 1979–1982, as chairman of the Scientific Committee of the European Federation of Medical Physics (EFOMP) 1990–1993 and chaired the Scientific Committee for Medical Physics at the International Conference of Bioengineering and Medical Physics held in Nice in 1997. He was member of the editorial boards of several journals (European Journal of Medical Physics, Radiotherapy and Oncology and Cancer/Radiothérapie) and associate editor of the European Journal of Medical Physics from 2008 to 2010.

He is now retired, but still doing some teaching, and preparing various reports for the medical physics community. The SFPM recently asked him to manage a working group to elaborate a guide on "good practice of medical physics". The guide was published in 2012.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP



1963-2013

Hans Svensson

Hans Svensson was Professor of Medical Radiation Physics, University of Umeå, Sweden, from 1982 until his retirement in 2000. He was one of the most international of the Swedish medical physicists, and as a creative scientist and outstanding dosimetry physicist he was a pioneer of modern radiotherapy dosimetry playing a vital role in promoting quality assurance in its early days. Hans Svensson's career spanned more than 50 years, during which he was fundamental in bringing together the medical physics and standard laboratory communities as well as a key player in many international and organizations and activities, where his political skills flourished.

Hans Svensson and his colleagues in Umeå and in Göteborg were very active in the development of a new dosimetry protocol for external radiotherapy, known as the NACP code of practice for reference dosimetry, and later adopted in the IAEA's TRS-277 guidelines. He was a forerunner in clinical research. Together with Anders Brahme he introduced the very first 50 MV Racetrack Microtron equipped with a computer controlled multi-leaf collimator (MLC) for both MV X-rays and electrons at his own department 1985. He possessed a great amount of humanity and contributed considerable to a world-wide spread of medical physics. He played a leading role in the IAEA dosimetry activities, and as was very active in ESTRO during many years. During the first ESTRO-meeting in London 1982 he and Alan Nahum gave the first lecture in physics on "How Accurate can Absorbed Dose to Tissue be Determined?" followed by many more courses. He was one of the driving forces to establish a separate physics meeting for those years when the annual ESTRO meeting was included in the ECCO meeting. The activity within IAEA significantly contributing by standardisation of protocols and organisation of dosimetry reviews, as well as development of protocols for standardised reporting of the target dose. Hans Svensson was the Chairman of the report committee on "Electron beam dosimetry" 1984, and an active member of ICRU committees on "Reporting photon and electron beam therapy" 1999 and 2004. Hans Svensson was general secretary in IOMP 1993-1997.

Among a number of awards during his career, he was designated an AAPM honorary membership 2001, a distinction rarely given, and he achieved the ESTRO Founding Members Award at the Anniversary Meeting in London 2011, a few months before his decease.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Tae Suk Suh

Dr. Tae Suk Suh, Professor of Medical Physics at the Catholic University of Korea is known for his work with his colleagues on the development of radiotherapy planning, multi-modality imaging, and, in particular, the radiosurgery system.

Tae Suk Suh contributed greatly towards the development of University of Florida radiosurgery system using unique bearing system as one of UF Teams during 1987-1990.

Professor Suh's career has spanned more than 30 years, a period which has witnessed huge advances in radiosurgery hardware and planning systems. He has contributed greatly towards the development of radiosurgery optimization techniques; and in 1998 at Kangnam St.Mary's hospital in Seoul, he was the first to undertake flattening filter free (FFF) beam-based radiosurgery in a clinical setting. He also pioneered many other technologies, including the development of the radiation treatment planning system and 3T active shield magnetic resonance imaging.

Having established his academic career in Korea, Professor Suh has served as an editor and editorial board member for many international journals of medical physics. During his leadership of the Korean Society of Medical Physics, he was well appreciated for his many contributions, including his promotion of medical physics in the Asia-Oceania region, and he organized the World Congress on Medical Physics and Biomedical Engineering in 2006 (WC 2006, Seoul) and the Asia-Oceania Congress of Medical Physics three times in Asia (AOCMP 2002, 2006, 2012).

Tae Suk Suh organized the WC 2006 in Seoul, Korea, in 2006. (Opening ceremony)

In 2001, the Korean Ministry of Science and Technology acknowledged Professor Suh's Radiation Biomedical Engineering Laboratory (RBEL) at the Catholic University of Korea as a National Research Laboratory. In 2009 the RBE Laboratory and Molecular Imaging Program at Stanford jointly established the Advanced Research Center for Medical Physics, as a center for international research. In 2006 and again in 2012, Professor Suh was honored with the Korean Government's Award for the Best Academic Achievement.

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Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

David Thwaites

David Thwaites is currently Professor of Medical Physics and Director of the Institute of Medical Physics in Sydney University, Australia, having previously been Head of the Department of Medical Physics and Engineering in Leeds Teaching Hospitals and Professor of Oncology Physics at Leeds University, UK, with prior posts in the Yorkshire and Edinburgh Cancer Centres.

Enduring career themes, with some examples of national and international level contributions, include:

i) combining academic and clinical service roles, thereby linking basic, translational and clinical research to practice, reflecting his strong belief that medical physics research should be rooted in and contribute to service quality and service development.
Career-long research interests include radiation dosimetry, radiation oncology physics, novel radiotherapy technologies and techniques, including imaging and particle therapy applications, and accuracy and precision in radiotherapy. These have produced more than 150 scientific publications, books and book chapters and a long-time physics editorship of 'Radiotherapy and Oncology'.
Contributions include: dosimetry parameter and protocol (code-of-practice) data and recommendations; establishment and development of dosimetry inter-comparison and audit programmes (UK, ESTRO, IAEA); development of quality assurance, Quality System and audit recommendations, structures and methodologies for radiation oncology and medical physics in Europe (ESTRO) and more widely via the IAEA; establishing productive research collaborations and networks between universities, hospitals and industry re developing technology applications; and participation in many steering/advisory/guidelines/ recommendations/evaluation groups eg. for clinical trials, novel technologies, dosimetric methods, quality issues (UK, Europe, Australia).

ii) a firm commitment to medical physics education, training and professional standards, including for developing countries. Examples at national/ international (ESTRO, EFOMP, ICRU, IAEA, IOMP, ISRO) levels include: staffing and other standards recommendations, a well-used text book for trainees and other significant syllabus, teaching and training materials in the UK, for ESTRO and for the IAEA; extensive involvement in direct teaching, training, assessment and accreditation in the UK, Europe and for developing countries (via IAEA, ESTRO, ISRO); and in Australia, eg. having recently established a national inter-university network for medical physics education and research.

iii) a strong interest in developing and supporting local, national and international collaborations, networks and teams between inter-disciplinary professional groups, including in education, based on the principle that ensuring effective engagement of medical physicists with partner clinicians and clinical services and a focus on quality and clinical needs ensures the best outcome for the patient. This applies equally to service activity as to professional organisation work and these contributions have gained recognition, eg. the first physicist elected to the ESTRO Board in full membership elections, awarded FRCR (UK Clinical Oncologists College) for contributions to education and practice of clinical oncology (UK) and, recently publicly announced by ESTRO, will receive the 2014 Emmanuel van der Scheuren award for scientific excellence and contributions to education, to ESTRO and to radiation oncology in Europe.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Giampiero Tosi

Giampiero Tosi was born in Novara in 1937 and graduated in Physics from the University of Milano in 1961. His thesis was titled "Study on a polarized proton source for an AVF cyclotron". He became early an assistant professor in the same University, carrying out studies on electrostatic accelerators at the Research National Council.

In 1963 he began work at a private hospital in Milan on a 32 MeV betatron for tumor radiotherapy and in 1967 he was invited to work on a 42 MeV betatron and a Cobalt-60 unit at the Niguarda Hospital, where he had the charge of Director of the Medical Physics Department from 1971 to 1993.

At the beginning of '70s, he developed the idea to create at the University of Milano the first post-graduate School in Medical Physics in Italy, giving an important contribution to its establishment in 1978. He was lecturer of this School until 2005. Following the School of Milano, 15 other post-graduate Schools were created in Italy.

At the beginning of 80's, he designed the first dedicated X-ray irradiator of blood components, that was largely adopted not only in Italy, and in 1991 he promoted with Ugo Amaldi the realization of the National Hadrontherapy Center, equipped with a synchrotron able to accelerate both protons and carbon ions. Its realization was completed in 2010, and the synchrotron is now treating selected patients in the so called National Center for Oncological Hadrontherapy (CNAO), in Pavia.

In 1993 he was called by Umberto Veronesi to direct the Medical Physics Unit of the European Institute of Oncology in Milano, where he was one of the promoters of the employ of dedicated linear accelerators for intra-operative radiotherapy, especially for the treatment of early breast cancers.

Between 1990 and 2002, he was Chairman of the IEC SC 62B on "Diagnostic Imaging Equipment", promoting the elaboration of many technical standards on the performance and quality control procedures of diagnostic radiological equipment.

Very recently he has been appointed as a fellow of the Academy of Sciences of Turin for the discipline "Medical Physics".

Now he is retired but he is still a reference for youngest Medical Physicists, carrying out his scientific activity especially in teaching.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

Jacob (Jake) Van Dyk

Prof. Van Dyk MSc, FCCM, PhD, DABMP, FCOMP obtained his BSc. from McMaster University and his M.Sc. from the University of Western Ontario, Canada in 1971, under the supervision of Dr. J.C.F. MacDonald (2007 COMP Gold Medal winner). He then joined the Clinical Physics group at the Princess Margaret Hospital, Toronto as a valuable member of the Johns and Cunningham "power house" in medical physics.

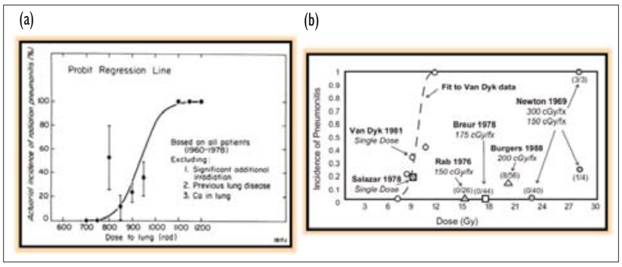

Figure 1.

(a) These dose-response data for radiation pneumonitis with single fraction, half-body irradiation were published by Van Dyk et al. in 1981. Along with pneumonitis data for total body irradiation, these data became a guide for dose prescriptions for the many patients treated with these techniques.

(b) The data are still referenced today is indicated by the figure from Marks et al. published in the recent (2010) QUantitative Analysis of Normal Tissue Effects in the Clinic (QUANTEC) review.

In 1995, Prof. Van Dyk relocated to the London Regional Cancer Centre to become Head of Clinical Physics, and in 1999, he became full Professor at Western University in London, Ontario. Prof. Van Dyk became Professor Emeritus on October 27th, 2011 - coincidentally on the 60th Anniversary of the world's first cobalt cancer treatment in London, Ontario. Prof. Van Dyk has won awards of excellence for teaching at both the University of Toronto and Western. He has produced three volumes on The Modern Technology of Radiation Oncology. These are used as major references around the world.

Prof. Van Dyk served as the President of the Canadian College of Physicists in Medicine (CCPM) from 1991-1995 and has participated as an examiner for the CCPM for over 15 years. He also served in numerous capacities for the Canadian Organization of Medical Physicists (COMP), the American Association of Physicists in Medicine (AAPM) and represented Canadian medical physics at the IOMP. He has received honorary fellowships from both the AAPM and COMP. In recent years, he has served as Consultant to the IAEA, living in Vienna and reaching out to assist developing nations. Prof. Van Dyk has authored over 135 peer-reviewed publications and presented over 200 invited lectures in over 30 countries. His collective works have been cited extensively. He is best known for clinically relevant radiobiology research on radiation-induced lung toxicity, multiple aspects of quality assurance (QA) and uncertainty analysis of modern radiation therapy. Prof. Van Dyk holds patents for the design of QA phantoms distributed worldwide by Modus Medical Devices. He has an inquisitive scientific mind, an honesty to admit when he does not understand something fully, attention to detail, leadership and organizational qualities, and a strong work ethic that brings key issues to decisive resolutions.

At the 2011 joint meeting of COMP and the AAPM, Prof. Van Dyk was honoured with the Gold Medal, COMP's highest honour which recognized his major national and international contributions to medical physics in research, education, and administration.

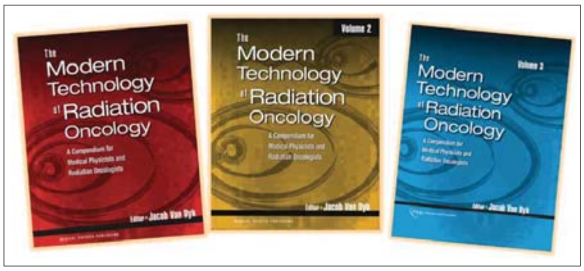

Figure 2. "The Modern Technology of Radiation Oncology" series have become a reference around the world for practicing medical physicists and especially for medical physicists who are sitting their certification exams. Volume 1 was published in 1999, Volume 2 in 2005 and Volume 3 in 2013.

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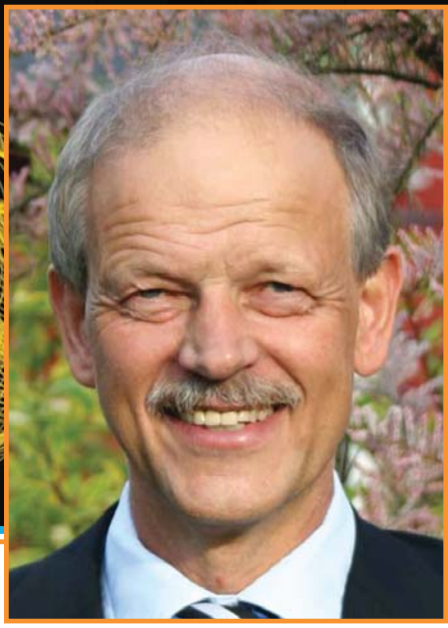


1963-2013

Willi Kalender

Willi Kalender, Ph.D., FBIR, FAAPM, is Professor and Chairman of Medical Physics at the University of Erlangen-Nuremberg. Right from the beginning of his research activities he focused on the development and improvement of diagnostic imaging in radiology, at first in the research laboratories of Siemens Medical Systems, Erlangen, Germany, and since 1995 as the head of the newly established Institute of Medical Physics at the University of Erlangen.

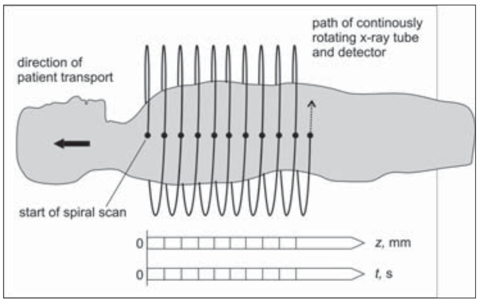


Figure 1: Spiral CT became possible in the late 1980s with the introduction of continuously rotating systems. It allows for fast and gapless acquisition of 3D data volumes at very high quality.

Willi's contributions to the field are well known. His introduction of volumetric spiral computed tomography in 1989, a technique that enabled the transition from sequential two-dimensional (2D) CT imaging to fast volumetric three-dimensional (3D) imaging (fig. 1), has led to a complete change of paradigm in CT imaging. In the 1990s he followed this up by developing phase-correlated cardiac imaging and attenuation-based tube current modulation (fig. 2) based on spiral CT. Nowadays, spiral CT has been fully integrated into clinical practice with considerable benefits for the patient by reduction of scan times and of patient dose.

Other fields of his research were radiation protection and the development of quantitative diagnostic procedures, e.g. for the assessment of osteoporosis, lung and cardiac diseases. Topics of his current research projects are dose assessment and reduction in CT and, in particular, high-resolution CT of the breast at dose levels equivalent to those in screening mammography. Willi has always emphasized the importance of interdisciplinary work and cooperated strongly with radiology, but also with other disciplines of medicine, natural sciences and engineering as well as industrial partners.

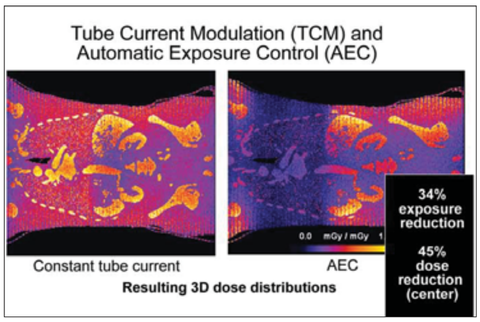


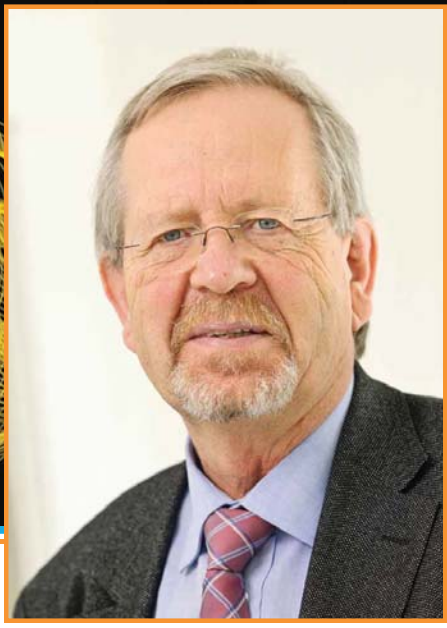
Figure 2: Dose can be optimized and reduced by tube current modulation and automatic exposure control. Spiral CT allows controlling these in real time by using the measured attenuation data.

Willi Kalender received a large number of awards reflecting the high recognition of his work by his peers worldwide. Among others, the European Science Foundation (ESF) awarded him the 2007 European Latsis Prize, the American Association of Physicists in Medicine honoured him with the William D. Coolidge Award in 2009. In the same year he was elected as member of the German National Academy of Sciences Leopoldina. In 2004 he received the Cross of the Order of Merit of the Federal Republic of Germany. His work is reflected by more than 900 publications, among these about 270 original articles.

Outstanding Contributions Over the Last 50 Years

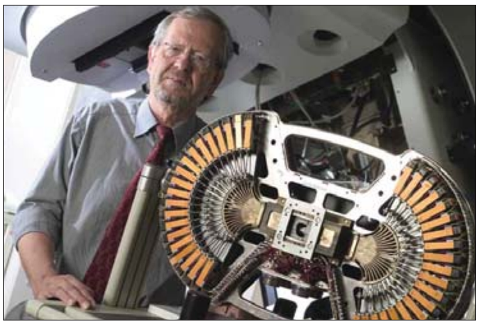
50 Years of IOMP

1963-2013



Wolfgang Schlegel

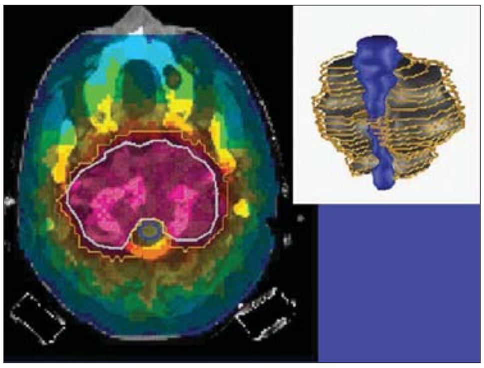
Wolfgang Schlegel is known for his pioneering work in radiotherapy physics. Under his leadership new technologies for radiotherapy were developed, which significantly enhanced the precision and effectiveness of cancer treatment with ionizing radiation. Wolfgang Schlegel studied Physics in Berlin and Heidelberg and was a graduate student at the Max-Planck-Institute for Nuclear Physics in Heidelberg where he graduated in 1970 and received the Ph.D. (Dr. rer. nat.) in 1972.



Wolfgang Schlegel with the „Micro-Multi-Leaf Collimator", which was developed by his group for applications in conformal stereotactic radiotherapy and radiosurgery.

Wolfgang Schlegel´s occupational career as a Medical Physicist started in 1973 when he became a Research Associate at the German Cancer Research Center (DKFZ) in Heidelberg. The University of Berlin appointed him to a professorship in Medical Physics in 1988. In 1993 he became a Professor of Medical Physics at the University of Heidelberg and the Head of the Department "Medical Physics in Radiotherapy" at the DKFZ.

His research covers important fields of radiotherapy physics and technology, such as 3D treatment planning, stereotactic radiosurgery, 3D conformal radiotherapy, intensity modulated radiotherapy (IMRT), image guided radiotherapy (IGRT) and ion therapy. The developments of his department initiated a breakthrough in radiotherapy concerning precision and conformality of dose delivery. By combining basic research and translation, the Heidelberg group belongs to those groups performing groundbreaking achievements in 3D treatment planning, radiosurgery of brain tumours, 3D conformal radiotherapy with Multi-Leaf-Collimators and IMRT. Recently his department was instrumental in establishing the "Heidelberg Ion Therapy facility" (HIT) as the first European Ion therapy unit.



2D- and 3D-IMRT plan for a chordoma patient (one of the first patients to be treated with IMRT at DKFZ in 1998).

Not only as a researcher, Wolfgang Schlegel also distinguished himself as an academic teacher and promoter of education in Medical Physics. He supervised more than 200 diploma-, masters- and PhD-theses in Medical Physics. He established the postgraduate further education programme "Medical Physics" at the University of Heidelberg, the on-line Masters programme "Advanced Physical Methods in Radiotherapy" (APMR) and the Masters programme "Clinical Medical Physics" which recently started as a collaboration between the Pontefica Universidad Catolica/Santiago de Chile (PUC) and the University of Heidelberg.

Wolfgang Schlegel is awardee of numerous scientific prizes: In 1996, he received the "Karl-Heinz Beckurts Award" of the German Ministry of Research and Education for successful technology transfer, he was nominated for the "Future-Award of the German President" in 2001, he received the "German Cancer Award 2003", the "Glocker Medal 2010" of the German Medical Physics Society (DGMP) for his lifelong achievements in Medical Physics and he became a honorary member of the German Society of Radiation Oncology (DEGRO) in 2013.

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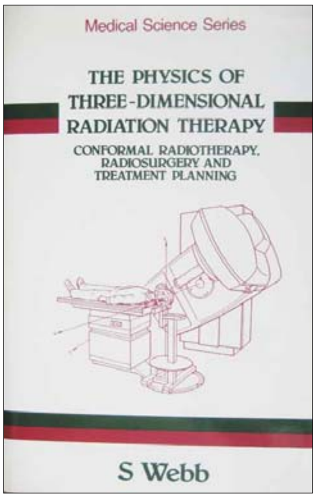
1963-2013

Steve Webb

Steve Webb PhD DSc was Professor of Radiological Physics in the University of London from 1996 - 2011 and is now Emeritus Professor. He was Head of the Joint Department of Physics at the Institute of Cancer Research (ICR) and Royal Marsden NHS Foundation Trust (RMH) from 1998 - 2011. He is known for his work in developing intensity-modulated radiation therapy (IMRT). IMRT treatments have now been established to improve the quality of life of cancer survivors and their prognosis, depending on the cancer site.

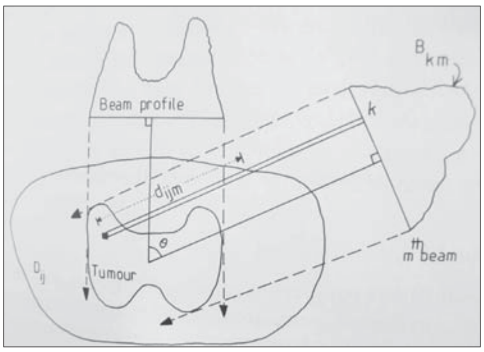


Cover of one of first books on IMRT published in 1993

Steve's early career in medical physics started in 1974 after postgraduate study in cosmic-ray physics at Imperial College. For the first 15 years he contributed to advances in radioisotope imaging (longitudinal tomography, SPECT and PET), x-ray CT for planning breast radiotherapy and Monte Carlo dosimetry. A fundamental switch in 1988 saw Steve commit the next 25 years largely to radiation therapy physics. In the late 1980s, he was one of a handful of people worldwide who started to create the techniques of intensity-modulated radiation therapy (IMRT). Working at the theoretical end of the research feeding pipe, he also guided others closer to practical clinical implementation. At ICR RMH, the almost unique research/clinical/teaching atmosphere, together with a galaxy of talented colleagues, were the key to substantial change and progress.

Perhaps uncharacteristically for a senior scientist with supervisory and management responsibilities, Steve continued independent personal research right up to retirement and some 96 of his 325 peer-reviewed papers were single-authored. He also published five single-author textbooks as well as editing a multi-authored book on medical imaging.

Steve was a Trustee of the Institute of Cancer Research for 12 years and is now a Member. He was Editor in Chief of IPEM's journal Physics in Medicine and Biology from 2006-2011. He was awarded the Silvanus Thompson Medal and the Barclay Medal of the British Institute of Radiology and is the 4th recipient of the EFOMP Silver Medal. He has held visiting professorships in many cancer centres worldwide. Steve led the teaching of radiation therapy physics for 14 years at the EFOMP/ESI European School for Medical Physics (Archamps).



Breakthrough in IMRT- demonstrating pencil rays individually modulated coming together from different directions to make a concave dose distribution. Illustration from Webb's first paper on IMRT in 1989.

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Outstanding Contributions Over the Last 50 Years

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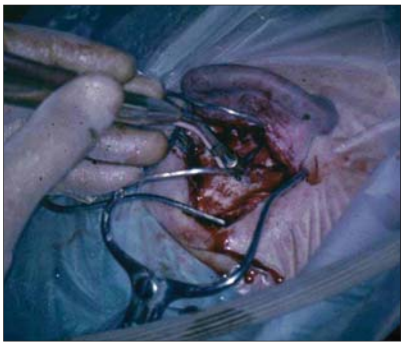
1963-2013

Peter Wells

Peter Wells CBE FRS FREng FMedSci FLSW is recognised internationally for his accomplishments in medical ultrasonics. His earliest work was concerned with ultrasound as a surgical tool and, since 1962, he and his colleagues have pioneered numerous techniques which have been clinically significant, many of which are in diagnostic use today. Perhaps most notable of these are the world's first ultrasonic static scanner with articulated arms, the first water-immersion automated ultrasonic breast scanner, the first realisation of dynamic ultrasonic beam focusing, the first ultrasonic characterisation of the liver in health and disease, one of the first of three simultaneous independent demonstrations of pulsed Doppler ultrasound, the discovery of the ultrasonic Doppler signal due to malignant tumour neovascularisation, and the development of continuous wave ultrasonic Doppler tomography.



Ultrasonic probe for the surgical treatment of Meniere's disease, a procedure pioneered in Bristol in the early 1960s.

He began his career in medical physics in 1959, as a trainee at Bristol General Hospital, having first served a student apprenticeship at the General Electric Company's Telephone Works in Coventry. After this, he worked as a Research Assistant at the United Bristol Hospitals, supported for 12 years by grants from the Medical Research Council. At the age of 35, he was appointed Professor of Medical Physics at the Welsh National School of Medicine, now Cardiff University School of Medicine. He returned to Bristol in 1975, as Area Physicist to the Avon Area Health Authority (Teaching) and Head of the Department of Medical Physics in what is now the University Hospitals Bristol NHS Foundation Trust, retiring from the Professorship of Physics and Engineering in Medicine at Bristol University in 2001. He was appointed Distinguished Research Professor in the School of Engineering at Cardiff University in 2004, where he continues to be active in scientific leadership and research. His most recent paper, his 170th in peer-reviewed journals, has recently been accepted for publication in Physics in Medicine and Biology.

Ultrasonic static scanner, the 1967 development of the first which was built in Bristol in 1963.

Peter Wells was the first recipient of the EFOMP Medal, as well as numerous other medals, awards, honorary fellowships and honorary degrees, both at home and abroad. Almost uniquely, he is a Fellow of three of the UK's National Academies, the Royal Society, the Royal Academy of Engineering and the Academy of Medical Sciences, as well as the Learned Society of Wales.

Outstanding Contributions Over the Last 50 Years

50 Years of IOMP

1963-2013

John Mallard

John Mallard OBE FRSE was Professor of Medical Physics at the University of Aberdeen from 1965 until his retirement in 1992. He is known for his pioneering work in the field of medical imaging as well as for his many contributions to the profession.

Professor Mallard with Aberdeen's first whole-body magnetic resonance imager.

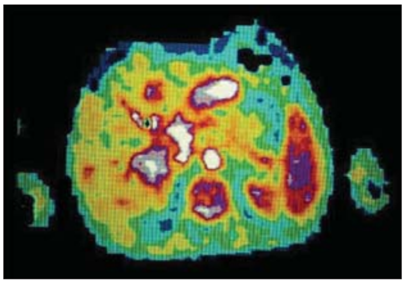
In the early 1970's he built the first British tomographic imager, for the 3D imaging of radionuclide distributions in the body.
This preceded the development of Hounsfield's X-ray CT scanner by several years.

He was a firm believer that positron emission tomography (PET) would prove to be a major clinical diagnostic technique and set up a PET facility in Aberdeen in 1976.

His major contribution to medical imaging was in Magnetic Resonance Imaging. His group was responsible for some of the discoveries which led to this technique becoming a clinically viable technique, including the concept of spin warp imaging which allowed truly 3D MR images of the whole body to be produced for the first time. The production of the first clinically valuable magnetic resonance images from patients in 1980 was a major scientific event.

John's final idea before retirement was for a new medical imaging technique, known as proton electron double resonance, which aims to image free radicals in vivo. His idea originated from a paper he first wrote for Nature in 1963 but worked based on this is now being carried out around the world.

He also made major contributions to the development of the profession of Medical Physics. He was a founder Secretary General of the International Organisation for Medical Physics and later its President. He was Founder President of the International Union of Physical and Engineering Sciences in Medicine. He was also President of both the Hospital Physicists Association and the Biological Engineering Society.



The first clinically useful magnetic resonance image of the trunk taken using the spin-warp technique on August 26th 1980. This section taken through the liver shows multiple hepatic metastases, and a previously unknown metastasis in the spine.

He has received many honours and prizes during his career including the Landauer Memorial Plaque of the American Association of Physicists in Medicine, the Academic Enterprise Competition Prize of the British Technology Group, the Royal Society Welcome Prize and Gold Medal, the George Van Hevesey Memorial Lecture medal, The Royal Society Mullard award and the Royal Medal of the Royal Society of Edinburgh.

He was made an Officer of the Order of the British Empire in the Queen's Birthday Honours List in 1992.

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