

Medical Physics: A Profession and Science

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Intensive Course and Workshop
The World of Medical Physics
King Faisal Specialist Hospital & Research Center
Riyadh, Saudi Arabia
December 7 - 9, 2010

Medical Physics

Profession and Science:

based on use of **Physics** and **High Technology** in Medicine for *diagnosis* and *treatment of disease*:

□ Profession

- Recognized since 2008
- Radiotherapy
- Imaging
- Health physics

□ Science

- Applied
- Translational
- Multidisciplinary
- Incremental

Physics in Medicine

- ❑ The study and use of ionizing radiation in medicine started with three important discoveries:
 - X rays by **Wilhelm Conrad Roentgen** in 1895.
 - Natural radioactivity by **Henri Becquerel** in 1896.
 - Radium-226 by **Pierre Curie and Marie Curie** in 1898.



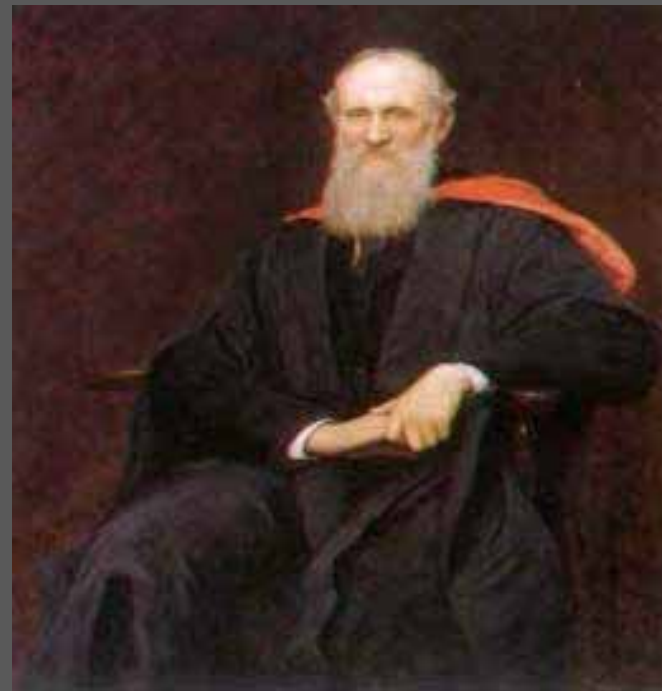
“X rays will prove to be a hoax”

William Thomson

Lord Kelvin

(1824 - 1907)

who had been appointed a professor of mathematics and physics at the age of 22 and who became one of the greatest scientist of his day.



Medical Physics: Areas of Activity

- Service (Raison d'être)
- Research (Road to advancement)
- Teaching (Hope for the future)
- Administration ("Necessary evil")



Ultrasonic imaging



Scanning electron
microscopy



Magnetic resonance
imaging (MRI)



Computerized
tomography (CT)

OUTLINE

- ❑ Professional Aspects of Medical Physics
 - Concentration of Medical Physicists around the World
 - Recognition of Medical Physics as Profession
 - Medical Physics Organizations
 - Best route to Medical Physics Profession
- ❑ Medical Physics in North America (Canada and U.S.)
- ❑ Accreditation and Certification
- ❑ Teaching and Research
- ❑ Conclusions

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Medical Physics Worldwide

Concentration of Medical Physicists

- ❑ World Population: ~6 800 million
- ❑ Number of Medical Physicists: ~ 18 500
- ❑ Mean concentration: ~ 2.7 per million population
 - In developed countries: (~ 15 – 20) per million population
 - In developing countries: (~ 1 – 5) per million population
 - In many undeveloped countries: 0

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Medical Physics: Profession

United Nations



United Nations
Department of Economic and Social Affairs
Statistics Division

International Labour Organization (ILO)



Founded in 1919
Headquarters: Geneva

International Standard Classification of Occupations (ISCO)

1958 (ISCO-58); 1968 (ISCO-68); 1988 (ISCO-88); **2008 (ISCO-08)**





ISCO

International Standard Classification of Occupations

Purpose of ISCO:

To organize jobs into a defined set of groups according to the **tasks** and **duties** undertaken in the job.

ISCO-08

Major groups: **10**

Minor groups: **28**

Unit groups: **116**

Subgroups: **390**



ISCO

International Standard Classification of Occupations

ISCO-08: 10 Major groups

- 0 Armed (defense) forces
- 1 Managers
- 2 Professionals**
- 3 Technicians and associate professionals
- 4 Clerks
- 5 Service, shop and market sales workers
- 6 Skilled agricultural, forestry and fishery workers
- 7 Craft and related trade workers
- 8 Plant and machine operators and assemblers
- 9 Elementary occupations



ISCO

International Standard Classification of Occupations

2 Professionals

21 Science and engineering professionals

22 Health professionals

23 Teaching professionals

24 Business and administration professionals

25 Information and communication technology professionals

26 Legal, social, and cultural professionals



ISCO

International Standard Classification of Occupations

2 Professionals

21 Science and engineering professionals

211 Physical and earth science professionals

2111 Physicists and astronomers (59 titles)

- Astronomers
- Astrophysicists
- Medical physicists
- Nuclear physicists
- Biophysicists
- Radioastronomers
- 52 other physics titles

2112 Meteorologists

.....



ISCO

International Standard Classification of Occupations

2 Professionals

21 Science and engineering professionals

22 Health professionals

221 Medical doctors

2211 Generalist medical practitioners

2212 Specialist medical practitioners

- Anaesthetists
- Cardiologists
- Nuclear medicine specialists
- Radiation oncologists
- Radiologists
- Surgeons

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Medical Physics Worldwide

Medical Physics Organizations

- International
- Regional
- Sub-regional
- National
- Sub-national

IAEA also deals with Medical Physics

Department of Nuclear Sciences and Applications

Division of Human Health

Dosimetry and Medical Radiation Physics Section

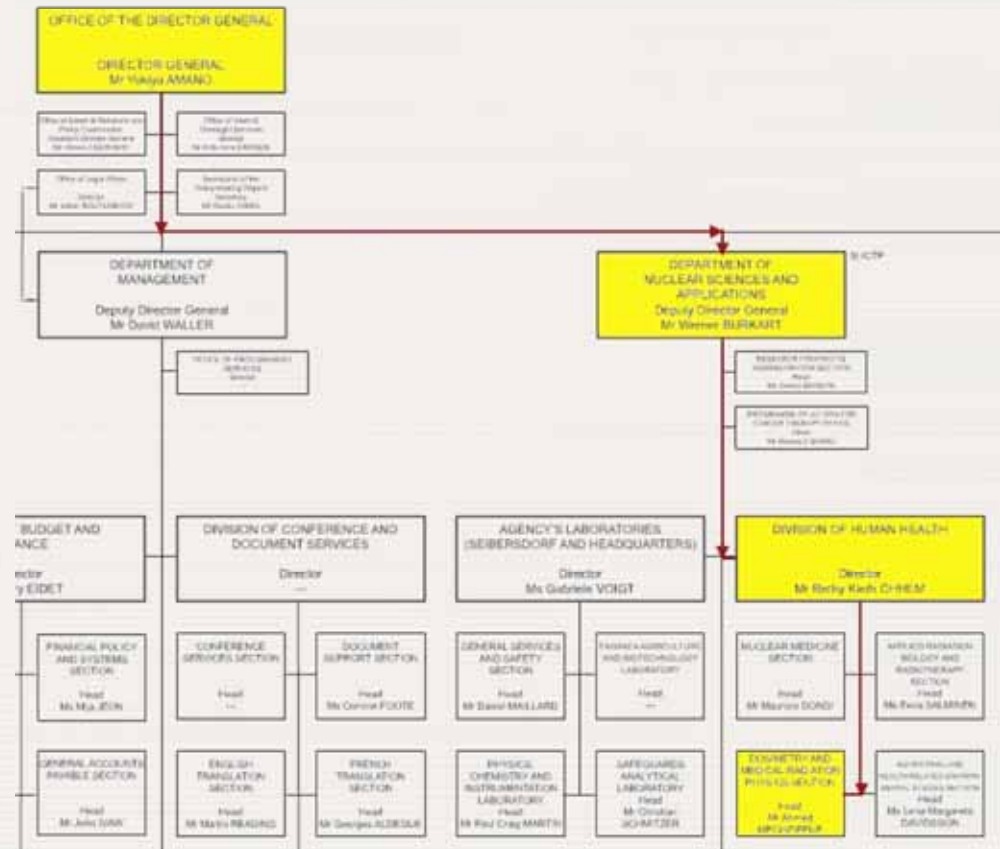
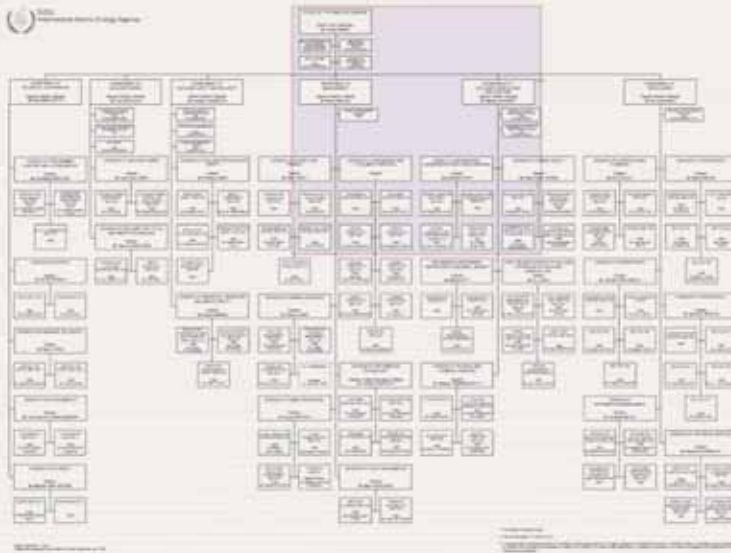




IAEA.org
International Atomic Energy Agency



- ❑ **IAEA**: International organization that promotes the **peaceful use of nuclear energy**.
- ❑ Established in **1957** as an independent international organization reporting to the United Nations General Assembly and Security Council.
- ❑ Headquarters in **Vienna, Austria**
- ❑ Member states: **151**
- ❑ The IAEA also promotes the development of **medical physics in developing countries**.



Department of Nuclear Sciences and Applications Division of Human Health

Dosimetry and Medical Radiation Physics Section

International Council for Science



International Union for Physical and Engineering Sciences in Medicine



International Union of Pure and Applied Physics

To stimulate and facilitate international cooperation in physics and the worldwide development of science.



IUPAC

International Union of Pure and Applied Chemistry



+ 22 other Scientific Unions



International Union of Physical Sciences and Engineering in Medicine

Sponsoring Organizations of the IUPESM:

- International Organization for Medical Physics (IOMP)



- International Federation for Medical and Biological Engineering (IFMBE)



International Federation for Medical and Biological Engineering

Medical Physics: Science and Profession



Regional, Sub-regional and National
Medical Physics Organizations

Medical Physics Worldwide

□ International Organization for Medical Physics (IOMP)



- Formed in 1963
- Inaugural sponsors: Canada, Sweden, UK, and USA
- Sponsored by: 80 national medical physics organizations.
- Representing about 18 500 medical physicists worldwide.

Medical Physics Worldwide

Regional Organizations (4 existing + 2 pending)

- ❑ Asia-Oceania Federation of Organizations for Medical Physics (AFOMP)

(16 countries)



ASIA-OCEANIA FEDERATION OF ORGANIZATIONS
FOR MEDICAL PHYSICS

- ❑ European Federation of Organizations for Medical Physics (EFOMP)

(38 countries, 5000 members)



European Federation of Organizations
for Medical Physics

- ❑ Southeast Asian Federation for Medical Physics (SEAFOMP)

(7 countries)



The South East Asian Federation of
Organizations for Medical Physics

Medical Physics Worldwide

Regional Organizations (cont)

- ❑ Latin American Medical Physics Association (ALFIM)

(13 countries)



- ❑ American Association of Physicists in Medicine (AAPM)

(7000 members)



American Association of Physicists in Medicine

Medical Physics Worldwide

Regional Organizations (pending)

- ❑ Federation of African Medical Physics Organizations (FAMPO)

(5 countries)

- ❑ Middle East Federation of Organizations for Medical Physics (MEFOMP)

Middle East Federation of Organizations of Medical Physics

a regional organization member of the International Organization for Medical Physics (IOMP)

(12 countries) Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia (SAMPS), Syria, United Arab Emirates, Yemen

Medical Physics Worldwide



European Federation of Organizations
for Medical Physics

Founded in 1980

Current membership: over 5000 belonging to
35 national organizations (27 EU countries + 8 adjacent countries)
and 3 affiliated national organizations

Official journal:



Physica
Medica

European Journal
of Medical Physics



Sub-regional Medical Physics Organizations

- ❑ **Nordic Association of Clinical Physicists (NACP)**
(5 Nordic countries)
- ❑ **Alpe – Adria Association for Medical Physics**
(4 Countries)
- ❑ **Chapters of the AAPM**
(20 Chapters)
- ❑ **Western Canada Medical Physics Association**
(Western Canadian Provinces)

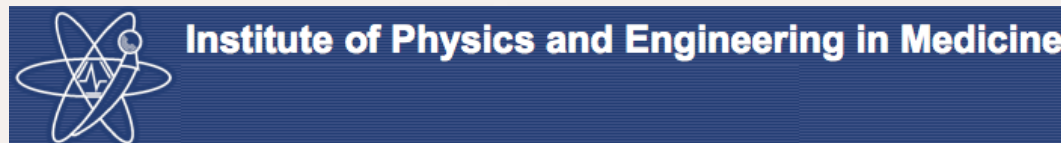
Medical Physics Journals

- ☐ **Medical Physics** (since 1973)



EDITOR: William Hendee

- ☐ **Physics in Medicine and Biology** (since 1956)



EDITOR: Steve Webb

- ☐ **Physica Medica** (since 1984)



Physica Medica
European Journal
of Medical Physics



European Federation of Organizations
for Medical Physics

EDITOR: Fridtjof Nusslin

Medical Physics Organizations in North America (Canada and U.S.)

Organization

Year
established

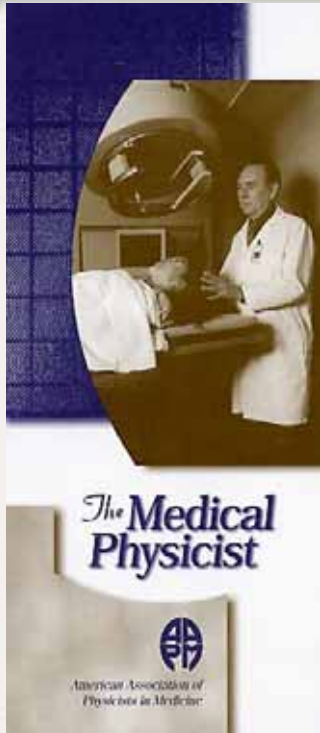
Current
membership

<input type="checkbox"/>	 <p>CANADIAN ORGANIZATION OF MEDICAL PHYSICISTS COMPOCPM ORGANISATION CANADIENNE DES PHYSICIENS MÉDICAUX</p>	1955	540 (70)
<input type="checkbox"/>	 <p>American Association of Physicists in Medicine</p>	1958	7000 (355)
<input type="checkbox"/>	 <p>THE CANADIAN COLLEGE OF PHYSICISTS IN MEDICINE LE COLLÈGE CANADIEN DES PHYSICIENS EN MÉDECINE</p>	1979	300
<input type="checkbox"/>	 <p>American College of Medical Physicists</p>	1982	450

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Best route to medical physics profession



- B.Sc. in physics
- M.Sc. and/or Ph.D. in medical physics from an **accredited** academic program.
- Residency in a medical physics specialty in an **accredited** residency program:
 - Diagnostic radiology physics
 - Health physics
 - Nuclear medicine physics
 - Radiation oncology physics
- Certification examination** from a national or international certification body.

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Medical Physics in Canada (2010)

- ❑ High level of professionalism.
- ❑ Strong national medical physics organizations.

CANADIAN
ORGANIZATION OF
MEDICAL PHYSICISTS



ORGANISATION
CANADIENNE DES
PHYSICIENS MÉDICAUX

540 members
70 work in the U.S.

- ❑ Concentration of medical physics clinical and academic work in larger centers across Canada.
- ❑ Access to academic tenure-track positions.
- ❑ Strong academic and residency programs in medical physics.

❑ **Medical Physics**
AVAILABLE ONLINE—See <http://www.medphys.org> September 2009 Volume 36, Number 9
The International Journal of Medical Physics Research and Practice

Published by the American Association of Physicists in Medicine (AAPM) with the association of the Canadian Organization of Medical Physicists (COMP), the Canadian College of Physicists in Medicine (CCPM), and the International Organization for Medical Physics (IOMP) through the American Institute of Physics. *Medical Physics* is the official science journal of the AAPM and is an official science journal of COMP/CCPM/IOMP.

Medical Physics in **Canada** (2010)

☐ **Strong ties with the AAPM:**

- 355 AAPM members work in Canadian institutions.
- **Canadians participate in the AAPM on:**

Board of Directors

Councils

Committee

Task Groups

- **AAPM meetings in Canada** in conjunction with the COMP:

1976 Ottawa (18-th)

1992 Calgary (34-th)

2002 Montreal (44-th)

2011 Vancouver (53-rd)



July 14 - 18, 2002

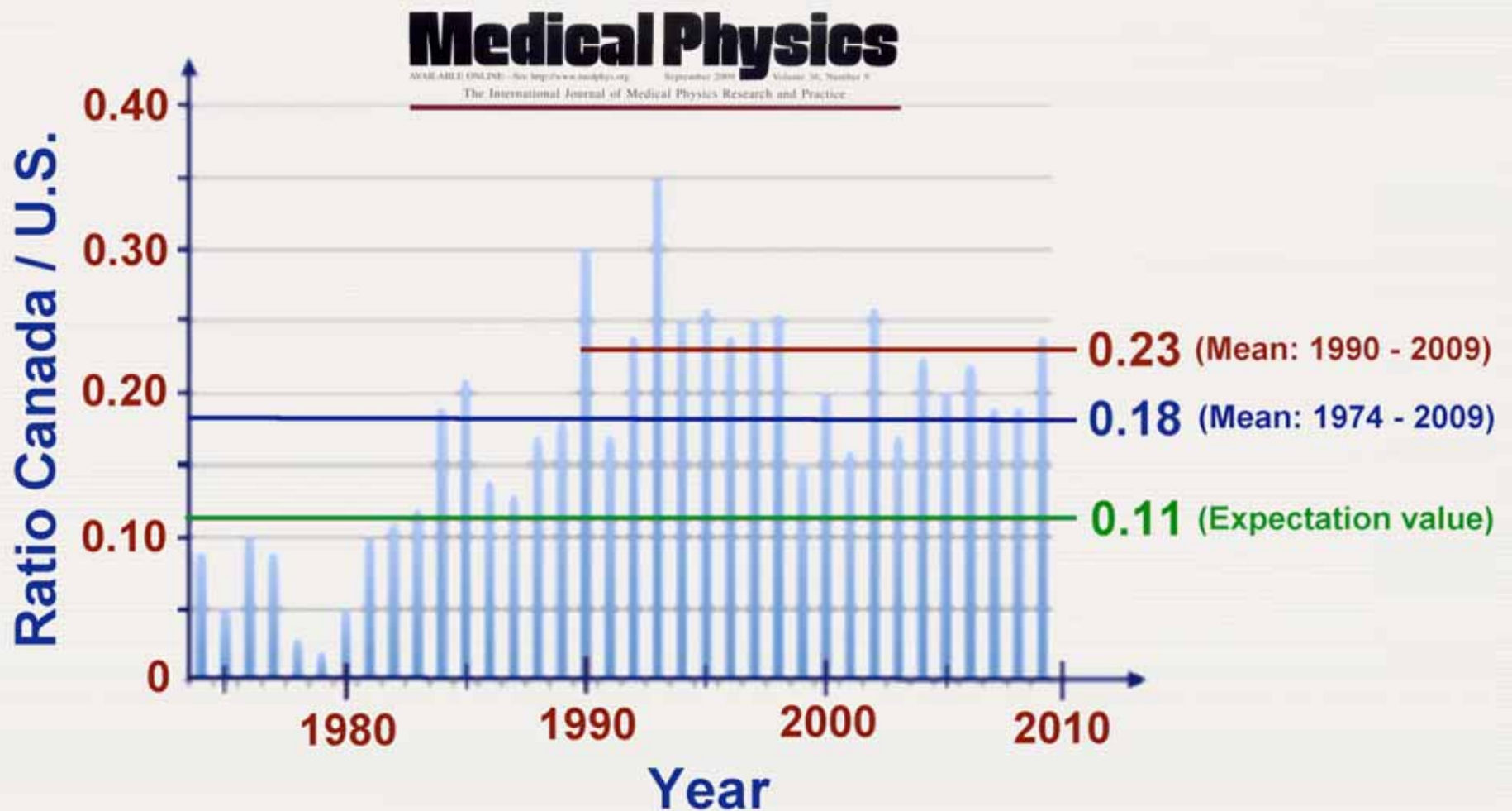
Palais des Congrès de Montréal

held in association with

COMP, the Canadian Organization of Medical Physicists and
CCPM, the Canadian College Of Physicists in Medicine

Peer-reviewed articles in “*Medical Physics*” (1974 - 2009) **Canada vs U.S.** (36 years)

Population ratio **Canada / U.S.** = 34 mil. / 304 mil. = **0.11**



American Association of Physicists in Medicine

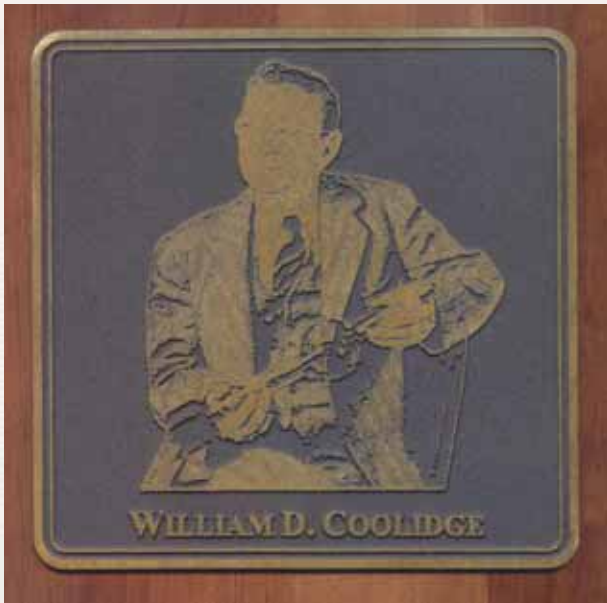
Awards (Canada vs. U.S.)

Farrington Daniels Award (since 1975) **14 of 36**

$$\text{CAN / U.S.} = 14 / 22 = 0.64$$

Sylvia Sorkin Greenfield Award (since 1983) **7 of 28**

$$\text{CAN / U.S.} = 7 / 21 = 0.30$$



Coolidge Award (since 1972)

4 of 39

$$\text{CAN / U.S.} = 4 / 35 = 0.12$$

1976, 1988, 2006, and 2010

CAN / U.S. (expectation value) = 0.11

Profession of MEDICAL PHYSICS

- Work of medical physicists directly or indirectly affects **patient safety** and **well-being**.

Therefore:

- Standards for education and professional conduct are set and maintained by various professional and governmental bodies through:
 - **Educational Accreditation**
 - **Professional Certification**
 - **Professional Licensure**

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Accreditation of Teaching Programs

- ❑ Issued to educational institutions
(e.g., universities, health care institutions,..)
for **academic** and **clinical programs in medical physics**.
- ❑ Appropriate accreditation bodies issue **accreditation certificates**,
typically for a period of 5 years.

Accreditation of Teaching Programs

Carried out mainly by **National Agencies**

that are sponsored or co-sponsored by Medical Physics organizations



Institute of Physics and Engineering in Medicine

U.K. and Ireland

CAMPEP

Commission on Accreditation of Medical Physics Educational Programs, Inc

U.S. and Canada



ACPSEM

**Australasian College of Physical
Scientists & Engineers in Medicine**

Australia and New Zealand



**European Federation of Organizations
for Medical Physics**



**ASIA-OCEANIA FEDERATION OF ORGANIZATIONS
FOR MEDICAL PHYSICS**

CAMPEP

CAMPEP, Inc.

One Physics Ellipse
College Park, MD 20740
Phone 301-209-3346
Fax 301-209-0862
Send general questions to campep_admin@campep.org

Commission on Accreditation of Medical Physics Educational Programs, Inc.

Accreditation of:

Graduate Education Programs
Residency Education Programs
Continuing Education Programs

Board of Directors

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Board of Directors:

8 members; 2 from each sponsoring organization

Sponsoring Organizations:

American Association of Physicists in Medicine (AAPM)
American College of Medical Physics (ACMP)
American College of Radiology (ACR)
Canadian College of Physicists in Medicine (CCPM)



CAMPEP-accredited graduate academic programs

in Medical Physics

Institution	Initial Accreditation	
Carleton University	2010	7
Columbia University	2009	
Duke University Medical Center	2008	
East Carolina University	2006	
Louisiana State University	2006	
McGill University	1993	1
University at Buffalo (SUNY) School of Med	2009	
University of Alberta - Cross Cancer Institute	2002	2
University of British Columbia	2004	3
University of Calgary - Tom Baker Cancer Centre	2005	4
University of California - Los Angeles	1994	
University of Chicago	2008	
University of Cincinnati	2009	
University of Florida	2001	
University of Kentucky Medical Center	1998	
University of Manitoba - CancerCare Manitoba	2008	5
University of New Mexico	2009	
University of Oklahoma HSC	2005	
University of Texas HSC - Houston	1989	
University of Texas HSC - San Antonio	1997	
University of Toledo Medical Center	2009	
University of Victoria - BC Cancer Agency	2009	6
University of Wisconsin	1988	
Vanderbilt University School of Medicine	2003	
Wayne State University	1988	

Currently

25 programs

18 of 25 in the U.S.
(72 %)

7 of 25 in Canada
(28 %)

$$\text{CAN} / \text{U.S.} = 7 / 18 = 0.39$$

$$\text{CAN} / \text{U.S. (exp. value)} = 0.11$$

Institution	Initial Accreditation
Therapy	
CancerCare Manitoba	2009 7
Cancer Institute of New Jersey, UMDNJ-Robert Wood Johnson Medical School	2010
Cross Cancer Institute - University of Alberta	2005 2
Duke University Medical Center	2009
Ireland Radiation Oncology Physics	2009
Kansas City Cancer Center	2009
London Regional Cancer Program	2006 4
M.D. Anderson Cancer Center Orlando	2008
Mayo Clinic	2003
McGill University	2000 1
Northwest Medical Physics Center	2010
Rush University Medical Center	2009
Scott and White Clinic	2009
Stanford University	2007
Stony Brook University Medical Center	2009
The Ottawa Hospital Cancer Center	2007 5
Thomas Jefferson University Hospital-Bodine Center for Cancer Treatment	2008
Tom Baker Cancer Centre	2005 3
University of California - Irvine Medical Ctr	2008
University of California at San Francisco	2009
University of Chicago Medical Center	2004
University of Florida	2000
University of Iowa	2007
University of Louisville School of Medicine	2003
University of Michigan	2009
University of Minnesota Medical School	2000
University of Nebraska Medical Center	2008
University of Pennsylvania	2009
University of Texas M.D. Anderson Cancer Center	2006
University of Texas Southwestern Medical Center	2009
University of Toronto	2008 6
University of Virginia	2010
University of Wisconsin	2004
Virginia Commonwealth University	2007
Washington University School of Medicine	1997
Imaging	
Cross Cancer Institute - University of Alberta	2005 1
Henry Ford Health System	2009
Stony Brook University Medical Center	2009
University of Texas M. D. Anderson Cancer Center	2002

CAMPEP-accredited residency programs

In Medical Physics

39 programs

35 in radiotherapy

4 in imaging

Radiotherapy programs

27 of 35 in the U.S. (77 %)

7 of 35 in Canada (20 %)

1 of 35 in Ireland (3 %)

Imaging programs

3 of 4 in the U.S. (75 %)

1 of 4 in Canada (25 %)

CAN / U.S. = $8 / 30 = 0.27$

CAN / U.S. (exp. value) = 0.11

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- Accreditation and **Certification**
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- Conclusions

CERTIFICATION IN MEDICAL PHYSICS

- ❑ Run by **national medical physics organization** either alone or in collaboration with a medical organization.
- ❑ Attests that the candidate is able to **competently execute a job or task** covered by the certification.
- ❑ Attained through a rigorous **examination process**.
- ❑ Does **NOT** confer legal right to practice.

CERTIFICATION IN MEDICAL PHYSICS

- Carried out by national medical physics organization either alone or in collaboration with a medical organization.



Schweizerischer Berufsverband für Medizinphysikerinnen und Medizinphysiker
Association Professionnelle Suisse des Physiciens Médicaux
Associazione Professionale Svizzera dei Fisici Medici
Swiss Professional Association of Medical Physicists



THE CANADIAN
COLLEGE
OF PHYSICISTS
IN MEDICINE



LE COLLÈGE
CANADIEN
DES PHYSICIENS
EN MÉDECINE

American Board of Medical Physics



ASIA-OCEANIA FEDERATION OF ORGANIZATIONS
FOR MEDICAL PHYSICS

International Board of Medical
Physics (IBMP)?



American College of Medical Physics

EUROPEAN BOARD OF MEDICAL PHYSICS ?



European Federation of Organizations
for Medical Physics

Certification of Medical Physicists in Canada

- ❑ National certification board run for medical physicists by medical physicists (CCPM)

THE CANADIAN
COLLEGE
OF PHYSICISTS
IN MEDICINE



LE COLLÈGE
CANADIEN
DES PHYSICIENS
EN MÉDECINE

- ❑ Rigorous certification examination process.

- ❑ Levels of certification
 - Basic level: Membership MCCPM
 - Advanced level: Fellowship FCCPM

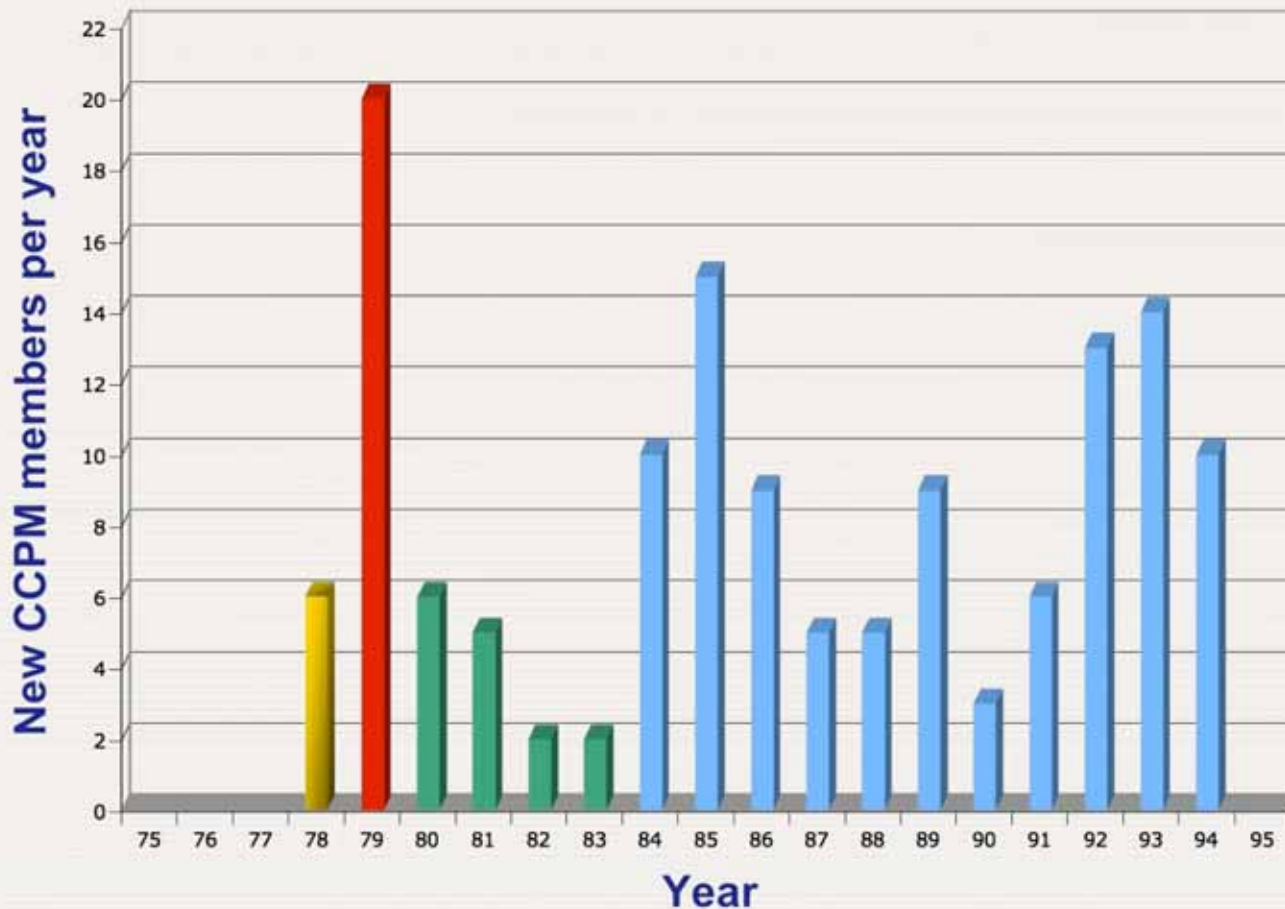
- ❑ Maintenance of certification (MOC) process.

- ❑ Continuing Professional Education (CPE) and Continuing Professional Development (CPD).

- ❑ CCPM sponsors

CAMPEP

Commission on Accreditation of Medical Physics Educational Programs, Inc.



Great Grandfathers (6)

S.O. Fedoruk
A.F. Holloway
H.E. Johns
J.C.F. MacDonald
R.M. Mathieu
M.E.J. Young

Fellows (20)
(Grandfathered)

Primary Fellows (15)
(written and oral exam)

Current rules:
(Membership and
Fellowship exam)

Current number of CCPM Members and Fellows: over **300**



Two categories of certification:

Membership and Fellowship

□ Membership (MCCPM)

- Graduate degree (Medical Physics, Physics, Science)
- Minimum of 2 years of clinical experience.
- 3 letters of reference (2 from medical physicists, 1 from physician)
- Written and oral examination.



Two categories of certification: **Membership and Fellowship**

Fellowship (FCCPM)

- CCPM Membership certification
- Significant contributions in clinical service, education, and research related to medical physics.
- Minimum of 7 full time equivalent years of experience in medical physics.
- 3 letters of reference (2 from medical physicists, 1 from physician)
- Oral examination.

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- ❑ Medical Physics in North America (Canada and U.S.)

- ❑ Accreditation and Certification

- ❑ **Teaching** and Research

- ❑ Conclusions

Modes of Education

Education

- Instruction
- Teaching

Good instruction transmits knowledge and produces competent technicians.

Good teaching provides understanding and produces competent professionals.

Education in Medical Physics

Teaching of Medical Physics:

- ❑ Should go beyond instruction.
- ❑ The teacher should not just convey a collection of facts but must also explain
to reasonable detail and depth
the physics behind the facts.

Characteristics of Good Teaching

- ❑ Talent and motivation for teaching.
- ❑ Knowledge of subject and of what to teach.
- ❑ Ability
 - to communicate.
 - to make material interesting and relevant.
- ❑ Receptive audience.
- ❑ Mutual respect between student and teacher.
- ❑ Discipline.

Education in Medical Physics

Good teaching is:

- ❑ **Very important** for the advancement of society in general.
- ❑ **Extremely important** for the profession of Medical Physics.
- ❑ **Difficult to define**
because it means different things to different people.

Education in Medical Physics

Teacher should be a practicing medical physicist with:

- ❑ Solid knowledge of **subject material**.
- ❑ Solid knowledge of **underlying physics**.
- ❑ Ability to express **enthusiasm** for physics.
- ❑ Ability to **convey understanding** of physics in a clear manner.

Education in Medical Physics

Medical Physicist as Teacher / Educator

- Graduate students in Medical Physics

- Residents in Medical Physics

 - Residents in Radiation Oncology Physics

 - Residents in Imaging Physics

- Medical Residents

 - Residents in Radiation Oncology

 - Residents in Diagnostic radiology

 - Residents in Nuclear Medicine

- Technology students

 - Radiotherapy Technology students

 - Imaging Technology students

- Radiation Dosimetry students

Education in Medical Physics

- ❑ Medical Physicists (didactic and clinical teaching)
- ❑ Medical Residents in Imaging and Radiotherapy
- ❑ Medical Technologists
- ❑ Medical Dosimetrists

Course descriptions for the four groups are similar in breadth but differ in depth to which the material is covered.

Education in Medical Physics

Graduate Student

- ❑ Easy to teach in a larger group.
- ❑ 6 - 12 students per program.
- ❑ Graduate student stipend
- ❑ In the second year can help with QA.

Physics Resident

- ❑ Needs more attention, coaching and supervision.
- ❑ 2 - 4 residents in accredited program.
- ❑ “Costs” more than graduate student.
- ❑ Close to graduation can work independently.

Expected outcome for Medical Residents

Medical Physics teaching should:

- ❑ Make students understand that:
 - To attain excellence in their profession they must know a fair amount of **physics and engineering**.
 - The driving force behind technological advances in their field are medical physics and technological development.
- ❑ Provide the students with **sufficient knowledge in physics and technology**, so that they can pass their specialty exams and function independently in their profession.
- ❑ Make students appreciate **medical physics as a profession and science** specialty.
- ❑ Show the **relevance of physics** to clinical practice.

Expected outcome for Medical Physicists

Didactic component (graduate program) should:

- ❑ Provide the students with in-depth theoretical knowledge of medical physics:
 - Covering all major areas of medical physics (radiation oncology, diagnostic radiology, nuclear medicine, health physics).
 - Including understanding of the underlying physics.

- ❑ Instill in students:
 - Appreciation of medical physics as profession and science.
 - Discipline and ethics in professional conduct.
 - Compassion for patients.

Expected outcome for Medical Physicists

Clinical component (residency) should:

- ❑ Provide students with practical clinical physics experience in all aspects of chosen specialty:
 - To allow them to work independently.
 - To pass the specialty examination.

- ❑ Reinforce in students:
 - Appreciation of medical physics as profession and science.
 - Discipline and ethics in professional conduct.
 - Compassion for patients.

What are students expected to know?

Recommendations in the form of:

- Syllabi** provided by various organizations.
- Institution-based syllabi.
- Accreditation** requirements by accreditation boards.
- Recommendations from **certification boards**.
- Requirements** by government radiation safety agencies.

What are students expected to know?

Teaching syllabi for education and training of medical physicists are readily available from the AAPM:

Didactic component

AAPM Report 197

AAPM REPORT NO. 197
(Revision of AAPM Report No. 79)



**Academic Program Recommendations
for Graduate Degrees in Medical Physics**

Report of the Education and Training of Medical
Physicists Committee

April 2009

Clinical component

AAPM Report 90

AAPM REPORT NO. 90
(Revision of AAPM Report No. 36)



**Essentials and Guidelines for Hospital-Based
Medical Physics Residency Training Programs**

Report of the Subcommittee on Residency Training
and Promotion
of the
Education and Training of Medical Physics Committee
of the AAPM Education Council
August 2006

What are students expected to know?

Recommendations in the form of syllabus:

- ❑ American Association of Physicists in Medicine (AAPM).
Education Council: Task Group reports
- ❑ International Organization for Medical Physics (IOMP)
Education and Training committee
- ❑ International Atomic Energy Agency (IAEA).
Teaching Syllabi and slide series
- ❑ Australian College of Physical Scientists and Engineers in Medicine (ACPSEM).
- ❑ Institute of Physics and Engineering in Medicine (IPEM).

What are students expected to know?

Motivation for following appropriate syllabus:

- To achieve Accreditation by Accreditation Board.
- To attain Certification by Certification Board.
- To fulfill Requirements by Radiation Protection Agencies.

Summary of Education Issues

There are no shortcuts to education.

- ❑ Hard work and steady work from both the student and the teacher are essential.
- ❑ Progress is slow and painstaking; rewards are large.
- ❑ Success of students depends strongly on the quality of teaching but good teaching is difficult to define.
- ❑ Computers and virtual web-based teaching enhance the learning experience but should not be considered a replacement for traditional “good teaching”.
- ❑ The creation of a good class requires an immense amount of work and discipline from both the teacher and the student.

OUTLINE

- Professional Aspects of Medical Physics
 - Concentration of Medical Physicists around the World
 - Recognition of Medical Physics as Profession
 - Medical Physics Organizations
 - Best route to Medical Physics Profession
- Medical Physics in North America (Canada and U.S.)
- Accreditation and Certification
- Teaching and **Research**
- Conclusions

Medical Physics Research

Research in medical physics is characterized as:

- Applied
- Translational
- Multidisciplinary
- Incremental

Medical Physics **Research** in Canada

During 1960s and 1970s

Princess Margaret Hospital (PMH), Toronto

- Installation of **high energy linac (Clinac 35)**.
- Development of **treatment planning software**.
- TBI and HBI**.
- Use of **CT** in **treatment planning**.
- Study of **radiation pneumonitis**.
- Development of **remote afterloader** for **brachytherapy**.
- Development of **cobalt unit** dedicated for **TBI**.

(1958 – 1995)



Princess Margaret Hospital

Ontario
Cancer
Institute

Toronto
500 Sherbourne St.

Harold Johns



Jack
Cunningham



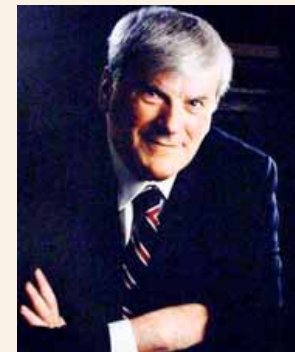
Bill Rider



Ray Busch



Derek Jenkin



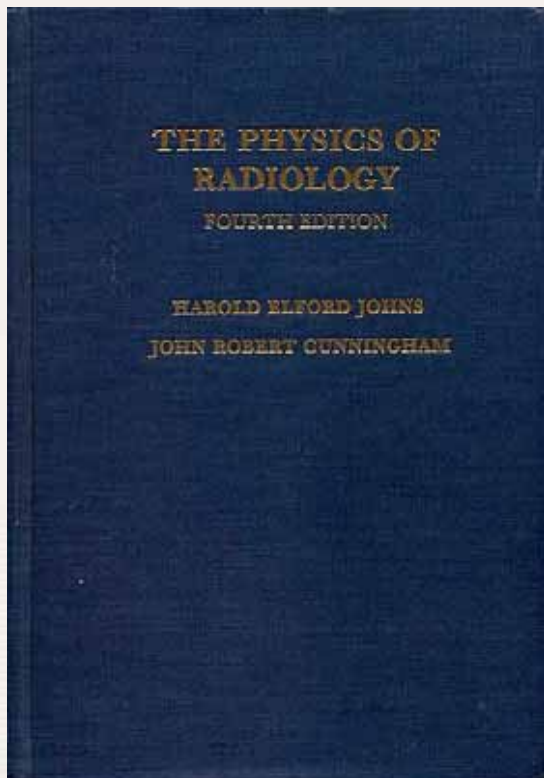
John
Simpson



Harold E. Johns (1915 – 1997)

H.E. Johns and J.R. Cunningham "The Physics of Radiology"

(four editions: 1953, 1961, 1969, 1983)



Harold E. Johns:
Inducted into Canadian Medical Hall of Fame in 1998

Canada Post: 1988

Cobalt-60 teletherapy machine

Canada's gift to the world

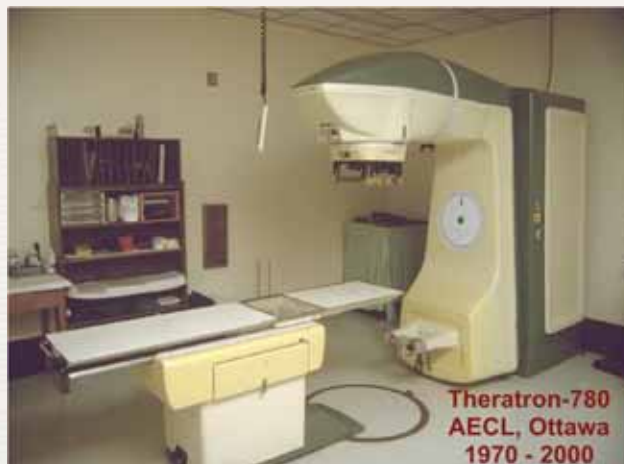


Table HCT-1. First cobalt-60 treatments in the world, 1951

	Saskatchewan	W. Ontario
Cobalt-60 source delivered	July 30	October 16
Unit installed	August 17	October 23
Calibration	11 weeks	—
First patient treated	November 8	October 27

AECL, Theratronics, MDS Nordion, Best Theratronics

Harold Johns Museum, Saskatoon Cancer Agency

Gordon
Whitmore

John
Hunt

Harold
Johns

Trevor
Craddock

Sylvia
Fedoruk

Jack
Cunningham

Doug
Cormack



Medical Physics in Canada (1980)

1980 - watershed year in Canadian Medical Physics:

- ❑ Harold E. Johns retired.
- ❑ Canadian College of Physicists in Medicine (CCPM) formed.
- ❑ Several **clinical centers** around Canada established or reorganized through rejuvenation or expansion.
- ❑ Several **new graduate programs** in medical physics opened.
- ❑ X-ray division of the **National Research Council (NRC)** expanded and reorganized.

Medical Physics **Research** in Canada

During 1980s

- ❑ Medical Physics research spread out from the PMH to many other provincial centers across Canada:

Vancouver, Edmonton, Calgary, Winnipeg, London,
Toronto Sunnybrook, Montréal, Québec, Halifax

- ❑ Imaging research became strong in many institutions:

Reichman Research Institute in Toronto Sunnybrook Hospital

Robarts Research Institute in London

Medical Physics Research

- ❑ At the end of 1980s many senior medical physicists in U.S. and Canada believed that radiotherapy physics was a completed discipline with exhausted research opportunities.
- ❑ Imaging was the place to be in medical physics.

Radiotherapy Physics Research

In 1990s research in radiotherapy physics exploded, mainly because of rapid advances in:

- Treatment planning
- Technology of dose delivery
- Imaging for radiotherapy

☐ NEW EQUIPMENT

- CT-simulator
- MR simulator
- Tomotherapy
- CyberKnife
- Hadron therapy

☐ NEW TECHNIQUES

- Stereotactic radiosurgery (cranial and extracranial)
- Conformal radiotherapy
- Intensity modulated radiotherapy (IMRT)
- Intensity modulated arc therapy (IMAT)
- Image guided radiotherapy (IGRT)
- Adaptive radiotherapy (ART)
- Respiration gated radiotherapy (RGRT)

Radiotherapy Physics Research: Example 1

Linac target and flattening filter study

Princess Margaret Hospital

Toronto



Princess Margaret Hospital, Toronto

Megavoltage radiotherapy in early 1970s:

- **Cobalt machine**

Manufactured by Atomic Energy of Canada, Ltd (AECL), Ottawa

- **Betatron**

Installed during 1960s

Manufactured by Allis-Chalmers, Milwaukee, WI

Operated at 25 MV

- **Linac**

Installed in 1972

Manufactured by Varian, Palo Alto (Model Clinac-35)

Operated at 25 MV

Linac versus betatron at 25 MV

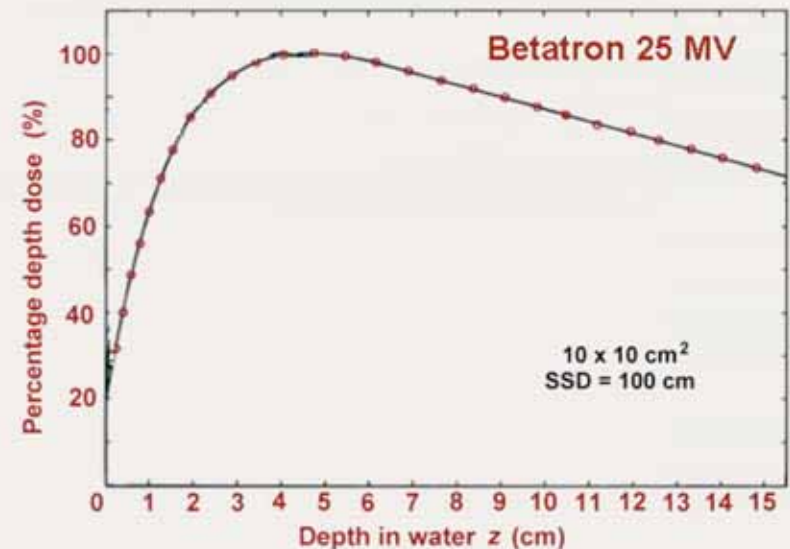
Main characteristics:

Output

- Betatron: up to 50 cGy/min
- Linac: up to 1000 cGy/min

Isocentric configuration

- Betatron: only partial beam rotation
- Linac: full gantry rotation

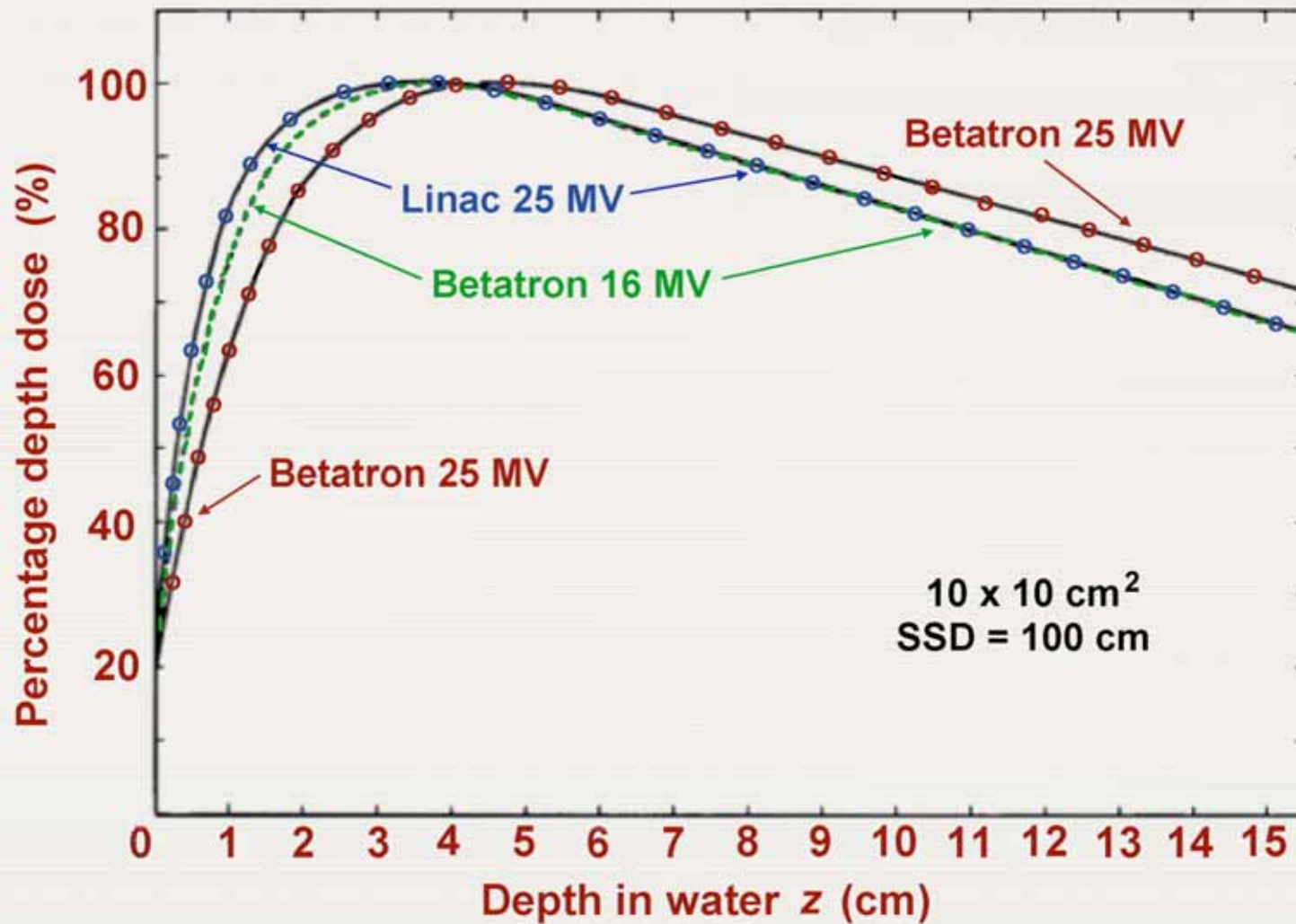


Electron beam energy striking the target: 25 MeV

Assumptions:

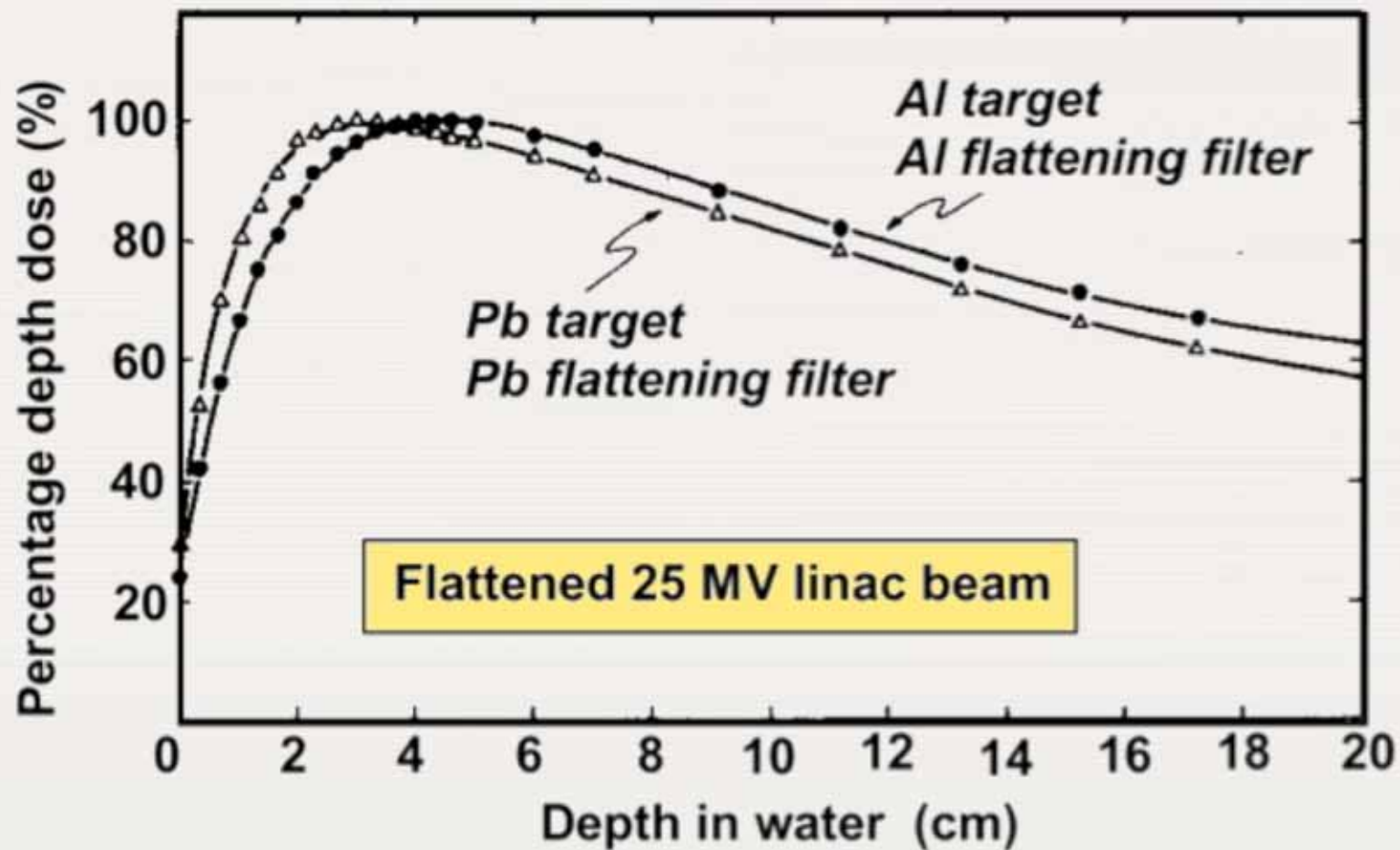
- Same photon spectrum produced in both machines
- Same penetration into tissue achieved with both machines

Percentage depth dose: **Betatron** versus **Linac**



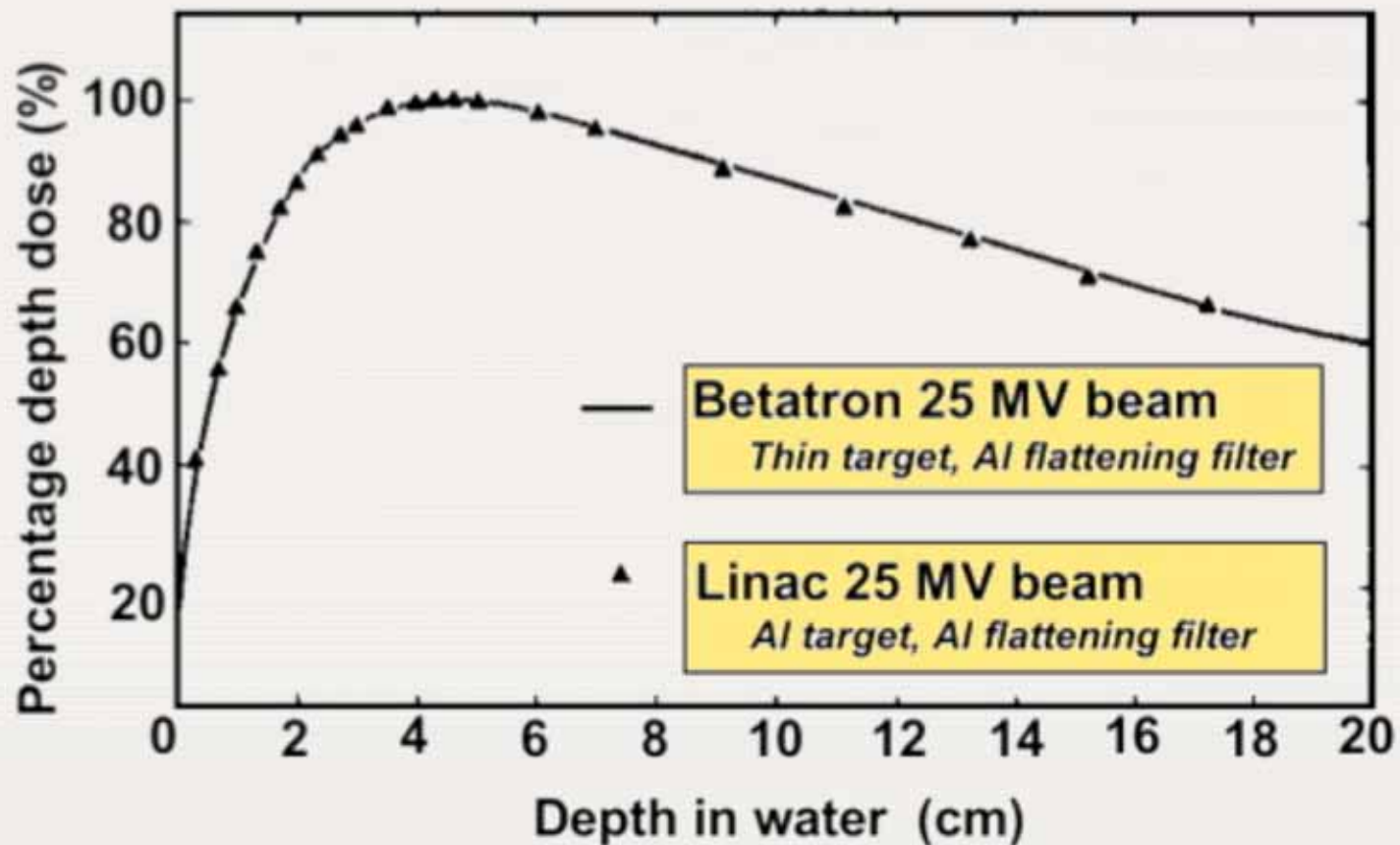
Central axis percentage depth doses in water

Pb target / Pb flattening filter compared to Al target / Al flattening filter



Central axis percentage depth doses

Betatron: 25 MV (solid curve) compared to Linac: 25 MV (data points)



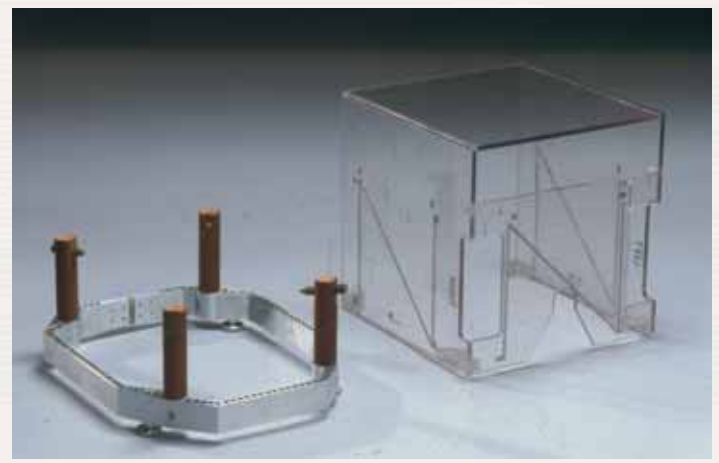
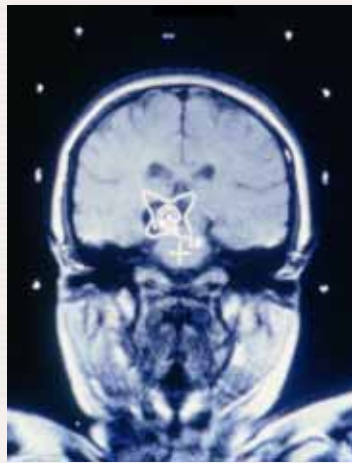
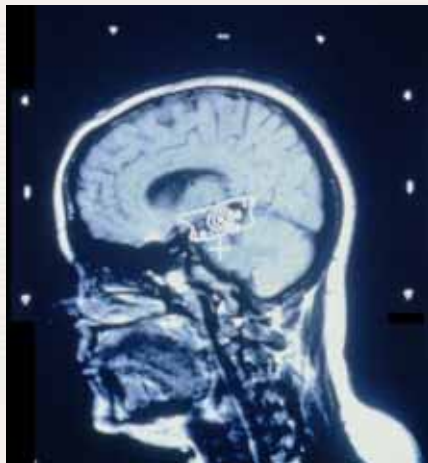
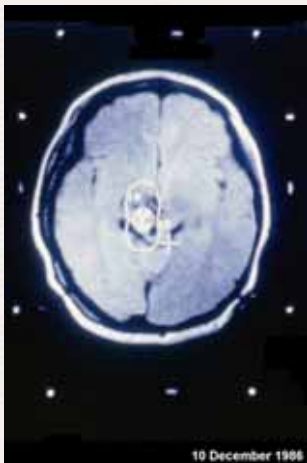
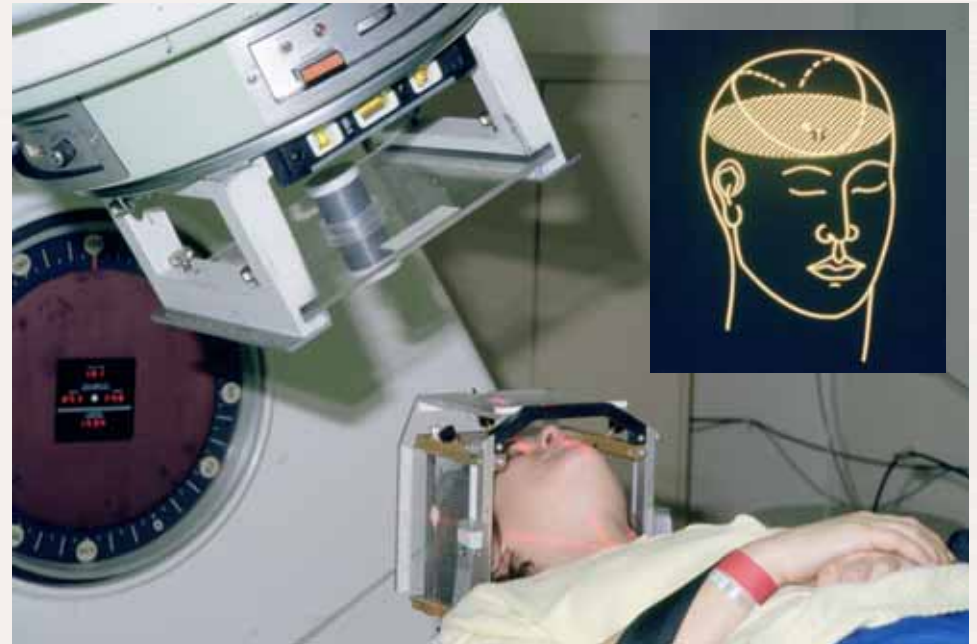
Radiotherapy Physics Research: Example 2

Dynamic Stereotactic Radiosurgery

Montreal General Hospital



Dynamic Stereotactic Radiosurgery (1986)



Simultaneous couch and gantry rotation (Varian 2010)



Issues in contemporary medical physics

- Is a Ph.D. necessary for a career in medical physics?

Yes, for an academic career.

No, for work as clinical physicist.

Issues in contemporary medical physics

Does our profession need:

- Undergraduate degrees in Medical Physics ?
- Physics assistants ?
- Professional Doctorates in Medical Physics ?

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- ❑ Teaching and Research
- ❑ **Conclusions**

Conclusions: Medical Physics

Science

Applied
Translational
Multidisciplinary
Incremental

Profession

Started soon after Röntgen's discovery of x rays
Has been recognized by the ILO since 2008.
Accepted as modern applied branch of physics.

Conclusions: Medical Physics

Concentration of Medical Physicists:

- World: ~ 18 000
- World average: ~ 2.7/million population
- Developed countries: ~ 15/million population
- Many undeveloped countries: 0

Medical Physics in North America

- ❑ Medical Physics in North America is in excellent shape but is affected to a certain degree by health care financing model in the U.S. and Canada.
- ❑ Teaching and accreditation are organized well.
- ❑ Certification has been available for many years but rules are still under development.
- ❑ Number of residency positions is much too small for actual needs.

Medical Physics Research (2010)

- ❑ High Technology plays an important role in medical physics.
- ❑ Imaging physics and radiotherapy physics converge.
- ❑ Imaging plays an increasingly more important role in radiotherapy:
 - PET scanner
 - Cone Beam CT
 - Tomotherapy
 - CyberKnife
- ❑ In contrast to standard anatomical imaging which relies on changes in tissue density, atomic number, or water content, molecular functional imaging promises non-invasive methods for cellular imaging using biomarkers.
- ❑ Close collaboration of medical physicists with radiation oncologists is of utmost importance.

Current Trends in Medical Physics

- ❑ High Technology:
 - PET/MR hybrid machine.
 - MR simulator.
 - MR machine integrated with cobalt-60 machine.
 - MR machine integrated with linac.
 - Compact proton accelerator in linac bunker.
- ❑ Convergence of radiotherapy and imaging.
- ❑ Monte Carlo Treatment Planning.
- ❑ Definition of Biological Target.

Medical Physics around the world

- Medical Physics is growing in importance both as a profession and as science, driven by the technological developments of societies in general and medicine in particular.



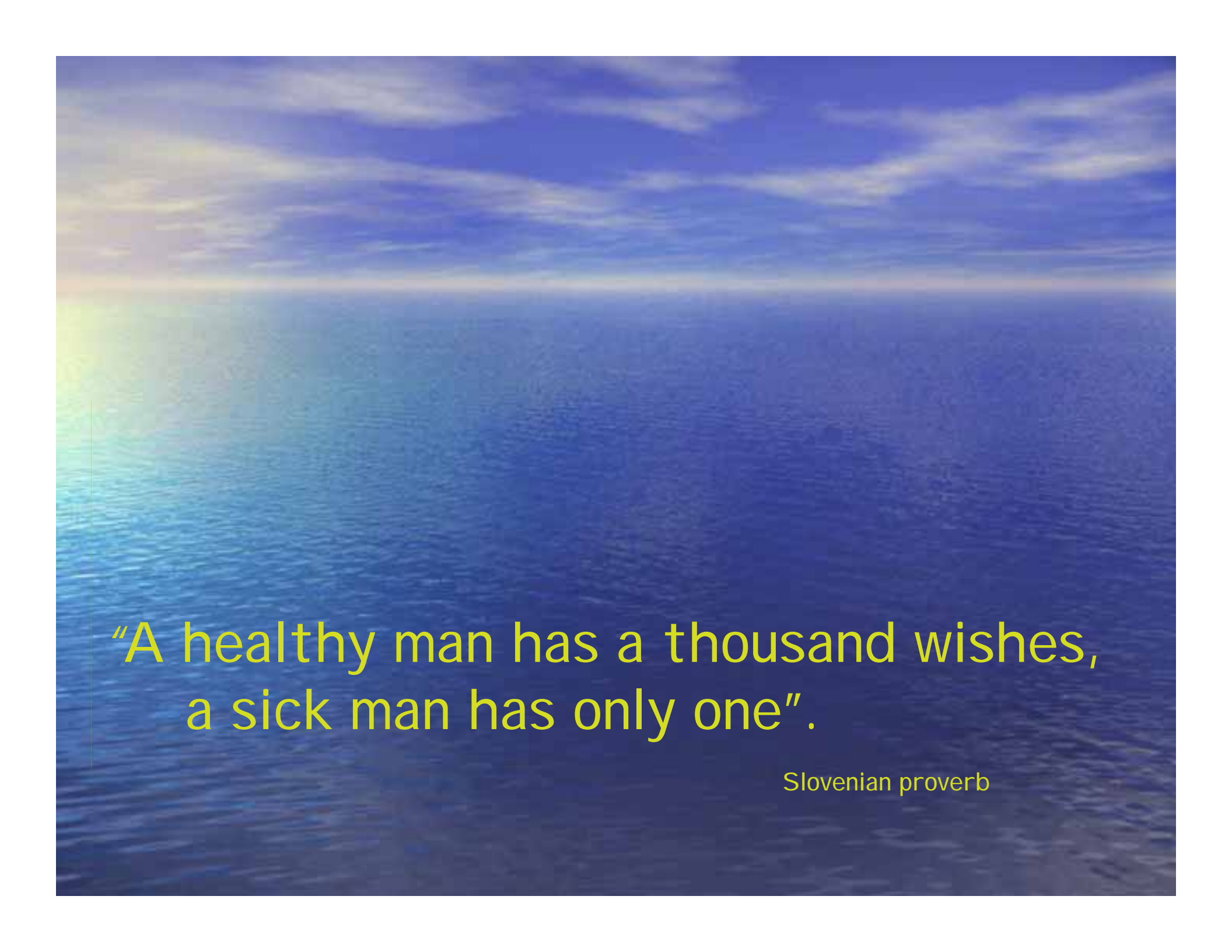
Medical Physics around the world

- ❑ Medical Physics **teaching programs** (both academic and clinical) have difficulties meeting the demand for well educated medical physicists.
- ❑ **Research is very important** for advancement of medical physics as a profession and science.

Health Care

The most important characteristics
of a health care system are:

Quality - Cost - Access



"A healthy man has a thousand wishes,
a sick man has only one".

Slovenian proverb