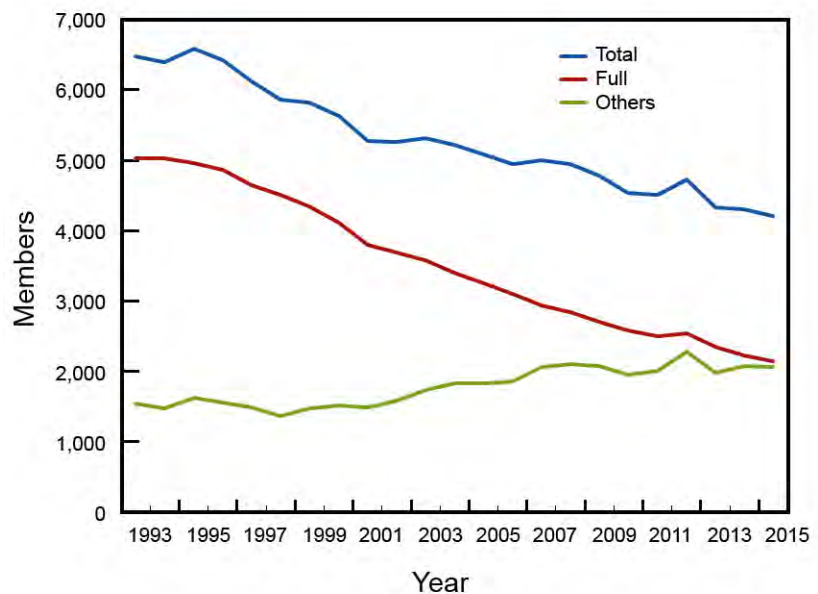


Fifty-Second Annual Meeting Program

Meeting the Needs of the Nation for Radiation Protection



April 11–12, 2016

Hyatt Regency Bethesda
One Bethesda Metro Center
7400 Wisconsin Avenue
Bethesda, MD 20814



Front cover: Membership of the U.S. Health Physics Society, 1993 to 2015 [NCRP Statement No. 12, *Where are the Radiation Professionals (WARP)?*, issued December 17, 2015]. Statement No. 12 is available for free at http://ncrponline.org/wp-content/themes/ncrp/PDFs/Statement_12.pdf.

NCRP Mission:

To support radiation protection by providing independent scientific analysis, information and recommendations that represent the consensus of leading scientists.



NCRP Resource Development Committee is launching a series of efforts to increase the financial stability of NCRP. The first effort is to request Council members and friends who shop online at Amazon to make a simple (no cost) modification. Simply register at AmazonSmile (<https://smile.amazon.com/>), and the AmazonSmile Foundation will donate 0.5 % of the purchase price to NCRP at no charge to you! It's easy!

Follow the directions and be sure to select the National Council on Radiation Protection and Measurements (from the pull down list or searchable request) as the 501(c)(3) public charitable organization to receive the Amazon contribution for each purchase. Donations are anonymous. However, we would like to recognize your support and if you notify NCRP (Laura.Atwell@ncrponline.org) we will add your name to the NCRP list of AmazonSmile contributors.

Meeting the Needs of the Nation for Radiation Protection

Fifty-Second Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP)

In June 2013, NCRP hosted a Workshop to address the question of “where are the radiation professionals?” This question regarding the future supply of qualified radiation professionals has been raised by professional societies, the National Academy of Sciences, and the U.S. Government Accountability Office as the largest birth cohort in U.S. history, the so-called “baby boomers” reach retirement age and transition out of the workforce. This issue, known by the acronym WARP, has been considered independently by various entities, and the purpose of the workshop was to bring representatives of professional societies, government agencies, educational institutions, and the private sector together to exchange information and develop action plans to mitigate a dichotomy between the growing use of radiological methods in medicine, research and industry, and the declining numbers of available experts in radiological protection. In addition, the threat of radiological terrorism exacerbates the potential need for a cadre of highly trained radiation experts.

NCRP recently published Statement No. 12, *Where Are the Radiation Professionals?* which summarizes the Workshop proceedings and the actions recommended by NCRP to ameliorate the situation. The Statement can be found on page 3 and the PDF can be downloaded from http://ncrponline.org/wp-content/themes/ncrp/PDFs/Statement_12.pdf. The meeting will take a more in-depth look at the issues raised by the WARP Workshop, featuring presentations by a number of experts from the concerned sectors and providing examples of actions already underway and additional actions needed to ensure that the needs of the United States for radiation protection expertise are met in the future.

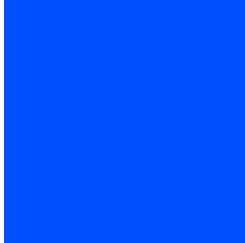
The 2016 Annual Meeting Program is divided into three sessions that consider how did we get to where we are now, where do need to be in the future, and how do we get there. The opening session will begin with a

consideration of the inexorable effects of population demographics on the future radiological workforce. The declining membership numbers of radiation-related professional societies will then be discussed, and the picture is not pretty. Next, a look at the current and future needs for radiation protection expert in medicine will be reviewed, and finally, the changing roles of health physicists, particularly in state radiation control programs, will be presented.

The second session begins with a look at the differences between education and training, and how both are needed. The next topic is the need for scientific researchers (and of course, research funding) to resolve remaining questions in fundamental radiobiology, such as low-dose and dose-rate effects, and the impact of molecular biology on our understanding of radiation risk. An example of the establishment of a “hub” or perhaps “center of excellence” in radiation protection will be presented, and finally, the needs of federal and state governments for an adequate number of radiation professionals to develop, interpret and enforce radiation protection guidance will be reviewed.

The third session considers concrete steps that need to be taken to ensure the adequacy of radiation protection practice for the United States. A vital first step is knowledge capture and management, to ensure that the lessons learned by present-day experts are not lost with their retirements. The last three presentations then discuss methods to meet future needs in industry, medicine, and emergency response.

The 13th Annual Warren F. Sinclair address will be given by Dr. Richard E. Toohey, who will review the WARP-related activities of NCRP and set the stage for subsequent presentations. The 40th Lauriston S. Taylor Lecture will be delivered by Dr. John W. Poston, Jr. who will discuss radiation protection and regulatory science.



The meeting will conclude with NCRP President Dr. John Boice's presentation of an overview of current NCRP activities and his vision for the future of NCRP.

NCRP and the Radiation Research Society (RRS) are pleased to welcome the fourth NCRP/RRS Scholars to this year's Annual Meeting. The three young scientists below received competitive travel awards made possible by the generosity of RRS. These awards are aimed at encouraging and retaining young scientists in the field of radiation science. Eligible applicants included junior faculty or students in the radiation sciences or junior health or medical physicists:

Daniel Adjei
Military University of Technology, Institute of
Optoelectronics, Poland

Shaowen Hu
Wyle Science, Technology & Engineering Group,
Houston, Texas

Yuan-Hao (Chris) Lee
Municipal Wan Fang Hospital, Taiwan

Questions can be submitted on cards during each session. Oral questions from the floor will not be accepted. The session chairs and speakers will address as many questions as time permits. All questions and answers will be published in *Health Physics* as part of the proceedings of the Annual Meeting.

NCRP is grateful to the Joint Armed Forces Honor Guard from the Military District of Washington D.C. who will open our Annual Meeting and to Kimberly Gaskins of the U.S. Nuclear Regulatory Commission who will sing our National Anthem.

Where Are the Radiation Professionals (WARP)?

NCRP Statement No. 12, December 17, 2015

Since the discovery of x rays and radioactivity in the 1890s, sources of ionizing radiation have been employed in medicine, academia, industry, power generation, and national defense. To provide for the safe and beneficial use of these sources of radiation, the United States developed a cadre of professionals with the requisite education and experience. Unfortunately, their numbers have diminished alarmingly (AAAS, 2014; GAO, 2014; HPS, 2013; NA/NRC, 2012).

Methods

To study the decline in radiation professionals and potential national crisis, the National Council on Radiation Protection and Measurements (NCRP) sponsored a workshop in June 2013 in Arlington, Virginia to evaluate whether a sufficient number of radiation professionals exist now and into the future to support the various radiation disciplines essential to meet national needs. Attendance at this workshop included professionals from government, industry, academia, medicine, and professional societies. Presentations from over 30 groups (NCRP, 2013) resulted in the recommendations found in this Statement.

Findings

Evidence presented at the workshop revealed that the country is on the verge of a severe shortfall of radiation professionals such that urgent national needs will not be met. Factors contributing to the downturn include the economy, attrition, redirected national priorities, and decreased public funding. The magnitude of this shortfall varies with radiation disciplines and practice area. Radiation biology has already been critically depleted and other specialties are following the same downward spiral. All radiation professionals share the same goals to develop or implement scientific knowledge to protect workers, members of the public, and the environment from harmful effects of exposure to ionizing radiation. Accordingly, the workshop concluded that the current and projected shortfall will adversely affect the public health, radiation

occupations, emergency preparedness, and the environment. Major shortfalls have already been observed in day-to-day operations, leaving policy development, regulatory compliance, research and development, environmental monitoring, emergency management, and military applications as unfunded and under-supported mandates.

The dwindling number of professionals will be of particular concern in mounting a response to a catastrophic nuclear or radiological incident, including terrorist attacks. The current concept of operations for response includes surge support from the existing body of radiation professionals to serve as technical subject matter experts to aid in the management of the consequences of such an event. However, as the number of radiation professionals decreases, the nation's resilience and ability to cope and manage a catastrophic nuclear or radiological event is severely degraded.

Deficit of Professionals

Federal, state and local governments employ radiation professionals in broad and diverse areas such as policy development, regulatory compliance, research and development, environmental monitoring and restoration, waste management, emergency preparedness and response, nuclear medicine, radiation therapy, diagnostic radiology, and nuclear forensics.

The U.S. Government Accountability Office (GAO, 2014) estimates that 31 % of the federal workforce will be eligible to retire by September 2017, and the percentage of engineering and technical professionals eligible to retire by September 2017 is even higher at 41 %. Similarly, a survey of the Conference of Radiation Control Program Directors (directors of state agencies that regulate the use of radioactive materials and radiation-producing devices within their states) predicted that over 50 % of the technical staff in the states' radiation control programs will need to be replaced in the next 10 y.

The National Academy of Sciences has expressed concern about the future supply of radiochemists (NA/NRC, 2012). The projected shortfall of skilled technical expertise within government will result in an inability to support day-to-day operations and will have a significant adverse

effect on the ability to manage the consequences of a catastrophic nuclear detonation or nuclear power plant accident in the United States. The basic radiation sciences and their real world applications are part of a vast enterprise that directly and materially benefits the U.S. population. This enterprise must be strategically managed to prevent atrophy of U.S. expertise and loss of world leadership in radiation sciences to Europe and East Asia.

Numerous professional societies represented at the workshop conclude that the current workforce demographics and expected retirements are such that the demand for replacement radiation professionals will substantially increase from 2015 to 2025 (Appendix A; NCRP, 2013).

Within the private sector (e.g., nuclear power, uranium production, consulting services), adequate numbers of some but not all skilled workers are available in the short term (5 to 10 y). However, in the longer term (10 to 20 y), experienced workers will be retiring, and insufficient replacements are projected to be available. Consequently, even outsourcing of traditional government work to the private sector, especially in large-scale incident response and remediation will unlikely be a viable option to cope with the numerous retirements of government workers.

Only two areas appear to have adequate personnel in the short term: medical physics and nuclear power. In medical physics, where radiation and the practice of medicine intersect, there appears to be no current or anticipated deficit, despite the tremendous growth of the use of ionizing radiation in medicine (NCRP, 2009). Unlike most areas where radiation professionals work, the demand is highly visible and the salaries for practice are attractive. In nuclear power, some utilities have begun educational programs in cooperation with local colleges to “grow their own” future staff. Further, military retirees, especially from the nuclear Navy, frequently transition from shipboard to civilian nuclear power operations. Nonetheless a surge of retiring employees, combined with a waning interest in the field by young professionals and a deficit of training programs in general, have contributed to the industry’s growing skills gap in the United States and in other countries.

Figures 1 and 2 demonstrate the long-term trends in the declining numbers of students enrolled in academic health physics programs (ORISE, 2015) and the declining number of members in the U.S. Health Physics Society.¹

1. Health Physics Society (2015). HPS Secretariat (McLean, Virginia).

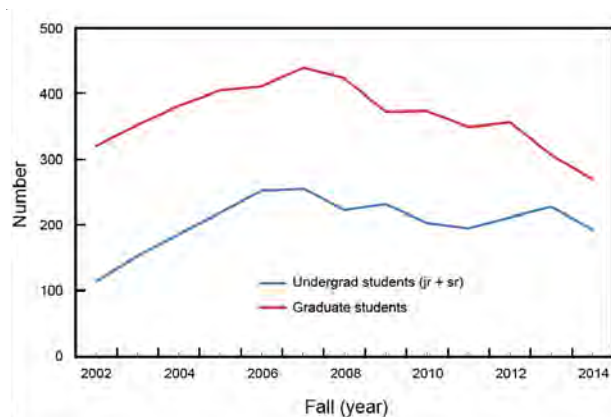


Fig. 1. Health physics enrollment trends, Fall 2002 to Fall 2014 (ORISE, 2015).

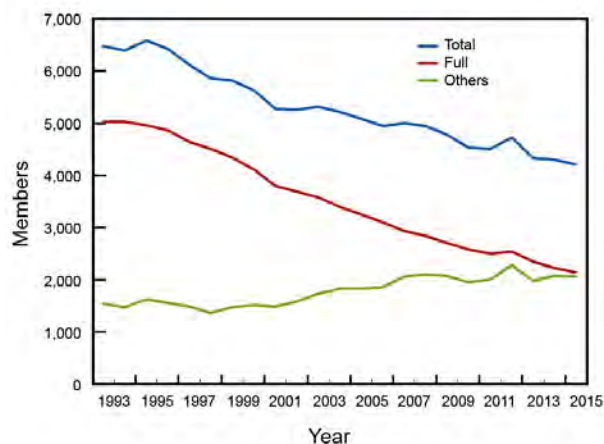


Fig. 2. Membership of the U.S. Health Physics Society, 1993 to 2015.

Deficit of Funding

Federal funding of student scholarships and postgraduate fellow programs have been disappearing. There are only 22 U.S. academic programs with students and staff involved with health physics education, including 12 small programs that graduate fewer than six students per year (ORISE, 2015). Only 12 U.S. programs have sufficient faculty and staff to train future students at B.S., M.S., and Ph.D. levels. Loss of research funding has decimated the ranks of university radiation biologists and other professionals (i.e., the professors needed to teach the next generation of radiation professionals).

The Biomedical Advanced Development and Research Authority (BARDA), the National Institute of Allergy and Infection Diseases, and the National Cancer Institute (all parts of the U.S. Department of Health and Human Services) sponsor research in radiological counter-measures, radiation oncology, and radiation epidemiology. The U.S. Department of Energy's (DOE) National Nuclear Security Administration established the Stewardship Science Academic Alliances Program in 2002, to fund academic research in the areas of materials under extreme conditions, low energy nuclear science, radiochemistry, and high energy density physics. One of the goals of the program is to provide hands-on training and experience to students who will be the next generation of scientists and physicists in the areas of interest and potentially be employed at one of our national laboratories (NNSA, 2015). However, these highly focused programs alone cannot support the required faculty and students needed to replace retiring radiation professionals.

Total current federal funding of the radiation sciences (including salaries, grants, contracts) is estimated to be approximately \$50 billion annually, including U.S. Nuclear Regulatory Commission training programs, the DOE low-dose radiation research program (before funding was significantly reduced last year), the Centers for Disease Control and Prevention Radiation Studies Branch, the NIOSH Division of Compensation Analysis and Support, the Armed Forces Radiobiology Research Institute, the National Cancer Institute Radiation Epidemiology Branch, and the National Nuclear Security Agency Office of Emergency Operations. NCRP considers it reasonable to provide funding to ensure a continued supply of radiation professionals for these and other programs at a level approaching 10 % of the annual operating costs (*i.e.*, \$5 billion annually), judiciously spread across education, training, research, professional development, career management, and development of surge capacity to meet emergency response requirements.

Recommendations

Courses of action to preclude and mitigate the disastrous outcome of not having sufficient radiation professionals to handle the current and future needs of the nation include:

- **Education:** The federal government considers science, technology, engineering and mathematics (STEM) education programs in kindergarten through twelfth grade as vital to the future economic development of the United States (NA/NRC, 2011). Recently

the administration published a *Federal STEM Education 5-year Strategic Plan*, with FY15 funding of almost \$500 million requested. Support for education of radiation professionals should be considered equally as vital to the health and safety of the United States. University programs must be enlarged and adequately funded to build on STEM learning experiences. The opportunities for higher education in radiation science have been particularly threatened by double-digit budget cuts and higher tuition costs, both of which contribute to decreasing enrollment. Reduced faculty support affects basic research as well as the ability to educate the next generations of radiation professionals. As an example, DOE funds for low-dose radiation research have all but vanished; this hampers acquisition of fundamental knowledge for basic understanding of risk to human populations from low radiation doses needed for radiation protection and for risk management.

- **Research:** Research funding is a necessary condition for education in the radiological sciences. It supports student activities and the faculty who will teach the next generation of students. Without external research support, colleges and universities cannot maintain academic programs in the radiological sciences. Consequently research funding needs to be restored and in fact increased to answer the crucial questions that affect aspects of government operations and policy (*e.g.*, what are the health effects of low-dose radiation exposures comparable to those routinely received from medical procedures, environmental circumstances and occupational endeavors?). The House Committee on Science, Space, and Technology approved the Frontiers in Innovation, Research, Science and Technology (FIRST) Act to prioritize federal investments at the National Science Foundation and the National Institute of Standards and Technology by funding research and development to address national needs (HR, 2014). Maintaining an adequate and well-trained cadre of radiation professionals is one of those needs, as is determining the actual health effects, and magnitude, of low-dose radiation exposures. The importance of public support for radiation research is highlighted in the *Low-Dose Radiation Research Act of 2015* which was passed by the U.S. House of Representatives and awaits approval by the U.S. Senate (HR, 2015).
- **Training:** To provide a significant and guaranteed supply of replacements for radiation professionals lost to retirement, jobs with more opportunities, and

death, new graduates will require months to years of practical, hands-on experience to replace senior professionals. Consequently support must be provided not only for formal academic education, but also for internships, practicums, post-doctoral positions, and similar post-graduate training programs. Such developmental positions at national laboratories and with federal agencies should be funded and guaranteed for the long-term, so that prospective employees can expect career stability. In addition, training grants should be made available to develop a surge capacity of radiation professionals in emergency response to augment the small number of federal and state radiological staff in the case of a potential large radiation emergency involving mass casualties. Competing for emergency response funds has been difficult because of the assumed low probability of such an event. While such events might be low probability, they are of high consequence, and the country cannot afford to be unprepared. Not only are more radiation professionals required for day-to-day activities, but their expertise needs to be leveraged efficiently to train all other responders (e.g., medical, security) about managing such incidents.

- **Joint Program Support Office (JPSO):** The federal government should create a (radiation) JPSO to more efficiently manage radiation professionals in the civil service. The JPSO would: centralize and provide better visibility for the function of radiation professionals; monitor federal staffing levels and needs; enhance mechanisms for interagency collaboration; diminish cross-organizational stovepipes; and centralize recruiting and development of future radiation professionals.
- **Continued monitoring and advocacy:** The status of the availability of radiation professionals, training programs, graduation rates, research opportunities, career opportunities, and professional development obviously needs continued monitoring and follow-up. Consequently, NCRP has established Council Committee 2 specifically to carry out this role and provide advice on this radiation issue to the federal government, consistent with NCRP's Congressional Charter.

Conclusion

The looming shortage of radiation professionals represents a serious threat to the United States: scientific leadership is being lost, competition in world markets is affected, and protection of our citizens and country

diminished. NCRP advocates a sequence of activities in the areas of education, training, research, and personnel management to address this urgent national need:

- Restore significant federal and state funding for scholarships, fellowships, and faculty research to increase and sustain a credible workforce of radiation professionals.
- Reinvigorate partnerships among universities, government, and the private sector to ensure undergraduate and graduate programs are adequately resourced to support the training and qualification of radiation professionals, including those who will educate the next generation.
- Establish a Joint Program Support Office (JPSO) for radiation professionals in the federal civil service to manage utilization and career development of personnel more effectively.
- Monitor trends in the supply of and demand for radiation professionals.
- Establish basic and advanced competency profiles to serve as guidance upon which to base the education, training, qualification and appropriate use of radiation professionals.

Public health, radiation safety, emergency preparedness, and the environment are all at risk. The clarion call to act is now!

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Monday, April 11, 2016

Opening Session

- 8:10 am **Presentation of the Colors**
Joint Armed Forces Honor Guard
from the Military District of
Washington, DC
- Singing of the National Anthem**
Kimberly Gaskins
U.S. Nuclear Regulatory Commission
- 8:15 am **Program Welcome**
Judith L. Bader
Program Committee Co-Chair
- 8:20 am **Welcome**
John D. Boice, Jr.
President, NCRP

Thirteenth Annual Warren K. Sinclair Keynote Address

- 8:30 am **WARP: Where are the Radiation
Professionals?**
Richard E. Toohey
M.H. Chew & Associates

How Did We Get Here?

Jacqueline P. Williams &
Patricia R. Worthington, *Session Co-Chairs*

- 9:00 am **Radiation Brain Drain? The Impact
of Demographic Change on U.S.
Radiation Protection**
Hedvig Hricak
*Memorial Sloan-Kettering Cancer
Center*
- 9:25 am **Membership Trends in the Health
Physics Society: How Did We Get
Here and Where Are We Going?**
Kathryn H. Pryor
*Pacific Northwest National
Laboratory*
- 9:50 am **Q&A**
- 10:10 am **Break**

- 10:40 am **Review of the Workforce for
Radiation Protection in Medicine**
Wayne D. Newhauser
Louisiana State University
- 11:05 am **Changing Roles of State Health
Physicists**
Ruth E. McBurney
*Conference of Radiation Control
Program Directors, Inc.*
- 11:30 am **Q&A**
- 11:50 am **Lunch**

Where Do We Need To Be?

Ralph L. Andersen & Robert C. Whitcomb, Jr.,
Session Co-Chairs

- 1:15 pm **Commercial Nuclear Power:
Assessing and Meeting the Need**
Jerry W. Hiatt
Nuclear Energy Institute
- 1:40 pm **Education or Training: Does it
Matter?**
Kathryn A. Higley
Oregon State University
- 2:05 pm **Estimating Cancer Risks at Very
Low Radiation Doses: What Can
be Done?**
David J. Brenner
Columbia University Medical Center
- 2:30 pm **Q&A**
- 2:55 pm **Break**
- 3:25 pm **Developing a Radiation Protection
Hub**
Nolan Hertel
*Georgia Institute of Technology /
Oak Ridge National Laboratory*
- 3:50 pm **Meeting Regulatory Needs**
Michael Weber
U.S. Nuclear Regulatory Commission
- 4:15 pm **Q&A**
- 4:35 pm **Break**

Meeting the Needs of the Nation for Radiation Protection

Fortieth Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm **Introduction of the Lecturer**
Michael T. Ryan

**Radiation Protection and
Regulatory Science**
John W. Poston, Sr.
Texas A&M University

6:00 pm **Reception**
Sponsored by Landauer, Inc.

Tuesday, April 12

8:15 am **NCRP Annual Business Meeting**

9:10 am **Break**

How Do We Get There?

Pamela J. Henderson & Chad A. Mitchell,
Session Co-Chairs

9:30 am **Critical Issues in Knowledge
Management in Domestic
Radiation Protection Research
Capabilities**
Shaheen Dewji
Oak Ridge National Laboratory

9:55 am **The Business of Health Physics:
Jobs in a Changing Market**
Matthew P. Moeller
Dade Moeller

10:20 am **Break**

10:45 am **Meeting the Needs of First
Responders: Scientific
Experiments to Operational
Tactics for the First 100 Minutes
After an Outdoor Explosive
Radiological Dispersal Device**
Stephen V. Musolino
Brookhaven National Laboratory

11:10 am **Meeting the Needs of the Nation
for Radiation Protection: How Do
We Get There? Meeting Medical
Needs**
Donald P. Frush
Duke University School of Medicine

11:35 am **Q&A**

Session 4: Conclusions

John D. Boice, Jr., *Session Chair*

11:55 am **NCRP Vision for the Future and
Program Area Committee
Activities**
John D. Boice, Jr.
President, NCRP

12:20 pm **Closing Remarks**
John D. Boice, Jr.
President, NCRP

12:30 pm **Adjourn**

Meeting the Needs of the Nation for Radiation Protection

Monday, April 11, 2016

Opening Session

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Program Welcome

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Program Committee Co-Chair

8:20 am

Welcome

John D. Boice, Jr., *President*

National Council on Radiation Protection and Measurements

Thirteenth Annual Warren K. Sinclair Keynote Address

8:30 am

WARP: Where are the Radiation Professionals?

Richard E. Toohey

M.H. Chew & Associates



In July 2013, the National Council on Radiation Protection and Measurements (NCRP) convened a workshop for representatives from government, professional organizations, academia, and the private sector to discuss a potential shortage of radiation protection professionals in the not-too-distant future. This shortage manifests itself in declining membership of professional societies, decreasing enrollment in university programs in the radiological sciences, and perhaps most importantly, the imminent retirement of the largest birth cohort in American history,

the so-called “baby boomer” generation. This group comprises those born from approximately 1945 to 1965, the first quarter of whom have already reached the traditional retirement age of 65 y. Each speaker at the workshop presented a “quad chart” that showed “who we are,” “what we do,” “how we do it,” and “our needs.” Consensus emerged that shortages already are, or soon will be felt in government agencies (including state radiation control programs), membership in professional societies is declining precipitously, and student enrollments and

university support for radiological disciplines are decreasing, with no reversals expected. The supply of medical physicists appears to be adequate at least in the near term, although a shortage of available slots in accredited clinical training programs looms large. In general the private sector appears stable, due in part to retirees joining the consultant ranks. However, it is clear that a severe problem exists with the lack of an adequate surge capacity to respond to a large-scale reactor accident or radiological terrorism attack in the United States. The workshop produced a number of recommendations, including increased funding of both fellowships and research in the radiological sciences, as well as creation of internships,

practicums, and post-doctoral positions. A federal joint program support office that would more efficiently manage the careers of radiological professionals in the civil service would enhance recruiting and development, and increase the flexibility of the various agencies to manage their staffing needs. NCRP has electronically published the proceedings of the WARP workshop, and NCRP Statement No. 12 has been completed and issued, along with a one-page synopsis. NCRP has also established Council Committee 2, which is charged with continuing to monitor the situation and periodically report to the Council and stakeholders on the issue.

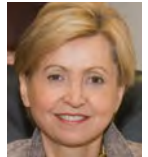
How Did We Get Here?

Jacqueline P. Williams & Patricia R. Worthington, *Session Co-Chairs*

9:00 am

Radiation Brain Drain? The Impact of Demographic Change on U.S. Radiation Protection

Hedvig Hricak
Memorial Sloan-Kettering Cancer Center



Since the discovery of x rays and radioactivity, and especially since the “Atoms for Peace” initiative, the use of radiation has had a significant, beneficial impact in the United States, particularly in medicine, energy production, basic science research, and industrial applications. Radiation protection knowledge and experience are required to continue to develop and implement scientific knowledge to protect workers, members of the public, and the environment from potential harmful effects of ionizing radiation while facilitating the beneficial use of radiation-based technologies. However, several demographic changes are negatively impacting U.S. radiation protection and response capabilities. These changes are

most evident in the medical, energy, research, and security arenas.

Demographic shifts in the U.S. population are expected to contribute to substantial increases in the incidence of cancers and other diseases over the coming decades. For example, it is projected that by 2030, 40.5 % of the U.S. population will have some form of cardiovascular disease (CVD), with a tripling of total direct medical costs. While cancer-related and CVD death rates have been decreasing as a result of improved imaging and therapeutic approaches, a significant increase in the beneficial and safe use of radiation in medicine will be needed to continue fighting these diseases in the future. Accordingly, the need for radiation protection for

Meeting the Needs of the Nation for Radiation Protection

patients, staff, and members of the public will also increase.

With respect to energy, it is projected that from now through 2040, U.S. consumption will continue to grow while rising costs for electric power generation, transmission and distribution will increase the average price of electricity by 18 %. Given these changes, the increasing concerns about climate effects and the resulting shift toward greater use of renewables, it will be necessary to maintain or increase the availability of nuclear energy in the U.S. as well as to develop new technologies. These endeavors will require excellence in professional and scientific leadership in radiation sciences.

There is also, unfortunately, a real and mounting specter of terrorism that must be dealt with. Terrorists continue to adapt to the challenges of emerging forms of conflict and exploit changes in technology and society. They are developing new capabilities of attack and improving the efficiency of their existing methods. Are we as a nation responding with sufficient speed and commitment? NCRP, the National Research Council, the U.S. Government Accountability Office, as well as the Health Physics Society (HPS) have each clearly stated that responding to a major U.S. radiation accident or terrorist attack will require a huge surge in radiation professionals to manage the consequences of such an incident.

Regrettably, there are significant shortfalls in radiation protection, radiobiology, nuclear expertise, and radiation research infrastructure in the United States. HPS concluded that “[T]he critical human capital shortage in radiation safety is overwhelming the Society's efforts to help respond to this crisis.” A report published by the Oak Ridge Institute for Science and Education reiterated this concern, stating “[I]t is highly likely that the number of job openings for new graduate health physicists will continue to exceed the number

of new graduates available in the labor supply.” Indeed, in 2013, the number of graduate-level enrollees in radiation protection programs was the lowest reported since the early 1970s, and it is anticipated that there will continue to be decreases in master's and doctoral degree recipients. A survey of faculty members employed in radiation biology in U.S. and Canadian residency programs revealed similar concerns over the declining numbers of radiobiologists; it showed both that faculty members with degrees in radiation biology are scarce and that those responsible for teaching radiation biology to radiation oncology and radiology residents are aging. In fact, age distributions for workers in radiation protection, medical physics, and nuclear power are heavily and increasingly skewed toward the higher end of the spectrum. Furthermore, in addition to asking: “Where are the radiation professionals?” it is essential to ask, “Where are the radiation facilities?” Research infrastructure and resources continue to decay and decline.

For public, private and government entities alike, the increasing shortage of radiation scientists and radiation protection specialists as well as the lack of infrastructure stand in sharp contrast to emerging scientific opportunities and the need for new knowledge to address issues of health, growth and security. The radiation brain drain is real and requires immediate attention, as the workforce in radiation sciences will soon be inadequate to fill the multiple roles it occupies in the academic, medical, energy and defense sectors.

While necessity may be the mother of invention, preparation is the father of inspiration. Could it be that such challenges create opportunities for improvement? Though for many years, the United States has been the world leader in radiation protection and radiation sciences, the country clearly lacks a coordinated, long-term,

milestone-driven strategic plan for reversing the radiation brain drain. Addressing the problem will require significantly increased federal and state funding as well as formal partnerships and initiatives

amongst academia, research, government, and the private sector. It will also require unique and creative courses of action and may lead to remarkable advances we are, as yet, unable to imagine.

9:25 am

Membership Trends in the Health Physics Society: How Did We Get Here and Where Are We Going?

Kathryn H. Pryor
Pacific Northwest National Laboratory



The Health Physics Society (HPS) has been a diverse body since its beginnings in 1956, encompassing professionals from different disciplines with an interest in radiation safety issues. Health physics was just beginning to emerge as a distinct discipline, initially spurred by the development of the atomic bomb, and amplified by the commercial use of nuclear power. There was a need for a professional group to discuss issues and share ideas and experiences in the field. Both the field of health physics and the ranks of the HPS membership experienced a steady increase in numbers and interest.

HPS continued to grow in numbers and thrive through the mid-1990s, and then began to retract. Concern regarding the “graying” of the HPS was being discussed as far back as the late 1990s. Despite efforts to broaden the base of membership through additional membership categories, the numbers of plenary (now referred to as Full) members continued to shrink.

The “graying” of the HPS is real - although age demographic data are only available for about the past 15 y (and is provided voluntarily), the shift in age distribution over this timeframe is clear. A recent

survey indicated that over 50 % of HPS members are over 50 y of age, and over half of the respondents plan to retire within 10 y. As our members age, they convert to emeritus memberships or drop their membership altogether. Some members simply aren't able to continue for financial or health-related reasons. There is now an age gap – members in their 30s and early 40s are missing from the mix.

Potential causes for declining membership may include smaller enrollments in academic programs, reduced employment opportunities, and societal factors. There appears to be reduced employer support for participation in professional activities and travel to conferences. Societal factors include easy access to professional information through the internet, balancing of family commitments, other volunteer opportunities, and a general decline in joining professional groups.

So, what is the fate of the HPS? We are not alone – other professional groups are experiencing the same overall trends in membership to differing degrees. A number of initiatives have been launched or are being considered by HPS in an effort to offset this trend.

9:50 am

Q&A

10:10 am

Break

Meeting the Needs of the Nation for Radiation Protection

10:40 am

Review of the Workforce for Radiation Protection in Medicine

Wayne D. Newhauser
Louisiana State University



Within the health care industry, several professions share responsibility for the protection of patients and staff from radiation, including the scientific specialties of medical physics and health physics, the medical specialties of radiation oncology and radiology, with important supporting roles played by registered therapy technologists, engineers, and information technologists. This talk will review the current status of the workforces of selected radiation professions in the United States, with emphasis on medical physics, health physics, and radiation oncology, based on a survey of the literature.

The presentation will cover the current size and general characteristics of the workforces. Data will be presented on trends in the supply and demand for entry level positions in various professions. Factors influencing demand for radiation professionals, e.g., changes in number of incident cancers, the utilization of

radiation treatments, and changes in health care economic policies will be mentioned.

Several education-related topics will be reviewed, including relevant trends in higher education, such as the numbers and types of degree programs, their capacities, graduation rates, and other performance indicators.

The presentation will also mention selected factors that influence the supply of radiation professionals, including the cost of higher education (e.g., tuition), admission and graduation rates degree programs and residency training fellowships, the perceived attractiveness of various professions to students, job duties, job satisfaction, and rates of compensation. Funding for academic programs will also be discussed, including trends in state and federal support for research and education.

11:05 am

Changing Roles of State Health Physicists

Ruth E. McBurney
Conference of Radiation Control Program Directors, Inc.



State radiation control programs are responsible for many aspects of radiation protection under their purview. Although some federal agencies have a specific role in radiation protection at the federal level, radiation control programs have been established in each state, New York City, the District of Columbia, Los Angeles County, and Puerto Rico. Most of these state, local and territorial programs, under legislative authority and mandates, address all aspects of radiation protection

for sources of radiation not exclusively under federal control, including the use of some sources of radiation not regulated by the federal government, including industrial and medical uses of x ray (other than mammography) as well as certain types of naturally occurring radioactive material.

The role of state health physicists is ever-evolving, and the scope of their work is constantly expanding. In addition to regulatory duties involved with the control of

radioactive material and radiation machines (x ray and accelerators), as well as sources of nonionizing radiation, such as lasers and ultraviolet radiation, state radiation control staff are also involved in environmental radiation issues and preparing for radiation emergencies.

Those states in the planning zones of nuclear power plants are involved in off-site emergency planning and exercising, including scenario development, accident assessment, contamination control and environmental monitoring. Since the events of September 11, 2001, radiation control programs are also involved in planning for other radiological incidents, including terrorist acts. States and local governments that have experience in emergency planning have been shown to be better equipped and prepared for handling other types of radiological incidents, but preparing for radiological dispersal device and improvised nuclear device events present unique challenges to all programs and their staff.

Emerging technologies, especially in healing arts applications, present ever-changing training needs for radiation control staff. Source security, financial security for decommissioning and disposal of radioactive material are challenges that have

come more to the front in the past few years. In addition, new challenges, such as technologically enhanced naturally occurring radioactive material, as well as its associated risk and methods for regulatory control, are adding to the need for health physics resources and knowledge base.

To develop a consistent and scientifically sound approach to radiation protection policies across state and federal agencies, and to avoid unnecessary duplication of effort, the Conference of Radiation Control Program Directors (CRCPD) fosters the exchange of ideas and information among the states and the federal government concerning radiation control. It also provides a forum for state and federal agencies to work together and apply their limited resources to address radiological health issues of mutual interest. CRCPD uses working groups assigned to specific issues, annual meetings for presentations and discussion of issues of mutual interest, new developments in the field, upcoming challenges and recommendations, along with training and workshops to keep state and federal regulatory personnel informed and educated on new technologies, issues, and regulatory procedures.

11:30 am

Q&A

11:50 am

Lunch

Where Do We Need To Be?

Ralph L. Andersen & Robert C. Whitcomb, Jr., *Session Co-Chairs*

1:15 pm

Commercial Nuclear Power: Assessing and Meeting the Need

Jerry W. Hiatt
Nuclear Energy Institute



The purpose of this presentation is to provide an overview of the process used by

the commercial nuclear power industry in assessing the status of existing industry

Meeting the Needs of the Nation for Radiation Protection

staffing and projecting future supply-demand needs. The most recent Nuclear Energy Institute developed “Pipeline Survey Results” will be reviewed with specific emphasis on the radiation protection specialty. Both radiation protection technician and health physicist specialties will be discussed.

The industry initiated Nuclear Uniform Curriculum Program will be reviewed as an example of how the industry has addressed the need for developing additional resources. Furthermore, the reality of challenges encountered in maintaining the needed number of health physicists will also be discussed.

1:40 pm

Education or Training: Does it Matter?

Kathryn A. Higley
Oregon State University



Radiation protection professionals are an endangered breed. Health physics (HP) as a discipline and vocation is at a critical juncture. We are at a tipping point. Oak Ridge Associated University tracks enrollment and degrees in HP programs. In 2014 there were only 10 PhD, 81 MS, and 61 BS graduates nationwide in health physics. Why are these numbers important? Small programs do not cover their costs to operate. Higher education today is vastly different from what it was even 20 y ago. Every academic program must now make a budget case to justify its existence. Consequently, HP programs, which are by anyone's measure, minuscule, are in very real danger of closing. Given that the country will continue to need radiation protection expertise, we must take immediate steps to reinvigorate the profession and preserve academic programs. We simply cannot train or short-course our way out of this problem. Under routine conditions, individuals trained in basic health physics can be expected to safely manage daily operations. But life is full of the unexpected. When it involves radiation, we need someone grounded in the radiological fundamentals to understand, assess, and safely deal with it.

There are several specific steps that must be taken. The American Board of Health Physics (ABHP) in conjunction with the Health Physics Society (HPS) must

identify minimum curriculum content for health physics programs at the graduate and undergraduate level. Academic institutions should share curricular content to make program delivery more cost effective and to minimize redundancies. This should include establishing joint degrees and academic exchanges to enhance student mentoring and faculty experience. ABHP must require applicants for board certification (CHP) to have graduated from an approved academic program.

At the federal level, we need to recognize the discipline of health physics as meeting a “strategic national need.” The basic requirements for health physicist in the Office of Personnel Management's Classifications and Qualifications System (job series 1306) need to be revised and strengthened. Applicants for federal HP jobs must have a minimum number of credit hours in HP or radiation safety and have graduated from an approved program or hold CHP certification. At the federal and state level we need to mandate advanced radiation protection degrees and/or CHP for jobs with substantial radiation safety management or assessment responsibility. Federal programs with considerable radiation safety obligations must carve out funds for academic research for faculty from approved HP programs. Internship opportunities for undergraduate

and graduate HP students must be established and sustained.

The Institute of Nuclear Power Operations, a long standing supporter of education, must require accreditation of health physics professionals in the nuclear industry. Industry in general must do more to support knowledge transfer efforts, by teaming with approved academic institutions, to provide student internship opportunities, and support faculty sabbaticals or cooperative research efforts. Industry is

best suited to train and produce the job-specific skills needed for competent HPs.

Without these very specific steps, HP will be relegated to a subspecialty footnote within other academic programs, if it survives at all. The broad, interdisciplinary education that is the hallmark of a great health physicist will be lost. HP, as an academic discipline and as a profession represents a strategic national need. But it is in peril, and there is no single, “silver bullet” that will save it. Multiple actions must be taken, and soon.

2:05 pm

Estimating Cancer Risks at Very Low Radiation Doses: What Can be Done?

David J. Brenner
Columbia University Medical Center



Providing realistic estimates of radiation-induced cancer risks at very low doses is of importance in a number of societal arenas. Nuclear power is an obvious case, for example in terms of assessing the significance of, and response to, accidents such as at Chernobyl and Fukushima. Another example is providing the input to benefit-risk analyses for the multiple applications of x-ray imaging in medicine.

Epidemiological studies of populations exposed to low doses of radiation have and will continue to provide value, but as we move to lower and lower doses, to doses where the natural cancer background rate is increasingly dominant, even the largest scale studies will produce results with very wide confidence intervals, and with therefore only limited utility.

The situation is not dissimilar for animal models of radiation-induced cancer where, again, the natural cancer background limits the potential for large-scale radiation-carcinogenesis studies at very low radiation doses.

A third potential approach is use of *in vitro* cellular or molecular models of radiation-induced cancer. A limitation here is the

need for *in vitro* endpoints which can act as credible surrogates for radiation-induced cancer in man. Lacking these — and it may be that no single *in vitro* endpoint could fulfill this role — while such studies may be technically feasible at very low doses, their relevance may be questioned.

A fourth approach is the use of models. Among these there are two types of approaches: one relates to the long-discussed goal of providing a complete quantitative description of all the chemical, physical and biological steps involved in radiation-induced cancer on time scales ranging from picoseconds to years. Whilst long a programmatic goal, progress has been slow even for modeling limited subsets of this “grand scheme” approach, reflecting the extraordinary complexities involved at every mechanistic level.

The second type of modeling approach is not focused on providing absolute risk estimates, but is rather motivated by the goal of extrapolating radiation-induced cancer risks from epidemiologically tractable doses down to epidemiologically-intractable low radiation doses. An

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example here is the biophysical argument which underlies the linear nonthreshold model. An advantage of these extrapolation motivated approaches is that the assumptions underlying any particular extrapolation model can, at least in principle, be tested without the need for direct cancer-risk measurements at low doses.

A final approach uses the so called “upper limit” technique. Here the goal is to provide statements such as “the radiation-

induced cancer risk at dose D cannot be more than R , because if it were the risks would have been detected in low dose epidemiological studies.” Such statements have considerable value for clarifying low-dose radiation risks to the general public, for providing the data for risk-benefit analyses, as well as providing the data needed to design rational responses to large-scale radiological events.

2:30 pm

Q&A

2:55 pm

Break

3:25 pm

Developing a Radiation Protection Hub

Nolan Hertel

Georgia Institute of Technology / Oak Ridge National Laboratory



A National Council on Radiation Protection and Measurements (NCRP) committee estimates that in 10 y there will be a human capital crisis in the radiation safety community as a whole. The difficulty in responding to this shortage will be amplified by the fact that many radiation protection (health physics) academic programs will find it difficult to justify their continued existence, since they are low volume programs both in terms of enrollment and research funding compared to more highly subscribed and highly funded academic programs. In addition, radiation protection research groups have been disbanded or dramatically reduced in size across the national laboratory complex. The loss of both of these national resources is being accelerated by low and uncertain government funding priorities.

Borrowing from the U.S. Department of Energy (DOE) research hub model [e.g., the Consortium for Advanced Simulation of Light Water Reactors (<http://www.casl.gov>)], is it an opportune time to form a consortium that would bring together the radiation protection research, academic

and training communities? The goal of such a consortium would be to engage in research, education and training of the next generation of radiation protection professionals. The consortium furthermore could bring together the strengths of different entities in a strategic manner to accomplish a multifaceted research, educational and training agenda. This vision would forge a working and funded relationship between major research universities, national labs, 4 y degree institutes, technical colleges, and other partners. This consortium would differ from the DOE research hub model in that it would incorporate a greater educational and training mission.

An initial goal would be to secure consortium funding for a 5 y period that would be renewable upon satisfactory performance. Such a consortium would need to be structured so that it does not encroach on funding from any contracted radiation protection activities that its members normally would have received. An agenda would be formed that is truly research, education and training driven and not

driven by contracted product development or statutory regulatory needs.

It is envisioned that such a consortium would set up a large summer student intern program where the interns are placed at several national laboratories and other facilities to gain either research or operational radiation experience. The consortium would set up a practicum program where new hires by DOE, their laboratories, and/or other federal agencies are rotated through several facilities to broaden their understanding of

operational health physics. The consortium would also serve as a research hub for funding university and national laboratory research that advances the state of radiation protection knowledge and methods. This would require the development of a research agenda would be generated by the scientists and engineers who are part of the consortium in concert with an advisory committee consisting of radiation protection scientists.

It is time to form a Consortium for the Advancement of Radiation Protection.

3:50 pm

Meeting Regulatory Needs

Michael Weber
U.S. Nuclear Regulatory Commission



The world is experiencing change at an unprecedented pace, as reflected in social, cultural, economic, political and technological advances around the globe. Regulatory agencies, like the U.S. Nuclear Regulatory Commission (NRC), must also transform in response to and in preparation for these changes. In 2014, NRC staff commenced Project Aim 2020 to transform the agency by enhancing efficiency, agility and responsiveness, while accomplishing NRC's safety and security mission. Following Commission review and approval in 2015, NRC began implementing the approved strategies, including strategic workforce planning to provide

confidence that NRC will have employees with the right skills and talents at the right time to accomplish the agency's mission. Based on the work conducted so far, ensuring an adequate pipeline of radiation protection professionals is a significant need that NRC shares with the states and other government agencies. NRC is working to ensure that sufficient radiation protection professionals will be available to fulfill its safety and security mission and leveraging the work of the National Council on Radiation Protection and Measurements, the Conference of Radiation Control Program Directors, the Health Physics Society, and others.

4:15 pm

Q&A

4:35 pm

Break

Fortieth Lauriston S. Taylor Lecture on Radiation Protection and Measurements

5:00 pm

Introduction of the Lecturer

Michael T. Ryan

Meeting the Needs of the Nation for Radiation Protection

Radiation Protection and Regulatory Science

John W. Poston, Sr.
Texas A&M University



It took about 30 y after Wilhelm Konrad Roentgen's discovery of x rays and Henri Becquerel's discovery of natural radioactivity for scientists in the civilized world to formulate recommendations on exposure to ionizing radiation. We know of these efforts today because the organizations that resulted from the concerns raised in 1928 at the Second International Congress of Radiology still play a role in radiation protection. The organizations are known today as the International Commission on Radiological Protection (ICRP) and, in the United States, the National Council on Radiation Protection and Measurements (NCRP). Today, as we have some many times in the past, we honor Dr. Lauriston Sale Taylor, the U.S. representative to the 1928 Congress, for his dedication and leadership in the early growth of NCRP.

The mission of NCRP is "to support radiation protection by providing independent scientific analysis, information, and recommendations that represent the consensus of leading scientists." The developments in science and technology, including radiation protection, are occurring so rapidly that NCRP is challenged to provide its advice and guidance at a faster pace than ever before. The NCRP role has also expanded as the Council considers newer uses and applications of ionizing radiation in research and medicine as well as the response to nuclear or radiological terrorism. In such a technical world, new areas have been established to deal with the nexus of science and regulation,

especially in the United States. Lord Ernest Rutherford supposedly said, "That which is not measurable is not science. That which is not physics is stamp collecting." I wonder what he would say if he was alive today as now many embrace a new field called "regulatory science." This term was suggested by Professor Mitsuru Uchiyama in Japan in 1987 and was reviewed in literature published in English in 1996. Some have attributed a similar idea to Dr. Alvin Weinberg, for many years Director of the Oak Ridge National Laboratory (ORNL). He actually introduced the term "trans-science," which he defined as the policy-relevant fields for which scientists have no answers for many of the questions being asked. He was influenced with the heavy involvement of ORNL in developing methods to assess environmental impacts as mandated by the 1969 National Environmental Policy Act. Professor Uchiyama defined regulatory science as "the science of optimizing scientific and technological developments according to objectives geared toward human health." In essence, regulatory science is that science generated to answer political questions.

This presentation will introduce regulatory science and discuss the differences between what some call "academic science" and "regulatory science." In addition, a short discussion of how regulatory science has and will impact the practice of radiation protection and all areas involving the use of radiation and radioactivity.

6:00 pm

Reception in Honor of the Lecturer
Sponsored by Landauer, Inc.

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Tuesday, April 12

- 8:15 am **NCRP Annual Business Meeting**
- 9:10 am **Break**

How Do We Get There?

Pamela J. Henderson & Chad A. Mitchell,
Session Co-Chairs

9:30 am

Critical Issues in Knowledge Management in Domestic Radiation Protection Research Capabilities

Shaheen Dewji
Oak Ridge National Laboratory



In response to the severe atrophy of capabilities in health physics identified by the Health Physics Society in 2002, the National Council on Radiation Protection and Measurements created WARP (Where Are the Radiation Professionals?) to assess the “front-end” of the human capital pipeline in university education and training. Over a decade later, the human capital crisis in radiation protection continues to be of paramount concern to address the loss of expertise associated with the loss of radiation protection knowledge on the “back-end,” most notably with respect to research and development (R&D) capabilities of the field. In order to preserve the radiation protection knowledge in R&D that may be lost due to the growing number of retirements in the field

of radiation protection, knowledge management, and knowledge capture has become an extremely high priority that must be addressed immediately before the expertise is irreplaceably lost. As a hub of domestic capabilities, Oak Ridge National Laboratory's Center for Radiation Protection Knowledge has a mandate to develop and actuate a formal knowledge management strategy in the transfer knowledge from outgoing subject matter experts in the field of radiation protection. It is envisioned that such an effort will provide one avenue for preserving domestic capabilities to support stakeholder needs in the federal government and the nuclear industry, while continuing to lead and innovate in R&D on a global scale.

9:55 am

The Business of Health Physics: Jobs in a Changing Market

Matthew P. Moeller
Dade Moeller



Health physics is changing. The early legends have long since passed. The first generation of young health physics

professionals is now almost gone as well. Today's health physicists are no longer the specialists, scientists and educators who

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initially defined, established and developed our profession. To assess what the future holds, it is beneficial to characterize the type of health physics work performed in the past so as to speculate on the needs and jobs of the future. Since 1979, the market drivers have been:

- operating commercial nuclear power plants;
- initiating cleanup activities within the U.S. Department of Energy's weapons complex sites;
- responding to major nuclear accidents and their aftermaths;
- reducing costs through improved instrumentation and computer applications; and
- advancing medical treatments using radioactive materials and radiation-generating devices.

All these activities created jobs for health physicists decades ago. Today, we are a new generation of health physicists challenged with the burden of continuing past traditions while remaining relevant to changing industries and global markets. The business of health physics has changed rapidly in response to a new set of factors and conditions. These include dependence upon advanced technologies, constraints due to reduced budgets and competitive economic pressures, and the expectation that routine operations will always remain routine. Consequently, work once performed by health physics professionals has disappeared rapidly as well. Today, research projects are rarely funded. Radiation protection programs and protocols are already well established

and documented. Those professionals with niche expertise in specialized disciplines of health physics are in demand only in unusual circumstances. Today's reality is that generalists are conducting health physics programs and filling the majority of radiation protection jobs. The most fundamental step that should be taken to maintain jobs for health physicists, and to encourage new students to enter our profession, is to establish comprehensive standards specifying the minimum education, training, qualifications and experience necessary to perform the roles, duties and responsibilities of practicing health physics technicians and professionals in today's marketplace. Without such provisions, smart instruments will continue to replace qualified people. With opportunity, health physics jobs will be focused on:

- decommissioning U.S. nuclear power plants;
- commissioning and operating foreign nuclear power plants of new design;
- conducting environmental programs emphasizing virtually no emissions and therefore no harm;
- screening consumer products to detect inadvertent contamination; and
- supporting another generation of diagnostic and therapeutic medical devices.

Waste management, processing and disposal will be an international concern. The role of the health physicist in all of these endeavors will need to evolve from what it is today.

10:20 am

Break

10:45 am

Meeting the Needs of First Responders: Scientific Experiments to Operational Tactics for the First 100 Minutes After an Outdoor Explosive Radiological Dispersal Device

Stephen V. Musolino
Brookhaven National Laboratory



During radiological or nuclear emergencies, routine decisions and operations for state and local response agencies can become overwhelming. Prompt actions in the first few hours after an incident has occurred require scientifically sound pre-planning, and then operational integration, specialized tools, and response tactics to safeguard the public and responders. To answer the questions about what to do in a tactical sense in the first 100 minutes of a response to a radiological dispersal device required many years of explosive aerosolization experiments. This basic work in materials science was turned into pragmatic language of first responders to inform them of the realistic hazard boundaries, and the appropriate response actions in the first “100 minutes” of a response to radiological terrorism. The U.S. Department of Homeland Security has sponsored efforts to improve national planning and response for radiological

terrorism through programs such as “The First 100 minutes,” which has developed scientifically supported initial tactical response guidance for managing key activities, such as confirming a radiological release, shelter and evacuation, and conducting lifesaving operations in a radiation environment; RadResponder, a smartphone app that allows anyone to collect and integrate geo-positioned field measurements; and the Radiological Operations Support Specialist, which is a National Incident Management System-typed position that will help train, equip and certify radiation experts to assimilate with the incident command system during a radiological response. With the shrinking pool of radiation protection professionals, there will be challenges in the future to continue this support to radiological and response operations. The problem is much larger in the context of a nuclear detonation.

11:10 am

Meeting the Needs of the Nation for Radiation Protection: How Do We Get There? Meeting Medical Needs

Donald P. Frush
Duke University School of Medicine



Radiation and potential risk during medical imaging is one of the foremost issues for the imaging community. Because of this, there are growing demands for accountability including appropriate use of ionizing radiation in diagnostic and image-guided procedures. Factors contributing to this include increasing use of medical imaging; increased scrutiny (from awareness to alarm) by patients/caregivers and the

public over radiation risk; and mounting calls for accountability from regulatory, accrediting, healthcare coverage (e.g., Centers for Medicare and Medicaid Services), and advisory agencies and organizations as well as industry (e.g., NEMA XR-29, *Standard Attributes on CT Equipment Related to Dose Optimization and Management*). Current challenges include debates over uncertainty with risks with

Meeting the Needs of the Nation for Radiation Protection

low-level radiation; lack of fully developed and targeting products for diagnostic imaging radiation dose monitoring; lack of resources for and clarity surrounding dose monitoring programs; inconsistencies across and between practices for design, implementation and audit of dose monitoring programs; lack of interdisciplinary programs for radiation protection of patients; potential shortages in personnel for these and other consensus efforts; and training concerns as well as inconsistencies for competencies throughout medical providers' careers for radiation protection of patients. Medical care providers are currently in a purgatory between quality- and value-based imaging paradigms, a state that has yet to mature to reward this move to quality-based performance. There are also deficits in radiation expertise personnel in medicine. For example, health physics programs and graduates have recently declined, and medical physics residency openings are currently at a third of the number of graduates. However, leveraging solutions to the medical needs will require money and resources, beyond personnel alone. Energy and capital will need to be directed to:

- innovative and cooperative cross-disciplinary institutional/practice oversight of and guidance for the use of diagnostic imaging (e.g., radiology, surgical specialties, cardiologists, and intensivists);
- initiatives providing practical benchmarks (e.g., dose index registries);

- comprehensive (consisting of access, integrity, metrology, analytics, informatics) and effective and efficient dose monitoring programs;
- collaboration with industry;
- improved imaging utilization such as through decision support combined with evidence-based appropriateness for imaging utilization;
- integration with e-health such as medical records;
- education including information extending beyond the medical imaging community that is relevant to patients, public, and providers...and administration;
- identification of opportunities for alignment with salient media and advocacy organizations to deliver balanced information regarding medical radiation and risk;
- open lines of communication between medical radiation experts and appropriate bodies such as the U.S. Environmental Protection Agency, the U.S. Food and Drug Administration, and the Joint Commission to assure appropriate guidance on documents and actions originating from these organizations; and
- increased grant funding to foster translational work that advances our understanding of low-level radiation and biological effects.

11:35 am

Q&A

Conclusions

John D. Boice, Jr., *Session Chair*

11:55 am

NCRP Vision for the Future and Program Area Committee Activities

John D. Boice, Jr.
President, NCRP



Remember the popular books “Where's Waldo”? Well, similar to radiation professionals it seems that even allowing GPS location on his smartphone won't help much - if there's no one to answer the call! Where are the radiation professionals (WARP) and where are you? We're losing human capital and the losses are increasing. If you believe we have a national crisis, do you have ideas on how we can avert the impending disaster or mitigate its consequences? NCRP tried with our workshop in 2013 with representatives from government, academia, industry and societies which resulted in a synopsis and now a fuller statement available on the NCRP website (<http://ncrponline.org/>). We should not be limited by conventional notions of what is practical or feasible. We need to be imaginative and visionary. NCRP advocates a sequence of activities in the areas of education, training, research, and personnel management to address this urgent national need. But more can be done:

- restore significant federal and state funding for scholarships, fellowships, and faculty research to increase and sustain a credible workforce of radiation professionals;
- reinvigorate partnerships among universities, government, and the private sector to ensure undergraduate and graduate programs are adequately resourced to support the training and qualification of radiation professionals, including those who will educate the next generation;

- establish a Joint Program Support Office for radiation professionals in the federal civil service to manage utilization and career development of personnel more effectively;
- monitor trends in the supply of and demand for radiation professionals; and
- establish basic and advanced competency profiles to serve as guidance upon which to base the education, training, qualification and appropriate use of radiation professionals.

NCRP has created Council Committee-2, Meeting the Needs of the Nation for Radiation Protection, where we will continually monitor and make suggestions on ways to address the vanishing professionals. Further this year's 2016 Annual Meeting is similarly titled and new ideas to mitigate the impending disasters are anticipated.

Remember the days when people were smart and phones were dumb? When the call comes will there be anyone home to answer the phone (smart or otherwise)? Public health, radiation safety, emergency preparedness, and the environmental are all at risk. The clarion call to act is now!

And for a snapshot of NCRP recent and planned activities:

- Integration of Biology with Epidemiology (Chairs: Sally A. Amundson, Jonine Bernstein)— Commentary published late 2015;

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- Dosimetry for Workers and Veterans (Chairs: Andre Bouville, Richard E. Toohey);
- Million Person Study of Low Dose Health Effects (Coordinator: John D. Boice, Jr.);
- Radiation Protection Guidance for the United States (update NCRP Report No. 116) (Chairs: Kenneth R. Kase, John D. Boice, Jr.);
- Recent Epidemiologic Studies and Implications for the Linear Energy Transfer Model (Chairs: Roy E. Shore, Lawrence T. Dauer);
- Guidance on Radiation Dose Limits for the Lens of the Eye (Chairs: Eleanor A. Blakely, Lawrence T. Dauer);
- Radiation Exposures in Space and the Potential for Central Nervous System Effects (Chairs: Leslie A. Braby, Richard S. Nowakowski);
- Guidance for Emergency Responders (Chairs: Stephen V. Musolino, Adela Salame-Alfie);
- Emergency Response and Preparedness (2017 Annual Meeting; Program Chairs Armin Ansari, Adela Salame-Alfie);
- Radiation Safety of Sealed Radioactive Sources (Chair: Kathryn H. Pryor);
- Radiation Protection in Dentistry (Chairs: Alan G. Lurie, Mel L. Kantor);
- Radiation Safety Aspects of Nanotechnology (Chairs: Mark D. Hoover, David S. Myers);
- Evaluating and Communicating Radiation Risks for Studies Involving Human Subjects (Chair: Julie E.K. Timins);
- Improving Patient Dose Utilization in Computed Tomography (Chair: Mannudeep K. Kalra);
- Technologically Enhanced Naturally Occurring Radioactive Material in Unconventional Oil and Gas Production (at the Radiological Society of North America Annual Meeting in 2015 and a reprise hoped for 2016);
- Bioeffectiveness of Low Energy Radiation (Chair: Steven L. Simon);
- Naturally Occurring Radioactive Material and Technologically Enhanced Naturally Occurring Radioactive Material Hydraulic Fracturing (Chairs: William E. Kennedy, Jr. and John R. Frasier);
- Meeting the Needs of the Nation for Radiation Protection (now CC 2) (Chairs: John D. Boice, Jr., Kathryn H. Pryor, Richard E. Toohey); and
- “Boice Report”—a monthly column since June 2012 in *Health Physics News* intended to provide brief reports on recent activities in radiation protection, measurements, science, and health.

12:20 pm

Closing Remarks

John D. Boice, Jr.
President, NCRP

12:30 pm

Adjourn



Program Committee

Richard E. Toohy, Co-Chair
M.H. Chew & Associates

Kathryn H. Pryor, Co-Chair
Pacific Northwest National Laboratory

Judith L. Bader, Co-Chair
National Cancer Institute

Donald P. Frush
Duke University Medical Center

Chad A. Mitchell
Krueger-Gilbert Health Physics

Pamela J. Henderson
U.S. Nuclear Regulatory Commission

Wayne D. Newhauser
Louisiana State University

Jerry W. Hiatt
Nuclear Energy Institute

Robert C. Whitcomb, Jr.
Centers for Disease Control and Prevention

Kathryn A. Higley
Oregon State University

Jacqueline P. Williams
University of Rochester

William E. Kennedy, Jr.
Dade Moeller

Patricia R. Worthington
U.S. Department of Energy

Registration

Monday, April 11, 2016 7:00 am – 5:00 pm

Tuesday, April 12, 2016 7:00 am – 11:00 am

Register online: <http://registration.ncrponline.org>

2017 Annual Meeting

*Emergency Preparedness for Nuclear Terrorism:
What are Remaining Gaps and is There Need for
Realignment of National Efforts*

Armin Ansari & Adela Salame-Alfie, *Co-Chairs*

March 6–7, 2017
Bethesda, Maryland

Annual Warren K. Sinclair Keynote Address



Dr. Richard E. Toohey will present the 13th Warren K. Sinclair Keynote Address at the 2016 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP). The Address, entitled “WARP, an NCRP Initiative to Meet the Needs of the Nation for Radiation Protection,” will be a featured presentation at the 52nd NCRP Annual Meeting to be held April 11 and 12, 2016. The Address will be given at 8:30 a.m. on April 11, 2016 in the Crystal Ballroom, Hyatt Regency Bethesda, One Bethesda Metro Center, 7400 Wisconsin Avenue. The keynote speaker series honors Dr. Warren K. Sinclair, NCRP’s second President (1977 to 1991).

Dr. Toohey has been a member of the Council for 10 y and has served on the Board of Directors since 2010. He has served on the Budget and Finance Committee since 2006 and as Chair since 2007. Dr. Toohey was Chair of the 2012 Annual Meeting Program Committee on “Emerging Issues in Radiation Protection in Medicine, Emergency Response, and the Nuclear Fuel Cycle,” a member of the 2014 committee, and Co-Chair of the 2016 committee.

Dick Toohey is Chair of the Council Committee on “Meeting the Needs of the Nation for Radiation Protection” and Co-Chair of SC 6-9 on “U.S. Radiation Workers and Nuclear Weapons Test Participants Radiation Dose Assessment.” He was a member of the scientific committees that produced NCRP Report No. 164, *Uncertainties in Internal Radiation Dose Assessment* (2009); Report No. 163, *Radiation Dose Reconstruction: Principles and Practices* (2009); and Report No. 156, *Development of a Biokinetic Model for Radionuclide-Contaminated Wounds for Their Assessment, Dosimetry and Treatment* (2006); and was a participant in the 2013 workshop on “Where are the Radiation Professionals?”

Dr. Toohey received his PhD in physics from the University of Cincinnati in 1973. He spent the first part of his career at Argonne National Laboratory in both research and operational health physics. He is retired from Oak Ridge Associated Universities, where he served as director of the Radiation Internal Dose Information Center, as Senior Health Physicist for the Radiation Emergency Assistance Center/Training Site, Director of Dose Reconstruction Programs, and Associate Director of the Independent Environmental Assessment and Verification Program. He is currently a consultant with M. H. Chew and Associates of Livermore, California.

He is certified in comprehensive practice by the American Board of Health Physics, was the 2008 to 2009 President of the Health Physics Society, is Treasurer of the International Radiation Protection Association, and Chair of the Scientific Advisory Committee for the U.S. Transuranium and Uranium Registries. His specialties are internal radiation dosimetry, dose reconstruction, radiological emergency response, and litigation support. Dr. Toohey has 125 publications in the open literature, and is a retired Lt. Colonel, U.S. Army Reserve.

Lauriston S. Taylor Lecture



Dr. John W. Poston, Sr. will give the 40th Lauriston S. Taylor Lecture at the 2016 Annual Meeting of the National Council on Radiation Protection and Measurements (NCRP). The lecture, entitled Radiation Protection and Regulatory Science, will be the featured presentation at the 52nd Annual Meeting to be held April 11-12, 2016. The Lecture will be given in the Crystal Ballroom of the Hyatt Regency Bethesda, One Bethesda Metro Center, 7400 Wisconsin Avenue, Bethesda, Maryland at 5:00 p.m. on April 11, 2016. The lecture series honors the late Dr. Lauriston S. Taylor, the NCRP founding President (1929 to 1977) and President Emeritus (1977 to 2004). A reception sponsored by Landauer, Inc. follows the presentation and all are invited to attend.

In 1971, Dr. Poston graduated from the Georgia Institute of Technology (GIT) in Atlanta with a Ph.D. in Nuclear Engineering after receiving an M.S. from GIT in 1969 and a B.S. in Mathematics from Lynchburg College in Virginia.

Dr. Poston is a Professor in the Department of Nuclear Engineering and Associate Director of the Nuclear Power Institute. He has been at Texas A&M University since 1985 and served for 10 y as the Department Head. Prior to Texas A&M, he was on the faculty at the Georgia Institute of Technology and, earlier, at the Oak Ridge National Laboratory and the Babcock & Wilcox Company in Lynchburg, Virginia.

Dr. Poston was elected as a Distinguished Emeritus Member of NCRP in 2002 after serving 12 y on the Council. He served as the Scientific Vice President for Program Area Committee 3, Nuclear and Radiological Security and Safety from 2007 to 2014. John Poston chaired Scientific Committee (SC) 2-1 on Preparing, Protecting, and Equipping Emergency Responders for Nuclear and Radiological Terrorism; SC 2-2 on Key Decision Points and Information Needed by Decision Makers in the Aftermath of a Nuclear or Radiological Terrorism Incident; and SC 46-14, Radiation Protection Issues Related to Terrorist Activities that Result in the Dispersal of Radioactive Material; and has served as a member on 10 additional committees during his tenure included two annual meeting program committees.

He is a Fellow of the American Association for the Advancement of Science, the American Nuclear Society, and the Health Physics Society. He has received several honors including the Robley D. Evans Commemorative Medal from the Health Physics Society in 2005; the Loevinger-Berman Award in 2003 from the Society of Nuclear Medicine; the Glenn Murphy Award in 1996 from the American Society for Engineering Education; and he presented the First Annual Warren K. Sinclair Keynote Address at the NCRP 2004 Annual Meeting.

Biographies



Ralph L. Andersen recently retired from the Nuclear Energy Institute as the Senior Director of Radiation Safety and Environmental Protection. His 45 y career spans a variety of positions in the areas of health physics, low-level radioactive waste management, and environmental protection across the sectors of nuclear energy, education, medical, industrial, research, and regulation. Mr. Andersen continues to practice as a certified health physicist, serving as a consultant to NCRP Council Committee 1, and as an advisor to the Organization for Economic Co-operation and Development Nuclear Energy Agency on estimating the cost of nuclear accidents and the Electric Power Research Institute on low-dose radiation research. He has a BA from the University of Maryland and completed graduate studies in radiology and radiation biology at Colorado State University.



Judith L. Bader was a senior investigator in many cancer clinical trials, genetics and epidemiology research projects, and communications technologies projects during her 22 y in the U.S. Public Health Service at the National Cancer Institute (NCI), National Institutes of Health. She has been the Chief of the Clinical Radiation Branch of the Radiation Oncology Branch at NCI, Chief of Radiation Oncology at the Bethesda Naval Hospital (now Walter Reed), and founding physician of two private radiation oncology practices. Since 2004, Dr. Bader, has also served as a senior medical advisor to various U.S. Department of Health and Human Services (HHS) and interagency entities charged with planning for and responding to medical aspects of mass casualty radiation emergencies. She is the Founding and Managing Editor of the HHS/Assistant Secretary for Preparedness and Response-sponsored website *Radiation Emergency Management*. She has served on various committees for the American Society for Clinical Oncology and the American Society for Radiation Oncology.

Dr. Bader has a BA from Stanford University, MD from Yale University School of Medicine. She has been board certified in Pediatrics, Pediatric Hematology-Oncology and Radiation Oncology. She is the author of scores of publications in various disciplines including clinical cancer trials, genetics and epidemiology, computer usability technology, and planning for and responding to mass casualty radiation emergencies.



John D. Boice, Jr., *NCRP President* and Professor of Medicine at Vanderbilt University School of Medicine, Nashville, Tennessee. He is an international authority on radiation effects and currently serves on the Main Commission of the International Commission on Radiological Protection and as a U.S. advisor to the United Nations Scientific Committee on the Effects of Atomic Radiation. During 27 y of service in the U.S. Public Health Service, Dr. Boice developed and became the first chief of the Radiation Epidemiology Branch at the National Cancer Institute. Dr. Boice has established programs of research in all major areas of radiation epidemiology, with major projects dealing with populations exposed to medical, occupational, military and environmental radiation. These research efforts have aimed at clarifying cancer and other health risks associated with exposure to ionizing radiation, especially at low-dose levels. Boice's seminal discoveries and over 440 publications have been used to formulate public health measures to reduce population exposure to radiation and prevent radiation-associated diseases. He has delivered the Lauriston S. Taylor Lecture at the NCRP and the Fessinger-Springer Lecture at the University of Texas at El Paso. In 2008, Dr. Boice received the Harvard School of Public Health Alumni Award of Merit. He has also received the E.O. Lawrence Award from the Department of Energy - an honor bestowed on Richard Feynman and Murray Gell-Mann among others - and the Gorgas Medal from the Association of Military Surgeons of the United States. In 1999 he received the outstanding alumnus award from the University of Texas at El Paso (formerly Texas Western College). Dr. Boice recently launched the Million U.S. Radiation Workers and Veterans Study to examine the lifetime risk of cancer following relatively low-dose exposures received gradually over time.

Biographies



David J. Brenner is the Director of the Columbia University Center for Radiological Research, which is the oldest and largest radiation biology center in the United States. He is also Principle Investigator of the Center for High-Throughput Minimally-Invasive Radiation Biodosimetry, a multi-institute consortium to develop high-throughput biodosimetry technology to rapidly test individual radiation exposure after a radiological incident.

Dr. Brenner's research focuses on mechanistic models for the effects of ionizing radiation on living systems. He divides his research time between the effects of high doses of ionizing radiation (relating to radiation therapy) and the effects of low doses of radiation (relating to radiological, environmental, and occupational exposures). At low doses, he was the first to quantify potential risks associated with the rapidly increasing usage of computed tomography scans. At high doses, his proposal to use large-fraction radiotherapy for prostate cancer (hypo-fractionation) is increasingly being used in the clinic, with several randomized trials now published.

Dr. Brenner has published more than 300 peer-reviewed papers and is the author of two books on radiation for the lay person: *Making the Radiation Therapy Decision* and *Radon, Risk and Remedy*.

Dr. Brenner is a recent recipient of the Failla gold medal, the annual award given by the Radiation Research Society for contributions to radiation research, and the Weldon Prize, from Oxford University for the development of mathematical or statistical methods applied to problems in biology. He is a member of the U.S. National Academies Nuclear and Radiation Studies Board.



Shaheen Dewji is a Radiological Engineer at the Center for Radiation Protection Knowledge (CRPK) at Oak Ridge National Laboratory (ORNL). She received her PhD in the Nuclear and Radiological Engineering Program at the Georgia Institute of Technology, having studied at both the Atlanta and Metz, France campuses. She received her BSc in Physics from the University of British Columbia and has participated in the Education Abroad Program at University of California-Berkeley. She has completed a Masters in Nuclear Engineering at Georgia Tech in assaying internal contamination using hand-held radiation detectors in the event of a radiological dispersion device for the Centers for Disease Control and Prevention. Dr. Dewji's recent work with CRPK at ORNL has included assessment of patient release criteria for 131I patients for the U.S. Nuclear Regulatory Commission, as well as updates to the U.S. Environmental Protection Agency's Federal Guidance Report (FGR) 12 on external exposure to radionuclides in environmental media and FGR 13 on dose coefficients and radiation risk associated with the inhalation and ingestion of radionuclides. Dr. Dewji also holds a certificate in Nuclear Knowledge Management from the National Research Nuclear University MEPhI in Russia, which she obtained through the International Atomic Energy Agency in 2014.



Donald P. Frush is the John Strohbehn Professor of Radiology and Professor of Pediatrics, faculty member of the Medical Physics Graduate Program, and Vice Chair of Safety and Quality for Radiology and Medical Director of the Duke Medical Radiation Center at Duke University Medical Center in Durham, North Carolina. Dr. Frush earned his undergraduate degree from the University of California, Davis; medical degree from Duke University Medical Center; was a pediatric resident at the University of California, San Francisco; and completed a radiology residency at Duke Medical Center and a fellowship in pediatric radiology at Children's Hospital in Cincinnati. He is certified by the American Board of Radiology with additional certification in Pediatric Radiology. Dr. Frush's research interests are predominantly involved with pediatric body computed tomography (CT), including technology assessment, techniques for pediatric multidetector computed tomography examinations, assessment of image quality, and CT radiation dosimetry and radiation protection in medical imaging. Other areas of investigation include CT applications in children and patient safety in radiology. Dr. Frush is or has been a member of various committees and scholarly societies. Committee memberships include past chair of the Commission on Pediatrics, American College of Radiology; Trustee (Pediatrics), American Board of Radiology; past chair of the board and past president

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for the Society for Pediatric Radiology; board member, NCRP; chair of the Radiological Society of North America Refresher Course Committee; as well as current chair of the Alliance for Radiation Safety in Pediatric Imaging (Image Gently® Alliance). Dr Frush has also worked internationally with both the World Health Organization and the International Atomic Energy Agency with radiation protection projects in medical imaging. Dr. Frush is a member of numerous associations including the American Roentgen Ray Society, Society of Computed Body Tomography and Magnetic Resonance Imaging (Fellow), Radiological Society of North America, and is also a subspecialty Fellow and Section member for Radiology in the American Academy of Pediatrics.



Pamela J. Henderson graduated from the Georgia Institute of Technology in 1982 with an MS in Health Physics. She served as the Radiation Safety Officer for the University of California, Irvine Medical Center from 1983 to 1991. Ms. Henderson joined the U.S. Nuclear Regulatory Commission in 1991 and currently holds the position of Deputy Director in the Division of Material Safety, State, Tribal, and Rulemaking Programs in Office of Nuclear Material Safety and Safeguards.



Nolan Hertel is a Professor of Nuclear and Radiological Engineering at Georgia Institute of Technology. He received his PhD in Nuclear Engineering from the University of Illinois at Urbana-Champaign and was previously a faculty member at the University of Texas at Austin. He is an expert in radiation protection, shielding and dosimetry and has been actively engaged in education and research for over 36 y.

Through a Joint Faculty Appointment at Oak Ridge National Laboratory (ORNL), he is now serving as the Acting Director of the ORNL Center for Radiation Protection Knowledge. That Center is actively involved in internal and external computational dosimetry.

He also currently co-chairs the International Commission on Radiation Units and Measurements committee reviewing external operational dose quantities and is the chair of the Scientific Review Group for the U.S. Department of Energy Russian Health Studies Program. He was recently appointed the co-chair of the Radiation Effects Research Foundation American-Japanese working group being constituted to compute revised and expanded organ doses to for use in Atomic Bomb Survivor Dosimetry System 2002.

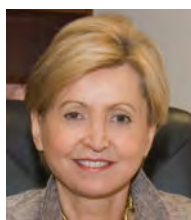


Jerry W. Hiatt is a Senior Project Manager - Radiation and Materials Safety for the Nuclear Energy Institute (NEI) and has more than 40 y of nuclear energy experience. He started his career as a radiation protection technician at the Surry Nuclear Station. Since Surry he worked for the U.S. Nuclear Regulatory Commission and a consulting company. Before joining NEI in January 2014 he spent 28 y with BHI Energy where he served in several positions including President and Chief Technical Officer. He is certified in Health Physics by the American Board of Health Physics, served on the Board for 4 y, in 2011 was the second power reactor health physicist to receive the William A. McAdams Award for “sustained and outstanding service to the American Academy of Health Physics,” and has been selected as a Fellow to the National Health Physics Society. Mr. Hiatt has also served on the curriculum advisory board for numerous technical colleges, assisting in the development of radiation protection technician degree programs. He has a BS degree in Biology with a Health Physics emphasis from Virginia Polytechnic and State University.

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Kathryn A. Higley is a Professor and Head of the School of Nuclear Science and Engineering in the College of Engineering at Oregon State University. Dr. Higley received both her PhD and MS in Radiological Health Sciences from Colorado State University, and her BA in Chemistry from Reed College. She has held both Reactor Operator and Senior Reactor Operator's licenses, and is a former Reactor Supervisor for the Reed College TRIGA Reactor. Dr. Higley started her career as a Radioecologist for Portland General Electric. She later worked for Pacific Northwest National Laboratory as a Senior Research Scientist in the area of environmental health physics. Dr. Higley has been at Oregon State University since 1994 teaching undergraduate and graduate classes on radioecology, dosimetry, radiation protection, radiochemistry, and radiation biology. Her fields of interest include environmental transport and fate of radionuclides; radioecology; radiochemistry; radiation dose assessment; neutron activation analysis; nuclear emergency response; and environmental regulations. She is Chair of Committee 5 (Protection of the Environment) of the International Commission on Radiological Protection, an NCRP Council member, a fellow of the Health Physics Society, and a Certified Health Physicist.



Hedvig Hricak is Chair of the Department of Radiology, Memorial Sloan-Kettering Cancer Center, a member of the Molecular Pharmacology and Chemistry Program, Sloan-Kettering Institute, and Professor, Gerstner Sloan-Kettering Graduate School of Biomedical Sciences. The hallmark of her research career has been the validation of new diagnostic imaging technologies, with a special emphasis on oncology. Her publication record includes more than 380 peer-reviewed original research articles, 18 books, and over 135 monographs and book chapters. She is a member of the National Academy of Medicine [formerly the Institute of Medicine (IOM)] of the National Academy of Sciences (NAS) and a "foreign" member of both the Russian Academy of Science and the Croatian Academy of Arts and Sciences. She has served on the Scientific Advisory Board of the National Cancer Institute, the Advisory Council of the National Institute of Biomedical Imaging and Bioengineering, and the Nuclear and Radiation Studies Board of NAS. She chaired the Committee on the State of the Science of Nuclear Medicine, which produced the highly cited report, *Advancing Nuclear Medicine Through Innovation*. She also served as Vice Chair of the National Academies Committee on Tracking Radiation Doses from Medical Diagnostic Procedures, and as chair of the IOM Committee on Research Directions in Human Biological Effects of Low Level Ionizing Radiation. In addition, she was a member of the National Academies Keck Futures Initiative Steering Committee on The Future of Advanced Nuclear Technologies: Building a Healthier and Safer Planet. Distinguished posts she has held include President of the California Academy of Medicine and President of the Radiological Society of North America (RSNA). She has won numerous awards for her efforts to promote education and international collaboration in imaging, including honorary memberships or fellowships in 12 national or international radiological societies; the Marie Curie Award from the Society of Women in Radiology; the gold medals of the International Society for Magnetic Resonance in Medicine, the Association of University Radiologists, the Asian Oceanian Society of Radiology, the European Society of Radiology and the RSNA; the Beclere Medal of the International Society of Radiology; the Schinz Medal of the Swiss Society of Radiology; the Morocco Medal of Merit; the Jean A. Vezina French Canadian Award of Innovation; and the Order of the Croatian Morning Star of Katarina Zrinska Presidential Award of Croatia. She holds an honorary doctorate from the Ludwig Maximilian University, Munich.



William E. Kennedy, Jr. has extensive experience as a project manager, task leader, and individual contributor covering a broad range of health physics and nuclear engineering topics. He received his BS and MS degrees in Nuclear Engineering from Kansas State University. Mr. Kennedy has been involved in the development of environmental pathway and radiation dosimetry models used to assess potential health and environmental impacts that resulted from releases of radionuclides to the environment.

He specializes in the use of these models in environmental dose reconstruction, radioactive materials transport, radioactive waste disposal, and evaluation of nuclear facility operating practices. Over the past 37 y, Mr. Kennedy has led and contributed to a variety of projects for the U.S. Nuclear Regulatory Commission,

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the U.S. Department of Energy, the Electric Power Research Institute, and private industry. He has been involved with development of the technical basis for revised standards and regulations, and serves as the chair of ANSI/HPS N13.12, Surface and volume Radioactivity Standards for Clearance. He served as a consultant to the International Atomic Energy Agency (IAEA), Vienna, Austria, and was a member of the IAEA Advisory Groups to evaluate the Derivation of Exempt Quantities for Application to Terrestrial Waste Disposal and Derivation of Exempt Quantities for Recycle of Materials from Nuclear Facilities.

He was an invited lecturer for IAEA training courses on Management of Radioactive Waste from Nuclear Power Plants at Argonne National Laboratory; on Safety Assessment Modeling for Low and Intermediate Radwastes in Rio de Janeiro, Brazil and in Cairo, Egypt; and on Environmental Monitoring in Kiev, Ukraine. In 1990, he received the Health Physics Society's (HPS) prestigious Elda E. Anderson Award. He served as a member of the HPS Board of Directors from 1998 through 2001 and was selected as a fellow of the society in 2002. He was a member of the U.S. delegation to the 10th Congress of the International Radiation Protection Association in Hiroshima, Japan.



Ruth E. McBurney is the Executive Director of the Conference of Radiation Control Program Directors. In that position, she manages and directs the administrative office for the organization. Prior to taking that position in January 2007, she was the Manager of the Radiation Safety Licensing Branch at the Texas Department of State Health Services, culminating 25 y of service in the Texas Radiation Control Program, most of which involved licensing and standards development. Ms. McBurney has served on the U.S. Nuclear Regulatory Commission's Advisory Committee on the Medical Use of Isotopes and the U.S. Food and Drug Administration's National Mammography Quality Assurance Advisory Committee. She is currently serving as a Member of NCRP, and is also on the Board of Directors. She served as a consultant to the International Atomic Energy Agency in the categorization of radiation sources and recently served on a committee of the National Academy of Sciences regarding replacement technologies for high-risk radiation sources. She has also been a U.S. delegate to the International Radiation Protection Association's 10th, 11th, 12th, and 13th Congresses. Ms. McBurney holds a BS in Biology from Henderson State University in Arkansas and an MS in Radiation Sciences from the University of Arkansas for Medical Sciences. She is also certified in comprehensive health physics by the American Board of Health Physics.



Chad A. Mitchell received his PhD in Biomedical Engineering from Ohio State University and is certified by the American Board of Radiology. His research interests have ranged from retrospective dosimetry to ultra-high field magnetic resonance imaging. After 20 y as a Navy Radiation Health Officer, he recently joined Krueger-Gilbert Health Physics as a medical physicist serving hospitals and clinics in Maryland and neighboring states.



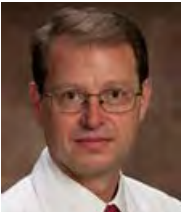
Matthew P. Moeller is Chief Executive Officer and Chairman of the Board of Dade Moeller, a company that he helped found in 1994. His primary responsibilities are to manage the long-term strategic planning and oversee the operations of the company. Mr. Moeller received an AB in mathematics from Cornell University's College of Arts and Sciences and an MS in Environmental Health Sciences (Radiological Health) from Harvard University's School of Public Health. He is certified by the American Board of Health Physics and is a Fellow of the Health Physics Society.

Biographies



Stephen V. Musolino is a scientist in the Nonproliferation and National Security Department at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory (BNL) in Upton, New York. With more than 30 y of experience in Health Physics, his current research interests are in nonproliferation, counterterrorism, and planning for response to the consequences of radiological and nuclear terrorism. Since 1981, he has been part of the DOE Radiological Assistance Program as a Team Captain/Team Scientist and has been involved in developing radiological emergency response plans and procedures, as well as participating in a wide range of radiological and nuclear exercises and field deployments. During the Fukushima crisis, he was deployed in Japan as an Assessment Scientist with the DOE response team that was measuring the environmental consequences of the radioactive material released from the damaged nuclear power plants. Working with the first responder community in the New York metropolitan area, Dr. Musolino was involved with the development of guidance for response to the aftermath of a radiological dispersal device, and served on the scientific committee that developed NCRP Report No. 165, *Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers*. Earlier in his career at BNL, he was a member of the Marshall Islands Radiological Safety Program and participated in numerous field missions to monitor the populations living on islands affected by nuclear testing.

Dr. Musolino is a Fellow of the Health Physics Society, Distinguished Alumnus of Buffalo State College, and a member of the editorial board of the journal *Health Physics*. He earned a BS in engineering technology from Buffalo State College, an MS in nuclear engineering from Polytechnic Institute of New York University, and a PhD in health physics from the Georgia Institute of Technology. He is certified by the American Board of Health Physics.



Wayne D. Newhauser is the Director of the Medical and Health Physics Program at Louisiana State University in Baton Rouge, holder of the Dr. Charles M. Smith Chair in Medical Physics, and Chief of Physics at the Mary Bird Perkins Cancer Center. He is a board certified and licensed medical physicist with specialization in advanced-technology radiotherapies. Dr. Newhauser is an expert in proton radiation therapy, dose reconstructions, and risk estimation and reduction. His current research projects seek to improve long-term outcomes of survivors of childhood and adult cancers. He and his multidisciplinary team of collaborators are known for their early use of Monte-Carlo methods and high-performance computing in proton therapy, including neutron shielding, treatment planning, and estimation of stray radiation exposures. He received the Innovation Excellence Award in 2012 in recognition of his laboratory's research involving in-silico clinical trials to compare advanced-technology radiotherapies. Dr. Newhauser has published more than 85 peer-reviewed journal articles, leads federal research grants, and mentors graduate students and post-doctoral fellows. He has served in leadership roles in the American Association of Physicists in Medicine, the American Nuclear Society, and the Health Physics Society. He serves on the International Advisory Board of the journal *Physics in Medicine and Biology* and is a corresponding member of the European Radiation Dosimetry Group. After receiving a BS in nuclear engineering and MS and PhD degrees medical physics from the University of Wisconsin, he worked at the German National Standards Laboratory, Harvard Medical School and Massachusetts General Hospital, and The University of Texas MD Anderson Cancer Center.



Kathryn H. Pryor currently holds the position of Chief Health Physicist at the Pacific Northwest National Laboratory (PNNL) in Richland, Washington, and has provided management and technical support to the PNNL Radiation Protection Division since 1992. She also served as the Chief Radiological Engineer for the design of the Pit Disassembly and Conversion Project. Ms. Pryor has previously held radiation protection technical support positions at the San Onofre Nuclear Generating Station and the Trojan Nuclear Plant, and was the Radiation Safety Officer at the University of Southern California Health Sciences Campus. Ms. Pryor has been a Council member since 2010 and is currently on the NCRP Board of Directors and is Scientific Vice President of Program Area Committee 2. She received her BS in Biology in 1979 and MS in Radiological Sciences in 1981, both from the University of Washington. Ms. Pryor is a Fellow member of the Health Physics Society (HPS) and served as President-Elect, President, and Past President from 2010 to

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2013. She is certified in comprehensive practice by the American Board of Health Physics (ABHP), and served on the ABHP both as a member and Chair from 1998 to 2002. Ms. Pryor was awarded the William McAdams Outstanding Service Award by ABHP in 2007 and the John P. Corley Meritorious Service Award by the Columbia Chapter of HPS in 2003.



Michael T. Ryan is an independent consultant in radiological sciences and health physics. He is an Adjunct Faculty member at Vanderbilt University in the Department of Environmental Engineering and the Texas A&M University in the Department of Nuclear Engineering. He was previously an Associate Professor in the Department of Health Administration and Policy at the Medical University of South Carolina (MUSC). He earned his BS in radiological health physics from Lowell Technological Institute in 1974. In 1976, he earned an MS in radiological sciences and protection from the University of Lowell under a U.S. Energy Research and Development Administration Scholarship. Dr. Ryan received the PhD in 1982 from the Georgia Institute of Technology, where he was recently inducted into the Academy of Distinguished Alumni. He is a recipient of the Francis Cabot Lowell Distinguished Alumni for Arts and Sciences Award for the University of Massachusetts Lowell.

Dr. Ryan is Editor In Chief of *Health Physics*. In 1989, he received the Health Physics Society (HPS) Elda E. Anderson Award, which is awarded each year to the one young member who has demonstrated excellence in research, discovery, and/or significant contribution to the field of health physics. Dr. Ryan has held numerous offices in HPS, including President of the Environmental Section and the Savannah River Chapter. Dr. Ryan served on the Technical Advisory Radiation Control Council for the State of South Carolina for 19 y. He is a member of NCRP. He has served as Scientific Vice President for Radioactive and Mixed Waste Management and Chair of Scientific Committee 87 and a member of the Board of Directors.

Dr. Ryan is certified in the comprehensive practice of health physics by the American Board of Health Physics. In addition to his adjunct appointment at Texas A&M University, Dr. Ryan has taught radiation protection courses on the undergraduate and graduate level at the University of South Carolina and the College of Charleston. In addition, Dr. Ryan has authored and coauthored many refereed articles and publications in the areas of environmental radiation assessment, radiation dosimetry, and regulatory compliance for radioactive materials.

Dr. Ryan is active in his consultancy with a number of national corporations and government agencies. This work generally involves radioactive waste management, radiological health and regulatory compliance for workplace and environmental issues. He most recently served for several years on the independent review panel for decommissioning work at Brookhaven National Laboratories. He completed a 9 y term as Chairman of the External Advisory Board for Radiation Protection at Sandia National Laboratories in 2007. He is a member of a similar external review board for Lawrence Livermore National Laboratory. He completed 8 y of service on the Scientific Review Group appointed by the Assistant Secretary of Energy to review the ongoing research in health effects at the former weapons complex sites in the Southern Urals. He has also served on several committees of the National Academy of Sciences producing reports regarding radioactive waste management topics. He also served as Chairman for the U.S. Nuclear Regulatory Commission Advisory Committee on Nuclear Waste and Materials. Dr. Ryan has served on Committee since 2002 until it was merged with the Advisory Committee on Reactor Safeguards (ACRS) in 2008. In June, 2008, Dr. Ryan became a member of the ACRS.

Prior to his appointment at MUSC, Dr. Ryan was served as Vice President of Barnwell Operations for Chem-Nuclear Systems, Inc., and had overall responsibility for operation of the low-level radioactive waste disposal and service facilities in Barnwell, South Carolina. Dr. Ryan's area of responsibility included management of a scientific, technical, and support staff; and implementation of the scientific programs to assure the safe and compliant operation of the company's low-level radioactive waste processing and disposal facilities. These programs included facility operations and implementation of policy and procedures for operation, environmental monitoring and regulatory compliance. Prior to this assignment Dr. Ryan served

Biographies

since 1988 as the Vice President of Regulatory Affairs, having responsibility for developing and implementing the company's regulatory compliance policies and programs to comply with state and federal regulators. Before joining Chem-Nuclear Systems, Inc., as Director of the Environmental and Dosimetry Laboratory in 1983, Dr. Ryan spent 7 y in environmental health physics at Oak Ridge National Laboratory.



Richard E. Toohy received his PhD in physics from the University of Cincinnati in 1973. He spent the first part of his career at Argonne National Laboratory in both research and operational health physics. He recently retired from Oak Ridge Associated Universities, where he served as director of the Radiation Internal Dose Information Center, as Senior Health Physicist for the Radiation Emergency Assistance Center/ Training Site, Director of Dose Reconstruction Programs, and Associate Director of the Independent Environmental Assessment and Verification Program. He is certified in comprehensive practice by the American Board of Health Physics, was the 2008 to 2009 President of the Health Physics Society, is a member and director of NCRP, Treasurer of the International Radiation Protection Association, and Chair of the Scientific Advisory Committee for the U.S. Transuranium and Uranium Registries. His specialties are internal radiation dosimetry, dose reconstruction, and radiological emergency response. Dr. Toohy has 125 publications in the open literature, and is a retired Lt. Colonel, U.S. Army Reserve.



Michael Weber has served as the Deputy Executive Director for Operations for Materials, Waste, Research, State, Tribal, and Compliance Programs of the U.S. Nuclear Regulatory Commission (NRC) since May 2010. He strategically leads NRC staff in developing and implementing Commission policy decisions and regulatory programs. Prior to this position, he served as the Director, Office of Nuclear Material Safety and Safeguards (NMSS) beginning in 2007. He represents the United States on the International Atomic Energy Agency's Commission on Safety Standards. In 2014, he led the NRC's Project Aim 2020 strategic transformation project. In addition, he served as Deputy Team Leader of the Integrated Regulatory Review Service Follow-up Mission to the Republic of Korea in 2014.

Mr. Weber joined the NRC in 1982 as a hydrogeologist in NMSS. He held a number of progressively more responsible positions including: Chief, Regulatory Issues Section; Chief, Low-Level Waste and Decommissioning Projects Branch; Chief, Fuel Cycle Licensing Branch; Deputy Director, Division of Waste Management; Deputy Director and Director, Division of Fuel Cycle Safety and Safeguards. In 2002, he was appointed as the Deputy Director of the newly established Office of Nuclear Security and Incident Response (NSIR) following the terrorist attacks on September 11, 2001. In 2006, Mr. Weber was appointed as the Deputy Director, Office of Nuclear Reactor Regulation.

Mr. Weber served as a Technical Assistant to former Chairman Ken Carr and as the Executive Assistant and Director of the Chairman's Office for former Chairman Shirley Ann Jackson. Mr. Weber is a graduate of the Senior Executive Service Candidate Development Program and the Office of Personnel Management's Executive Potential Program for Mid-Level Employees. He received the prestigious rank awards for Meritorious Executive from Presidents Clinton (2000) and Bush (2006). In 1996, he received the William A. Jump Meritorious Award for exemplary service in public administration. He also received NRC's Meritorious Service Award in 1993 for scientific excellence in protecting the environment. Mr. Weber earned a BS degree in Geosciences from the Pennsylvania State University.



Robert C. Whitcomb, Jr. joined the Centers for Disease Control and Prevention (CDC) in June 1993. He is the Chief of the Radiation Studies Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health. In this position he serves as Radiation Subject Matter Expert and CDC Spokesperson for technical and public health issues related to environmental radiation and nuclear/radiological emergency response. Previously, Dr. Whitcomb worked with the Illinois Department of Nuclear Safety. His primary area of expertise is the assessment of radionuclides released to the environment and the impact on public health. He has authored or coauthored numerous journal articles and has lectured

Biographies

nationally and internationally about the public health response in nuclear/radiological emergencies. Dr. Whitcomb is a member of NCRP and the Health Physics Society. He is certified in comprehensive practice by the American Board of Health Physics, and served on the Board of Directors of the Health Physics Society (2004 to 2007). Dr. Whitcomb holds a BS in Biology from Florida Southern College, an MS and a PhD in Environmental Engineering Sciences from the University of Florida.



Jacqueline P. Williams completed her undergraduate degrees at the University of Nottingham, followed by her post-doctoral training in radiation biology at St. Bartholomew's Hospital, University of London, U.K. Shortly after completing her studies, she joined the faculty at the University of Rochester, New York, in the department of Radiation Oncology, and recently in the department of Environmental Medicine. Since that time, Dr. Williams has accrued more than 25 y of experience in radiation biology and related fields and has been involved in a wide range of research areas, including clinically-related oncologic studies and clinical trials, tumor blood flow studies, long-term carcinogenic studies, and pharmacological and toxicological projects. Her current research interests involve identifying mechanisms that underlie the initiation and progression of radiation-induced late normal tissue effects as a consequence of high-dose clinical treatment/accidental exposures or the lower doses associated with either space travel or mass exposures with the goal of developing protection or mitigation strategies. Dr. Williams has served as the President of the Radiation Research Society, the Research Chair on the Board of the American Society for Radiation Oncology, and has been elected to, and is currently serving as, Council Member to the International Association for Radiation Research.



Patricia R. Worthington has 40 y of federal experience, the majority of which has been devoted to promoting and advocating the safety and health of the U.S. Department of Energy (DOE) federal and contractor workers, members of the public living in the vicinity of DOE sites, and advancing the Integrated Safety Management System (ISMS). Dr. Worthington currently serves as the Department's ISM Co-Champion. In this capacity, she works closely with DOE program offices, both headquarters and field, to continually enhance the safe execution of the DOE mission. Her office has responsibility for the DOE Voluntary Protection Program, which encourages and recognizes excellence in occupational safety and health protection and further builds on the continuous improvement component of ISM.

Dr. Worthington is currently the Director of the Office of Health and Safety, within the Office of Environment, Health, Safety and Security (AU) where she reports directly to Associate Under Secretary and supports him in establishing worker safety and health requirements and expectations related to a diverse set of potential hazard exposures, such as chemical, industrial, biological and radiological hazards. Currently, her office is conducting a number of health studies, including: (1) studies to determine worker and public health effects from exposure to hazardous materials associated with Department operations; (2) international health studies and programs in Japan, Spain, the Russian Federation, and medical screening and environmental monitoring in the Marshall Islands; and (3) medical surveillance and screening programs for current and former workers. Her office also plays a critical role in ensuring that DOE makes available worker and facility records and data to support the U.S. Department of Labor in the implementation of the Energy Employees Occupational Illness Compensation Program Act.

A critical aspect of the AU function is assistance. Dr. Worthington's office provides technical assistance to headquarters and field elements in the implementation of policy and resolving worker safety and health issues. Her office supports the DOE Radiation Emergency Assistance Center/Training Site, which provides professional training and medical countermeasures to occupational and nonoccupational exposures to ionizing radiation and in federal agency matters concerning bioterrorism.

Previously, Dr. Worthington served as the Director of the Office of Environment, Safety and Health Evaluations where she worked to improve current management practices for environment, safety, and health programs across the DOE complex and investigated historical operations. As such, she has indepth and



Biographies

firsthand knowledge of DOE sites, site-specific activities, and operational issues. Prior to joining DOE, Dr. Worthington gained invaluable, extensive experience at the U.S. Nuclear Regulatory Commission where she was responsible for managing the Severe Accident International Research Program, which involved working with over 10 countries to share technical knowledge of nuclear safety. She holds a PhD in Chemistry from Howard University.



Contracts/Grants/Contributors/Sponsors

These organizations have supported the work of the National Council on Radiation Protection and Measurements during the period of January 1 to December 31, 2015.

Contracts

Defense Threat Reduction Agency
U.S. Department of Homeland Security

Grants

Centers for Disease Control and Prevention
National Aeronautics and Space Administration
U.S. Department of Energy
U.S. Environmental Protection Agency
U.S. Nuclear Regulatory Commission

Contributors

American Academy of Health Physics
American Association of Physicists in Medicine
American College of Radiology Foundation
American Osteopathic College of Radiology
American Registry of Radiologic Technologists
American Roentgen Ray Society
American Society of Radiologic Technologists
Conference of Radiation Control Program Directors, Inc.
Council on Radionuclides and Radiopharmaceuticals
Health Physics Society
Landauer, Inc.
LSU Health Foundation
Radiological Society of North America
Society of Pediatric Radiology

Corporate Sponsors

3M
Landauer, Inc.
Nuclear Energy Institute

Meeting the Needs of the Nation for Radiation Protection

52nd NCRP Annual Meeting:
Welcome!

| *Judith L. Bader, M.D.* | April 2016

WARP: *Who* Are the Radiation Professionals?

- Radiation Oncology, Radiology, Nuclear Medicine
- Radiation biology
- Radiation epidemiology and late effects
- Radiation safety
- Health physics
- Medical physics
- Academic physics
- Power, Energy
- Industry
- Space
- Defense
- Preparedness and response

Preparedness and Response

- Routine Safety and SOPs
- Surveillance, Intelligence
- Operations during incidents large and small
- Training of radiation workers and “surge” workers
- Diagnosis of radiation injury
- Triage
- Countermeasures: use, deployment, development
- Treatment: acute, chronic, follow-up, surveillance
- Communications
- Teamwork among many professionals

WARP: *Where* Are the Radiation Professionals?

- Consider the evidence
 - 2016 Annual Meeting presentations
 - [NCRP Statement No. 12 about WARP \(2015\)](#)
- Communicate during the meeting
 - Twitter: @NCRP_Bethesda #NCRP2016
 - Write your questions during the presentations
- Actions after the meeting
 - Multi-professional working group(s) – identify issues, solutions and targets across the work force
 - Lobby for meaningful changes to enhance our work force

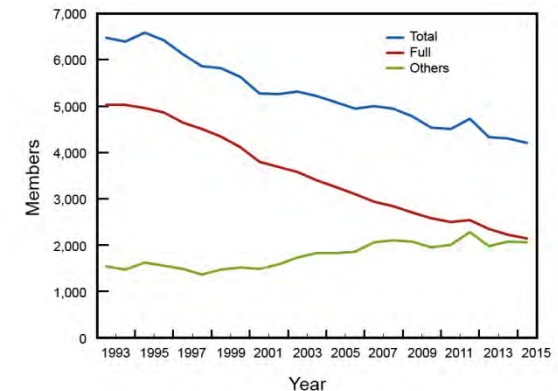


Welcome to NCRP 52nd Annual Meeting

John D. Boice, Jr.,
President

**Fifty-Second
Annual Meeting Program**

**Meeting the Needs of the Nation
for Radiation Protection**



April 11–12, 2016

Hyatt Regency Bethesda
One Bethesda Metro Center
7400 Wisconsin Avenue
Bethesda, MD 20814





2016 Annual Meeting Program Committee

Co-Chairs

**Judith L. Bader
Kathryn H. Pryor
Richard E. Toohey**



**Donald P. Frush
Pamela J. Henderson
Jerry W. Hiatt
Kathryn A. Higley
William E. Kennedy, Jr.**

**Chad A. Mitchell
Wayne D. Newhauser
Robert C. Whitcomb, Jr.
Jacqueline P. Williams
Patricia R. Worthington**



New & Continuing Initiatives



- **National Anthem and Presentation of Colors**
- **Written Questions & Published Answers**
- **Brief Bios & Photos in Program**
- **Recognition of Sinclair & Taylor Lecturers (Medals) – 2nd**
- **NCRP/RRS Scholars "Program" – 4th**
- **Rapid publication of summary in *Health Physics News***
- **Goal for Proceedings to be Published 2016**
- **Publication of Annual Dinner Presentation – 2nd**
- **Publication of Program Area Committee mission & activities**
- **Brief "email" <5 min survey after meeting**
- **Contact me for ways to improve – & future topics**



NCRP / RRS Scholars Travel Award Recipients



Daniel Adjei

Military University of Technology
Warsaw, Poland



Shaowen Hu

Wyle Science
Houston, Texas



Yuan-Hao (Chris) Lee

Municipal Wan Fang Hospital
Taipei, Taiwan



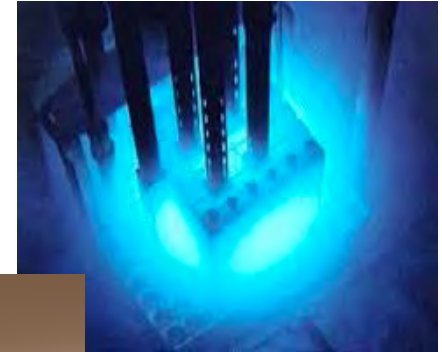
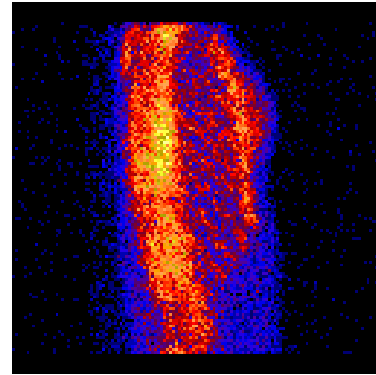
Radiation Brain Drain?

The Impact of Demographic Change
on U.S. Radiation Protection

*We are witnessing unprecedented
Convergence of the Life Science, Physical
Science and Engineering*

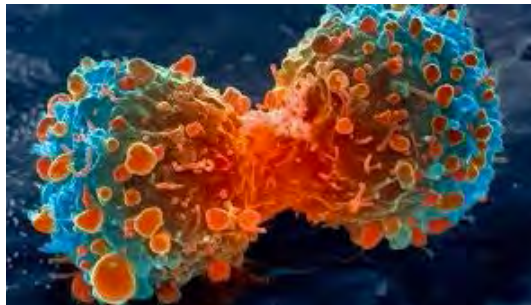
Benefits from Radiation Use

- Medicine
- Energy
- Basic Science
- Industrial Applications



Worldwide *Cancer* Rates on the Rise

- 14 million cases, 8.2 million deaths in 2012.
- **~22** million cases, **~13** million deaths by 2030.
(Globocan, 2010; WHO, 2014)
- Imaging and radiotherapy play essential roles in cancer management.
- Advances of last 10 y shifting goals from life preservation to cure with increased quality of life.



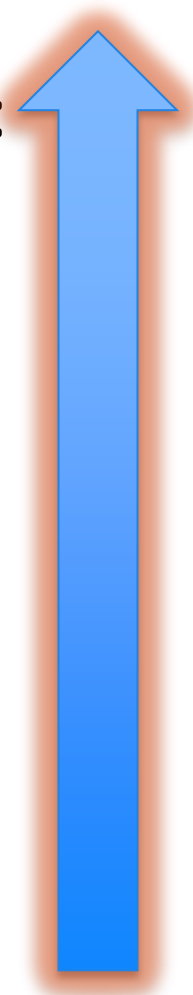
Worldwide *Cardiovascular Disease* Rates on the Rise

- **17.3** million deaths from CVDs in 2008.
- 7.3 million due to coronary heart disease.
- 6.2 million due to stroke.
- CVD to rise by 2030 to **25** million deaths.
- Imaging and interventional procedures play essential roles in CVD management.



Use of Radiation in Medicine on the Rise

- Annual dose per capita for medical procedures:
 - United States **0.5 mSv** (1980) to **3.0 mSv** (2006)
 - Worldwide **0.3 mSv** (1980) to **0.6 mSv** (2007)
- United States (2006)
 - 337 M Diagnostic/Interventional Radiology
 - 18 M Nuclear Medicine
- Worldwide (2006)
 - **3.6 B** Total
 - 3.1 B Diagnostic/Interventional Radiology
 - 0.5 B Dental
 - 37 M Nuclear Medicine





2000 – 2014 Trends in Utilization of CT

*National Trends**

2000-2009

96%

2009-2010

-1.7%

2010-2015

NA

MSKCC

2000-2009

147%

2009-2010

-0.9%

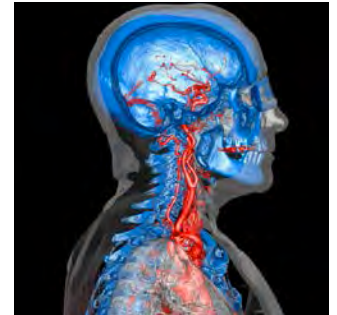
2010-2015

27.1%

**J Am Coll Radiol 2012*

Medical: Need to further increase beneficial and safe use of radiation

- More Disease – More Patients – More Use
- Increased need for radiation protection
 - Patients, Staff, Public (ICRP, NCRP).
- Increased need for innovation and management of radiation use while ensuring full benefits.
- Challenges: understanding radiation risk, justification and utilization, dose optimization, communication.



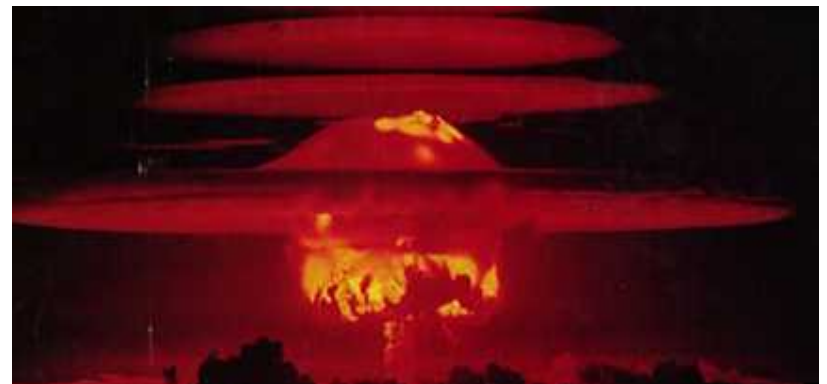
Energy: Higher Consumption and \$\$\$

- By 2040 expect growing consumption and 18% increase in price of electricity in U.S.
- U.S. transitions to net exporter of natural gas with growth through 2040.
- Climate effects (nuclear renaissance?)
- Technological innovation and growth: fracking, manufacturing, refining.
- ***All need excellence in radiation science!***



Security: Mounting Specter of Terror

- President Obama made preventing nuclear terrorism one of the U.S. top foreign policy priorities...**“the single most important threat”** to U.S. national security.
- Terrorist’s new capabilities and efficiencies.
- Are we responding with sufficient speed and commitment?



Security: Are we Able to Respond?

- Responding to a major event will require a huge surge of radiation professionals to manage consequences.
- “However, as the number of radiation professionals decreases, the nation’s resilience and ability to cope and manage a catastrophic nuclear or radiological event is severely degraded.” (NCRP, 2015).



Human Capital Crisis: Rad Profession

- U.S. GAO – 41% of engineering / technical professionals eligible to retire 2017.
- CRCPD – 50% of technical staff in state rad control programs will need replacing in 10 y.
- National Academy – noted concerns about future supply of radiochemists.



Demographic Shift: Radiation Physics

- **AAPM (2013)**

~37% of members 50+ y.

~67% of members 40+ y.

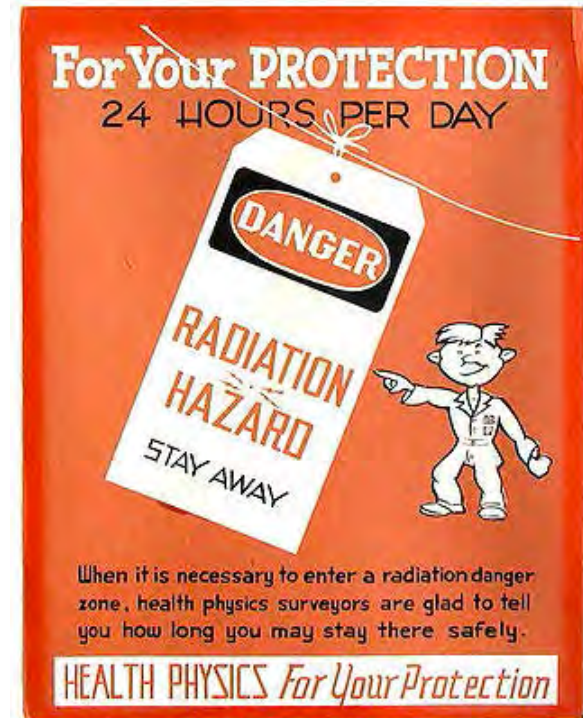
- **Health Physics Society - aging**

2000, 46% members 50+ y.

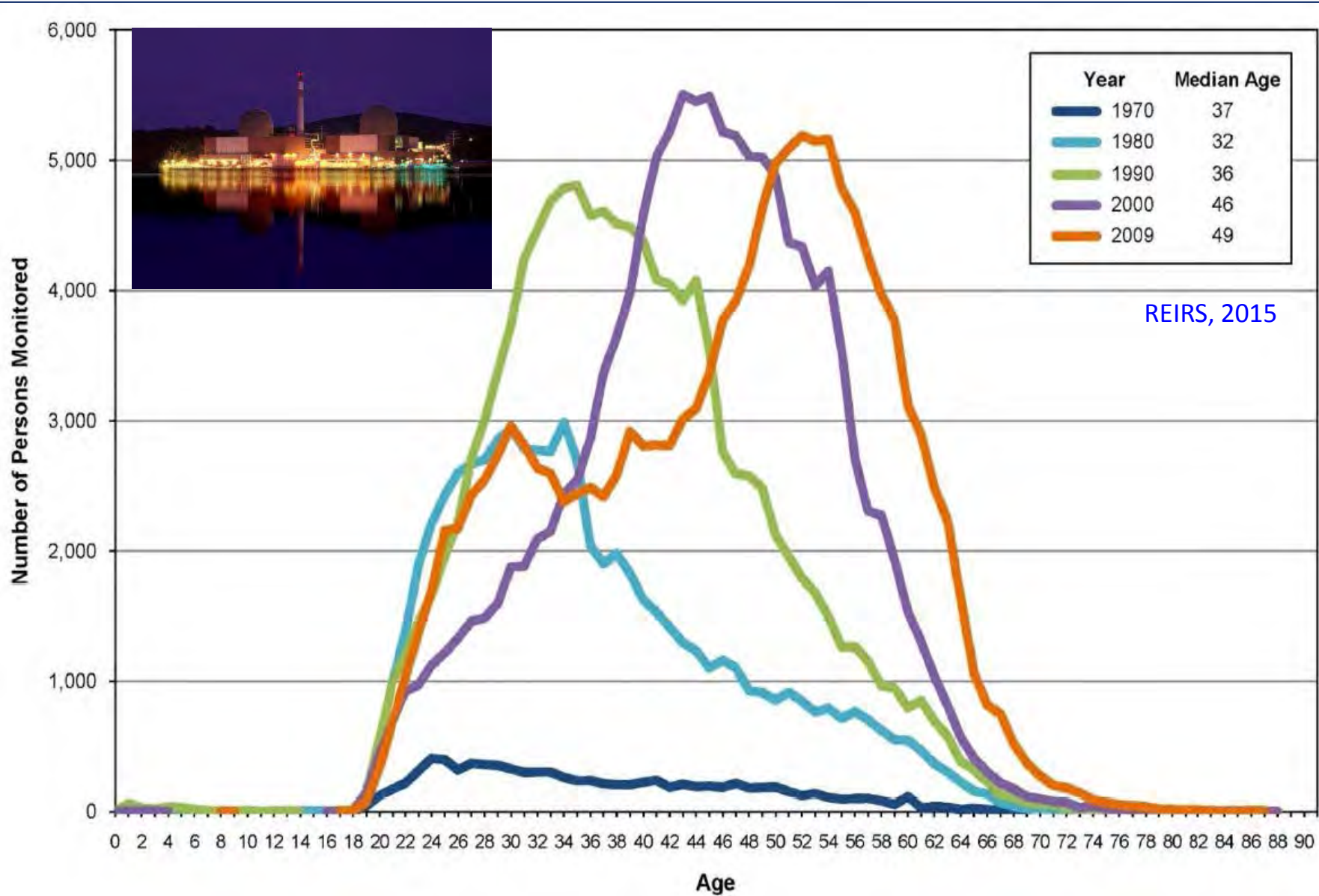
2005, 53% members 50+ y.

2013, 57% members 50+ y.

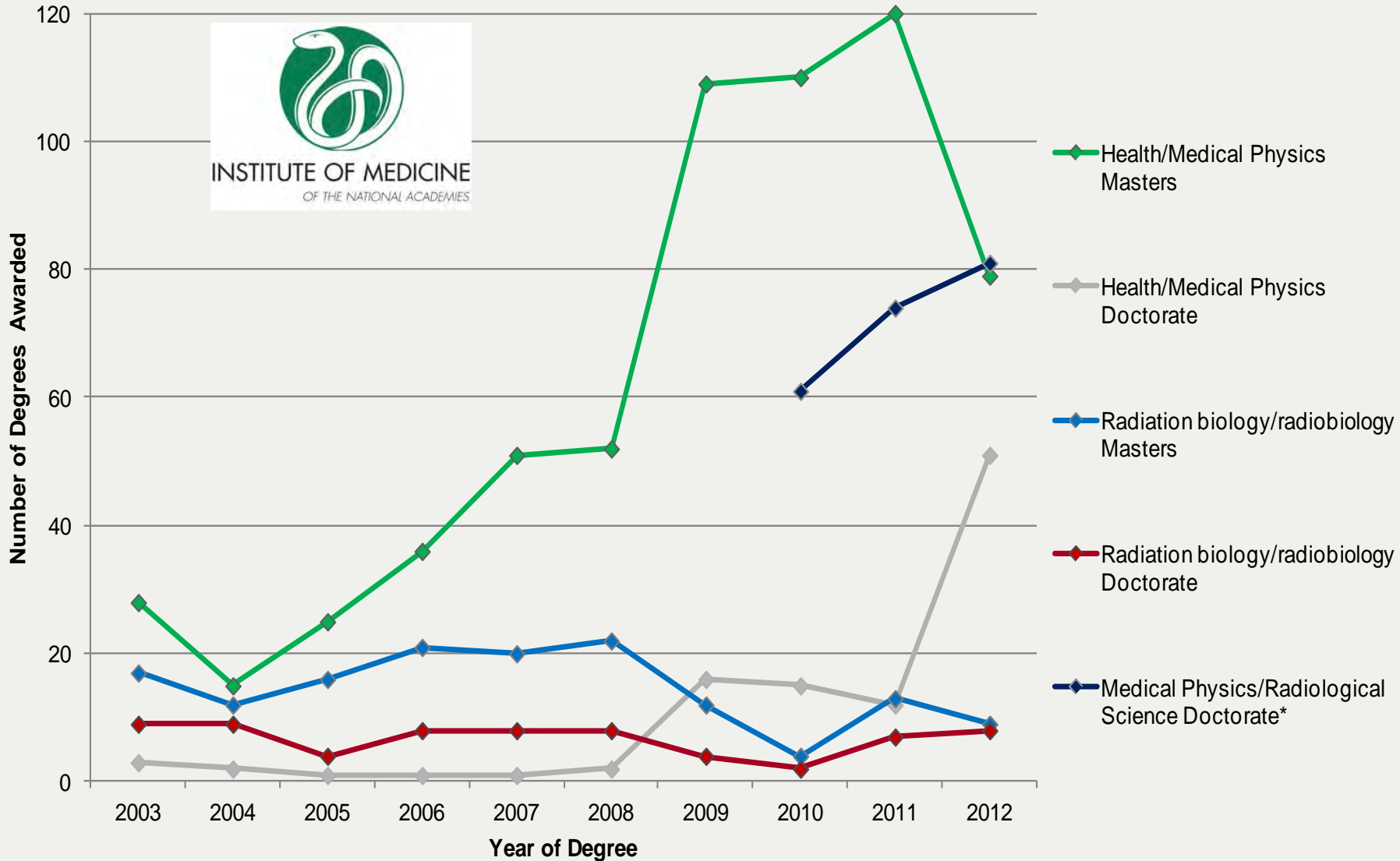
2013, 83% members 40+ y.



Demographic Shift: Nuclear Workforce



Demographic Shift: Graduates



Human Capital Crisis: Rad Protection

- **HPS** – “the critical human capital shortage of radiation safety is overwhelming the Society’s efforts to help respond to crisis.”
- **ORISE** – health physics job openings exceed graduates.
- Dwindling academic programs (<20 with sufficient faculty and staff to train future professionals).

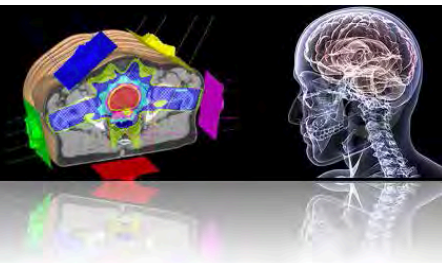


Human Capital Crisis: Radiobiology

- Declining numbers of radiobiologists (faculty members scarce and aging).
- Quality of didactic radiation biology education is threatened (even in medicine).
- Loss of research funding has decimated the ranks of university radiation biologists and other professionals.
- Who will teach the increased need and the next generation of professionals?

Radiobiology

Καθηγητής



Human Capital Crisis: Radiobiology

Low Dose Effects

- Uncertainty in understanding shape of the dose response and risk at low doses.
- Impact rad protection guidance in all areas.
- Need to support low dose epidemiology studies (*e.g.*, NCRP Million Person Study, CT studies – noting reasons for exams!).
- Need radiobiology integration.



Human Capital Crisis: Radiation Science

- Shortfalls in # of radiation scientists stand in sharp contrast to the emerging scientific opportunities and need for new knowledge.
- U.S. is facing serious attrition of nuclear scientists and engineers and capabilities.
- The supply of radiation health and radiobiology workforce will not meet demand (IOM).



Where are the Radiation Facilities?

- Specialized facilities needed for research and development.
- Academic facilities continue to close.
- Research infrastructure and resources continue to decay and decline.
- Research programs disappearing.



Radiation Brain Drain is Real

- Increasing shortage of radiation professionals.
- Lack of infrastructure.
- Sharp contrast to emerging scientific opportunities and the need for new knowledge to address issues of health, growth, and security.
- Immediate attention is needed!



Opportunities for Improvement

- U.S. lacks a coordinated, long-term, milestone-driven strategic plan (IOM, 2015).
- Low Dose Radiation Research Act of 2015 (HR, 2015) awaiting approval by Senate.
- NCRP “WARP” initiative.

114TH CONGRESS
1ST SESSION

H. R. 35

IN THE SENATE OF THE UNITED STATES

JANUARY 8, 2015

Received; read twice and referred to the Committee on Energy and Natural Resources

AN ACT

To increase the understanding of the health effects of low doses of ionizing radiation.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

Public Support for Radiation Research

- Crisis is already upon us!
- Solving the problem will require significantly increased federal and state funding as well as formal partnerships and initiatives amongst academia, research, government, and private sectors.
- Need unique and creative courses of implemented action.

“Rationality will not save us.”

R.S. McNamara: *The Fog of War*





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Membership Trends In The Health Physics Society – How Did We Get Here and Where Are We Going?

KATHRYN H. PRYOR, CHP

Pacific Northwest National Laboratory

NCRP Annual Meeting
Bethesda, MD

April 11, 2016

PNNL-SA-116802

Introduction

- ▶ Membership trends have been a topic of discussion within the HPS for the last 20 y
- ▶ Review membership trends over the life of the HPS
- ▶ Discuss trends and challenges facing HPS and other professional societies and associations
- ▶ HPS initiatives moving forward into the future

Health Physics Society

Specialists in Radiation Safety • Founded 1956 • <http://hps.org>

The “Early Years” – Birth of the HPS



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- ▶ Rapid expansion of the field of health physics in the 1940s and 1950s due to weapons development; birth of commercial nuclear power
- ▶ Organizational meeting held in Columbus, OH – May 13, 1955
 - Participants voted 180 to 15 to form distinct professional society
 - Also considered affiliation with other existing organizations (AIHA, AIP, ANS, etc.)
 - Health Physics Society was officially formed on June 25, 1956
- ▶ Word of the new professional society spread rapidly (by the standards of the 1950s)
- ▶ Membership ranks –
 - Began with 212 members
 - By the end of 1957 – 800 members



The “Early Years” – HPS “Firsts”



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- ▶ First Annual Meeting held in Ann Arbor, MI in 1956
- ▶ First Mid-Year Topical Symposium held in Chicago, IL in 1967
- ▶ *Health Physics Journal* first published in June 1958
- ▶ ABHP formed; first certification exam administered in 1960
- ▶ First local chapters were authorized by the HPS in 1959 (some in existence before this date)



Health Physics Pergamon Press 1958. Vol. 1. pp. 56-61

WHAT IS HEALTH PHYSICS?

WALTER D. CLAUS

Division of Biology and Medicine, U.S. Atomic Energy Commission,
Washington 25, D.C.

(Received 4 December 1957)

Abstract—The science of health physics is charged with the task of providing protection to all living things against the potential hazards of radiation, while at the same time making it possible for the human race to enjoy all the benefits which may arise from the use of atomic energy. “Health physics” is a term which came into being in the Plutonium Project about 1942, and which has now come to be used almost universally to mean the science or profession of radiation control in all its many aspects, including technology, philosophy, economics, labor relations, public relations, teaching and administration. Scientifically, it has common interests with a number of well recognized fields of specialization: physics, electronics, biophysics, chemistry, biochemistry, biology, physiology, genetics, toxicology and ecology.

The “Early Years” – Rapid Growth

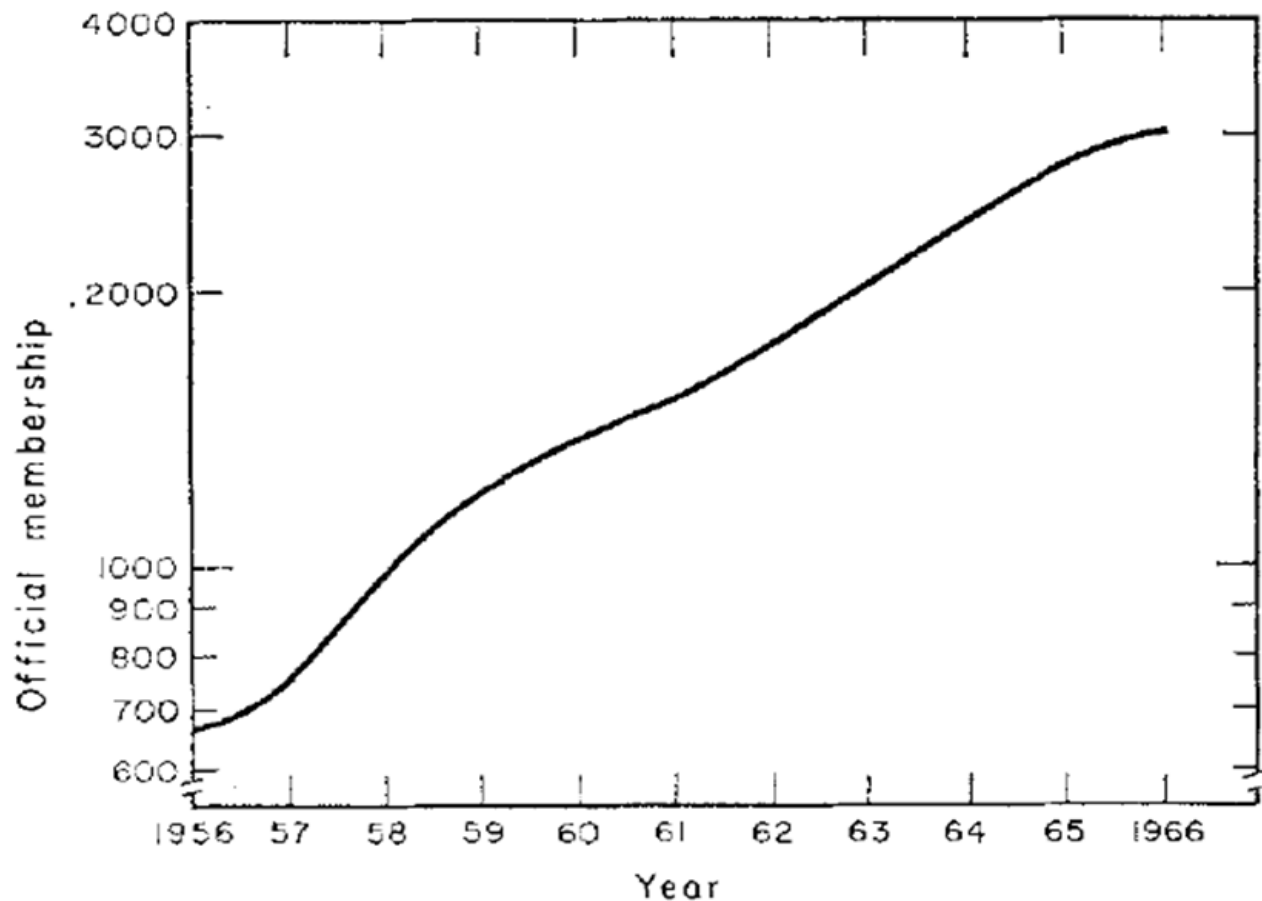


FIG. 1. Growth in Health Physics Society Membership, 1956–1966.

The “Middle Years” – Continuing to Thrive

- ▶ 1970s to mid-1990s – period of continued growth for HPS
 - Total membership numbers peaked in 1994 at close to 6,500
 - Plenary membership peaked in 1985 at 5,300
 - Emeritus and Fellow membership categories grew during this time
 - Emeritus membership - 490 by 1999
 - Fellows (awarded membership class established in 1984) - 82 by 1999
 - Student membership steadily increased from 1975 through the mid-1990s; peaked in 1995 at 600



1989 – HPS 5K, Albuquerque, NM



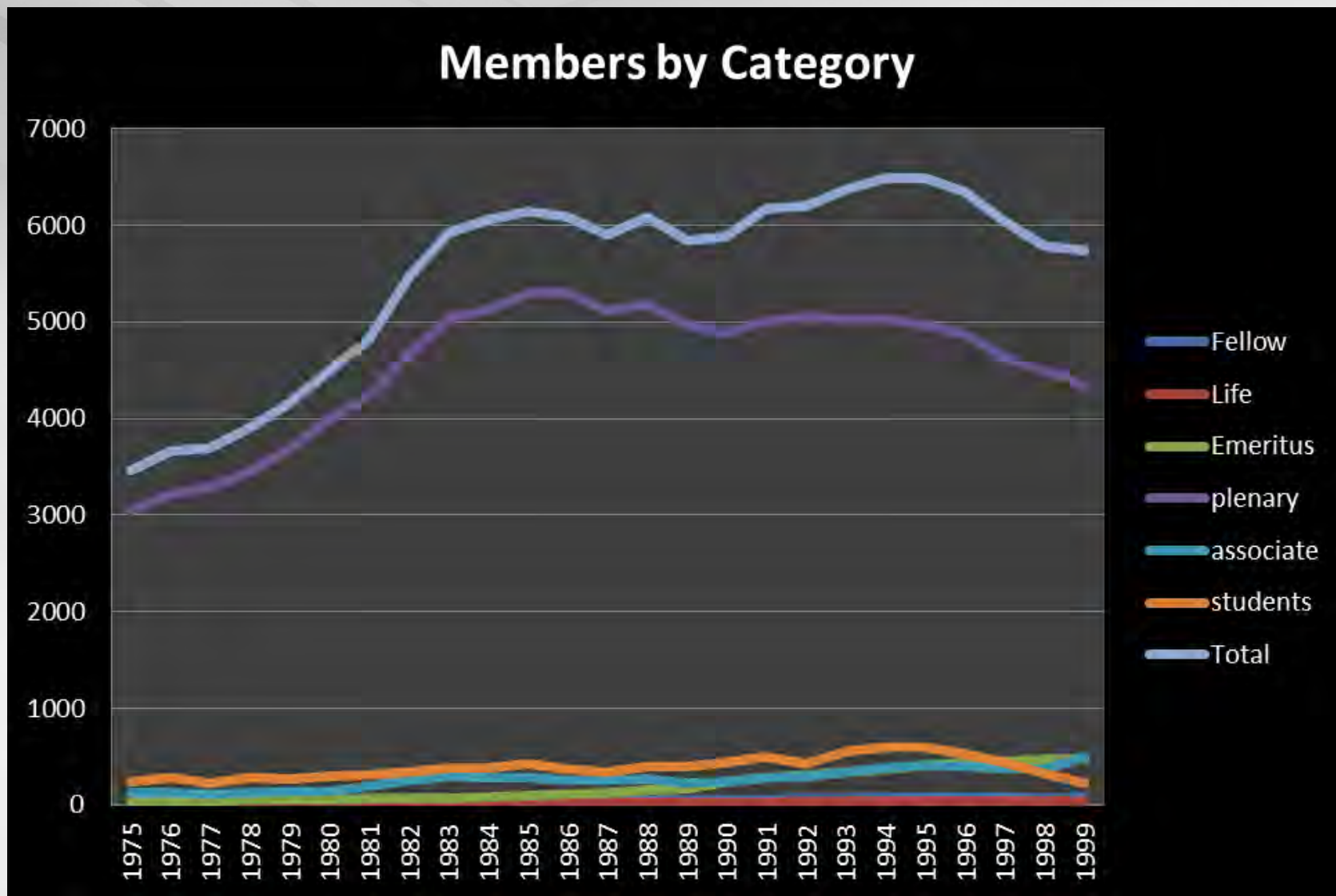
1988 Annual Meeting, Boston, MA

The “Middle Years” – Continuing to Thrive



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The “Middle Years” – Worrisome Trends

- ▶ Membership numbers were beginning to trend downward in late 1990s
 - Concerns about the “graying” of the HPS were beginning to emerge
 - Mossman and Poston paper (1988) on HP education and training identified loss of academic programs and potential for significant shortage of RP professionals in the next 15 y
- ▶ HPS leadership began to consider the effects of demographic trend during this time



1979 Annual Meeting, Philadelphia, PA



1990 Annual Meeting – Anaheim, CA

A New Century and a Shrinking Base

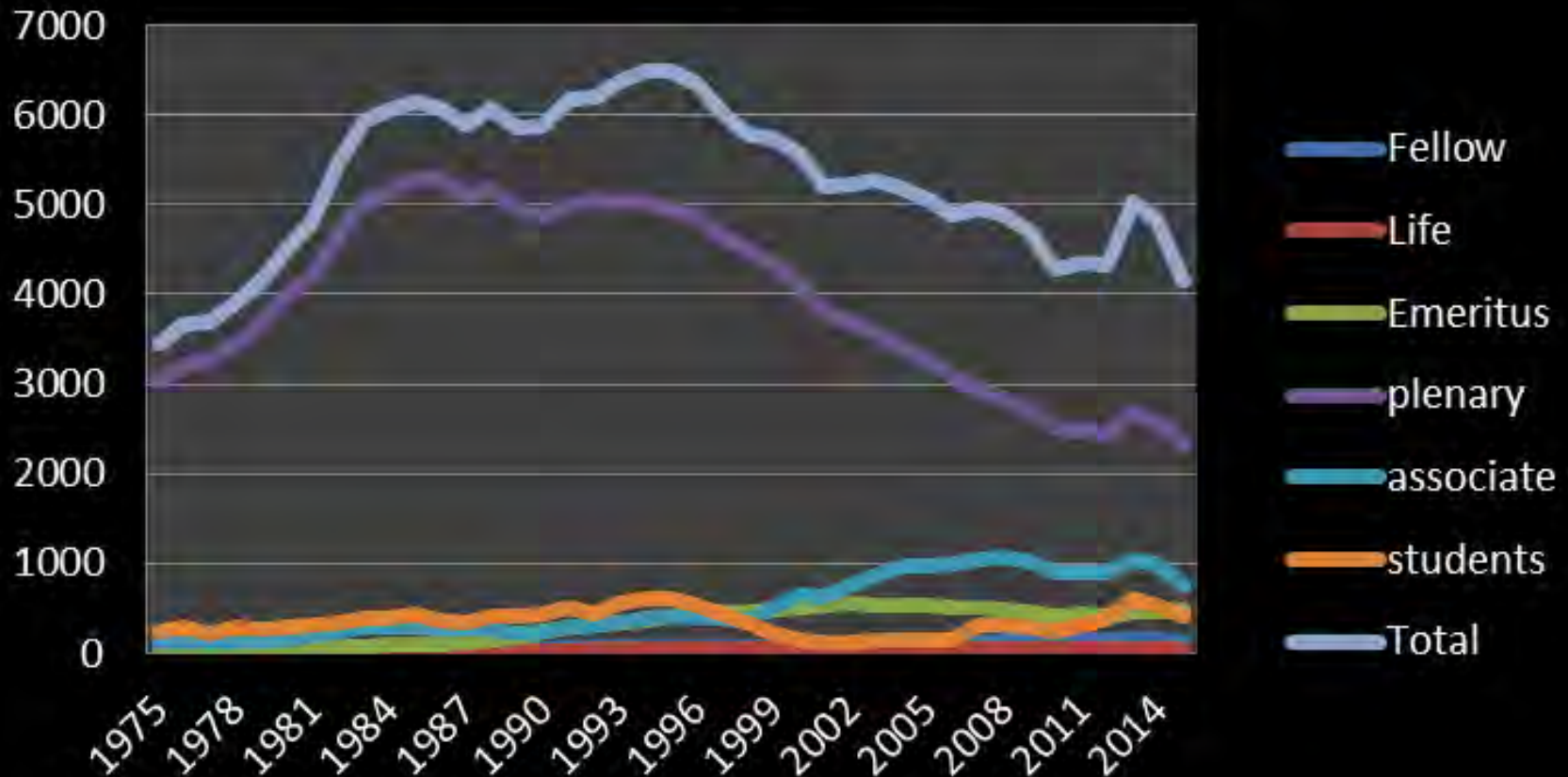


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- ▶ Membership numbers continued to decline
 - Plenary/Full members – ~2,500 in 2014
 - Spike in 2013 – may be result of interest after the 2011 Fukushima accident?

Members by Category



A New Century – Human Capital Crisis



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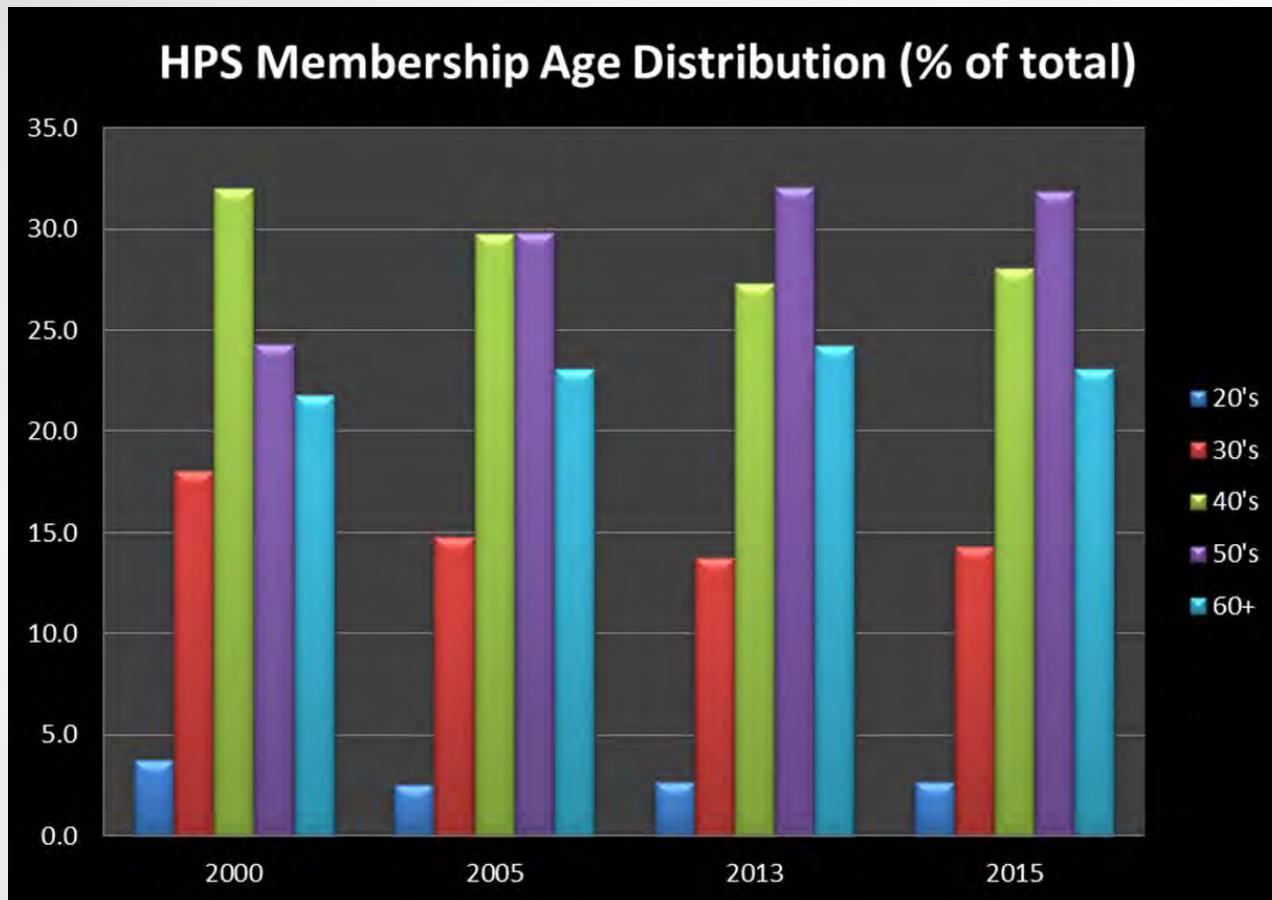
Proudly Operated by **Battelle** Since 1965

- ▶ HPS leadership recognized impending shortfall of qualified RP professionals across multiple employment sectors
- ▶ Human Capital Crisis Task Force – 2002
 - Chaired by Kevin Nelson, representatives from many employment sectors
 - Published white paper in July 2004
 - Identified need for at least 6,700 more RP professionals in the “near term”
- ▶ Position Statement PS015 – Human Capital Crisis in Radiation Safety



The “Graying” of the HPS

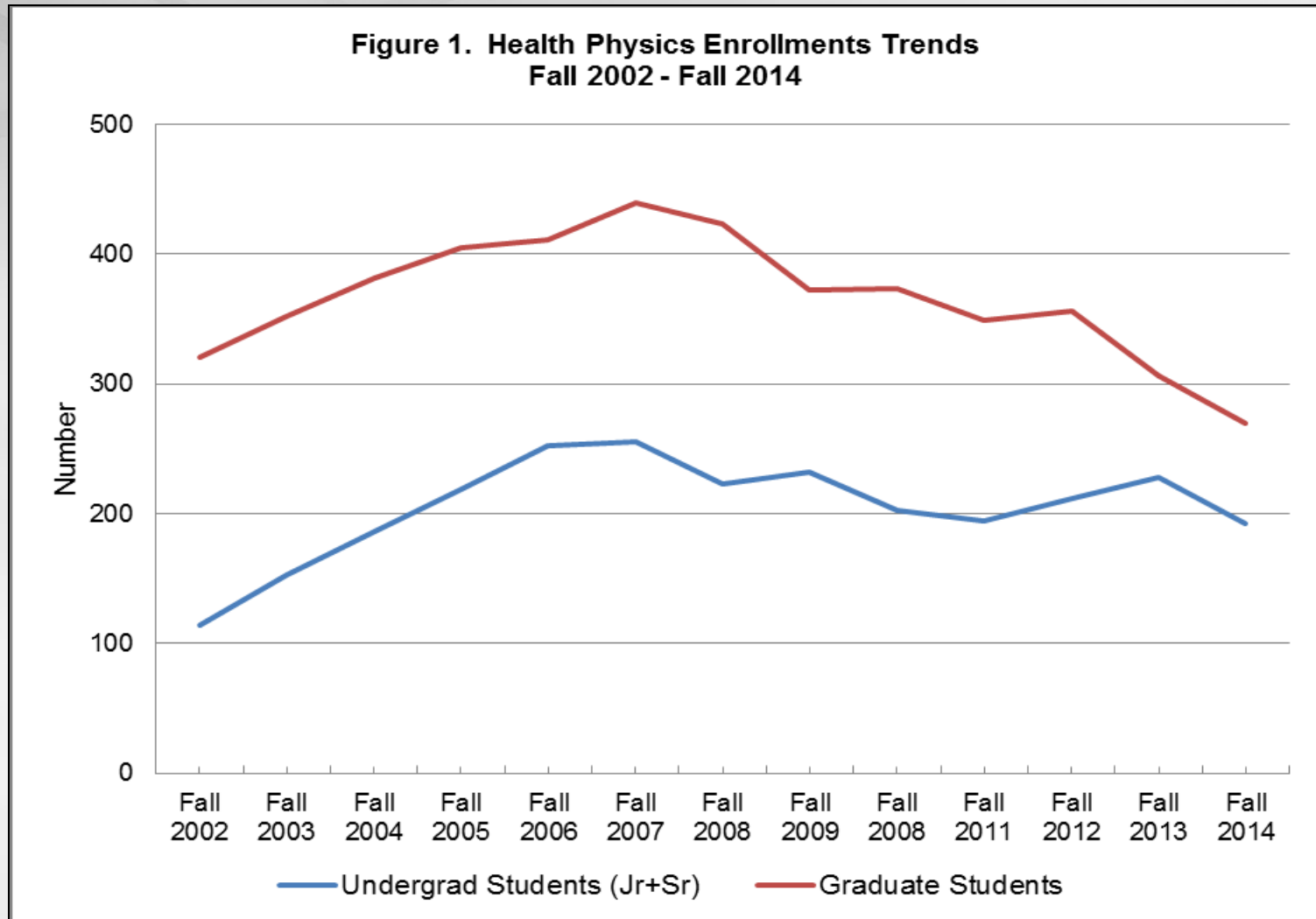
- ▶ Steady stream of applicants don't offset the loss of members due to age, illness/death, leaving the field
- ▶ Since 2005 - over 50% of the membership is over 50 yof age
- ▶ Age gap in membership – missing members in their 30s and early 40s



Academic Programs



- ▶ Fewer programs = fewer graduates



Source: Oak Ridge Institute for Science and Education

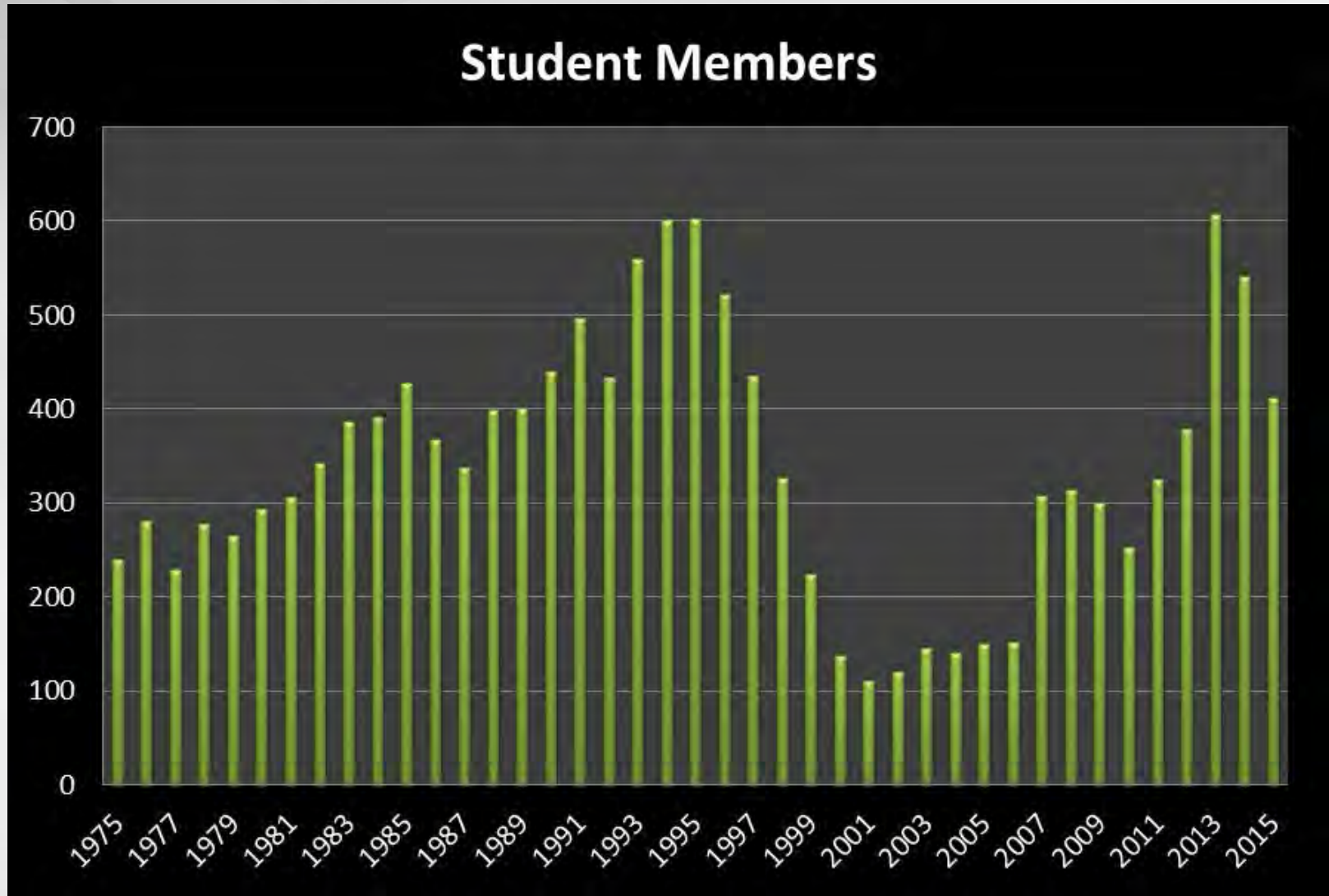
Student Membership Trends



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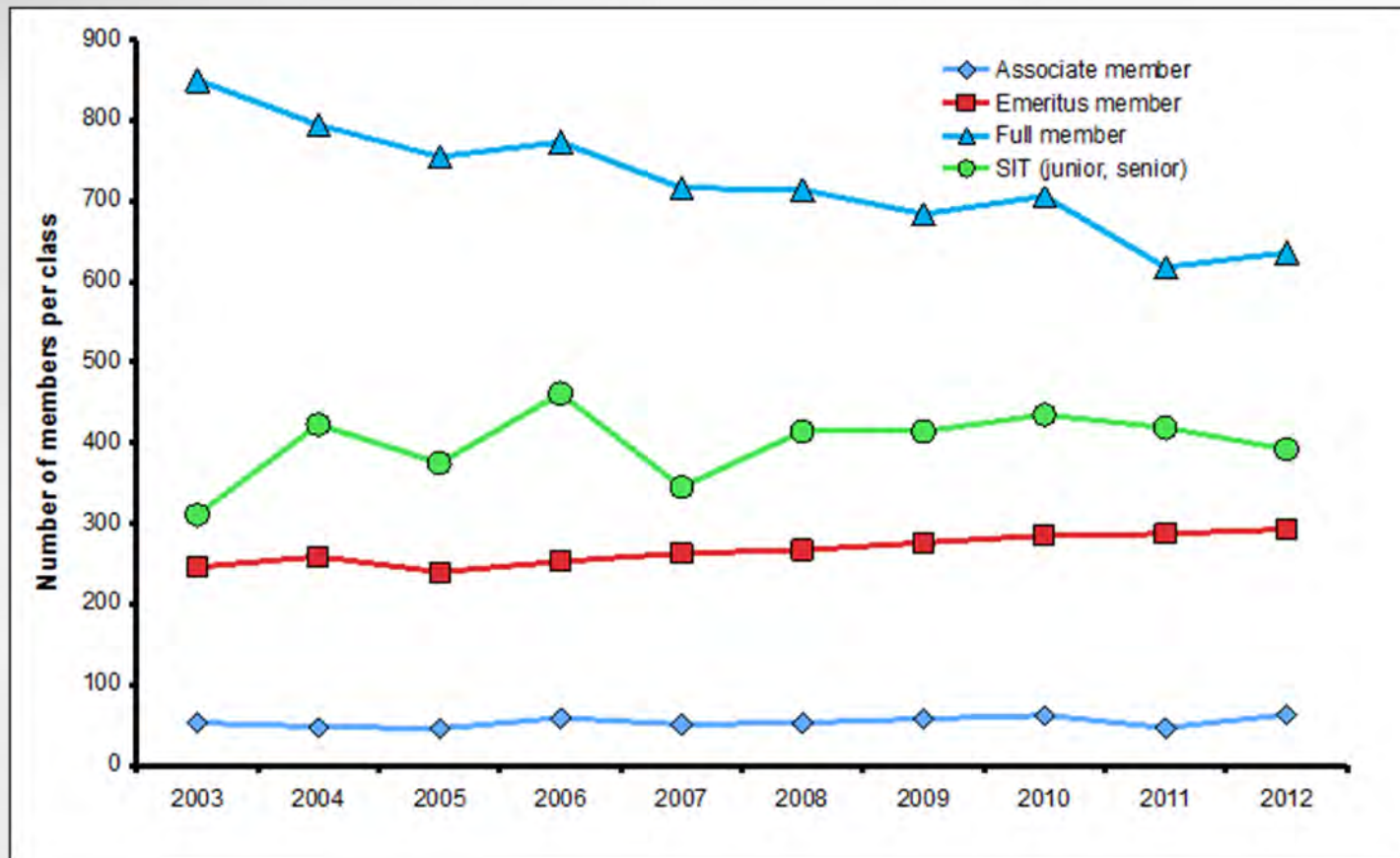
Proudly Operated by **Battelle** Since 1965

- ▶ Early 2000s – where are the students?
- ▶ Peaked in 2013; trending downward in last 2 y



Is This Problem Unique to the HPS?

- ▶ Declining membership trends –
 - Common problem for many professional organizations
 - Not isolated to radiation-related organizations
- ▶ Radiation Research Society – similar issues



What About Other Organizations?



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- ▶ ASAE Center for Association Leadership
 - ASAE Foundation conducts research on association management and leadership
 - Reports show associations are facing the same trends in declining membership
- ▶ Societal changes and factors influencing membership trends
 - Competition for time and attention - family, church, hobbies, recreation, other volunteer activities
 - Ability to capitalize on technology (e.g., social media)
 - Generational differences – expectations/values in joining; young professional groups
 - Market consolidation; narrow-focus specialty groups
 - Competition between professional organizations
 - Expectations for increased value of membership
 - Less employer support – tight budgets, travel restrictions



So What is the Answer?



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- ▶ NCRP Statement No. 12, WARP Report
 - Provides a set of recommendations to increase the number of radiation professionals
 - HPS strives to provide a “home” for RP professionals - networking, professional resources and continuing education opportunities
- ▶ HPS Board of Directors strategic planning initiative
 - Recently revisited HPS’s mission and vision statements
 - Where are we going? What do we want to be in the future?
 - Soliciting membership input – what does a strong and healthy HPS look like? What is important to you as a member?
 - Input from non-members is important but harder to collect
- ▶ Member engagement is critical to success
 - Member investment translates to member retention
 - Mentor/encourage involvement – locally, nationally
 - Create opportunities to volunteer and involve members despite shrinking employer support and tight travel budgets



Support the Students



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▶ Attracting and retaining students

- Interesting and well-paying job opportunities help attract students
 - Need to more clearly and effectively communicate the variety of radiation-related positions and opportunities
 - The term “health physics” is generally unfamiliar to the public (and future students)
 - HPS’s name has been a subject of debate since its inception
- Provide more financial support to students and academic programs
 - HPS leadership advocates for funding of the NRC’s Integrated University Program on every congressional visit
 - Only a fraction of the IUP funding supports academic programs in health physics; more support of academic programs is needed
 - HPS provides scholarships and grants to students
- Resources on employment and internships
- Support post-graduation – extension of student status; reduced dues

Student Engagement



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- ▶ Encouraging student participation in HPS activities
 - Student Support Committee – student representatives from the academic programs; Chair is member of President’s advisory panel
 - Travel grants to attend meetings
 - Opportunities to participate on projects with HPS committees
 - Involvement in student branches and local chapters



2015 HPS Annual Meeting, Indianapolis, IN

2014 HPS Annual Meeting, Baltimore, MD



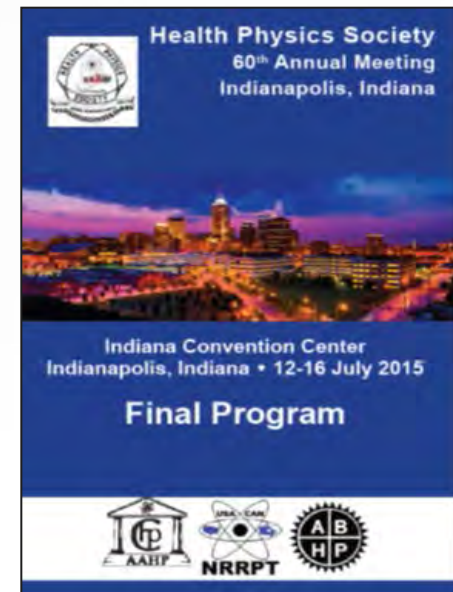
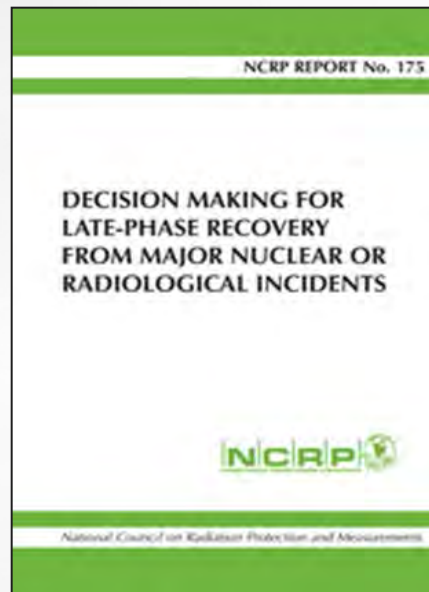
Value of Membership



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- ▶ Continuing to increase the value of HPS membership
 - ANSI/HPS N13, N43 standards, and ICRU reports provided at no cost
 - Discounts on NCRP reports and publications
 - Annual meeting presentations posted to the Members Only webpage
 - Professional development courses – available both at meetings and online



In Conclusion



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Proudly Operated by **Battelle** Since 1965

- ▶ HPS faces a number of challenges in maintaining future membership levels, as do many other organizations
- ▶ Focus on communication of opportunities, member engagement and student support
- ▶ HPS stands ready to support the NCRP in implementing WARP recommendations and in providing professional resources and support to the next generation of radiation protection professionals



Health physics students at the 2015 HPS Annual Meeting in Indianapolis, Photo courtesy of Casper Sun

A Review of the Workforce for Radiation Protection in Medicine

Wayne Newhauser, PhD, DABR



Acknowledgements and Disclosures

- NCRP for travel support.
- NRC for supporting the Health Physics Program at LSU.
- I do not have any conflicts of interest.

Introduction

- Since the discovery of radioactivity and x rays in the 1890s, ionizing radiation has been used in medicine, industry, academia, power generation, and national defense.
- The U.S. developed a community of **professionals for the safe and beneficial use of radiation.**
- The number of radiation professionals has shrunk alarmingly, as documented by AAAS (2014), GAO (2014), HPS (2013), NA/NRC (2012), and NCRP (2015).

Radiation Professions of Relevance to Medicine

- Medical Physics
- (Medical) Health Physics
- Radiobiology
- Radiation Oncology
- Radiology
- Nuclear Medicine
- Radiochemistry
- Nuclear Engineering



Dire Warnings of a Looming Crisis

- U.S. is on the “verge of a severe shortfall of radiation professionals such that **urgent national needs will not be met.**”
- Projected shortfalls will adversely affect the **public health**, radiation occupations, emergency preparedness, and the environment.

NCRP Statement 12, 2015

Factors Effecting the Adequacy of the Workforce

Demand

- ↑ Cancer incidence will increase about 20% per decade due to increasing size and age of the population
- ↑ Utilization of radiation has been increasing (*e.g.*, CT scans) but ...
- ↑ Number and complexity of new technologies
- ↓ Productivity gains

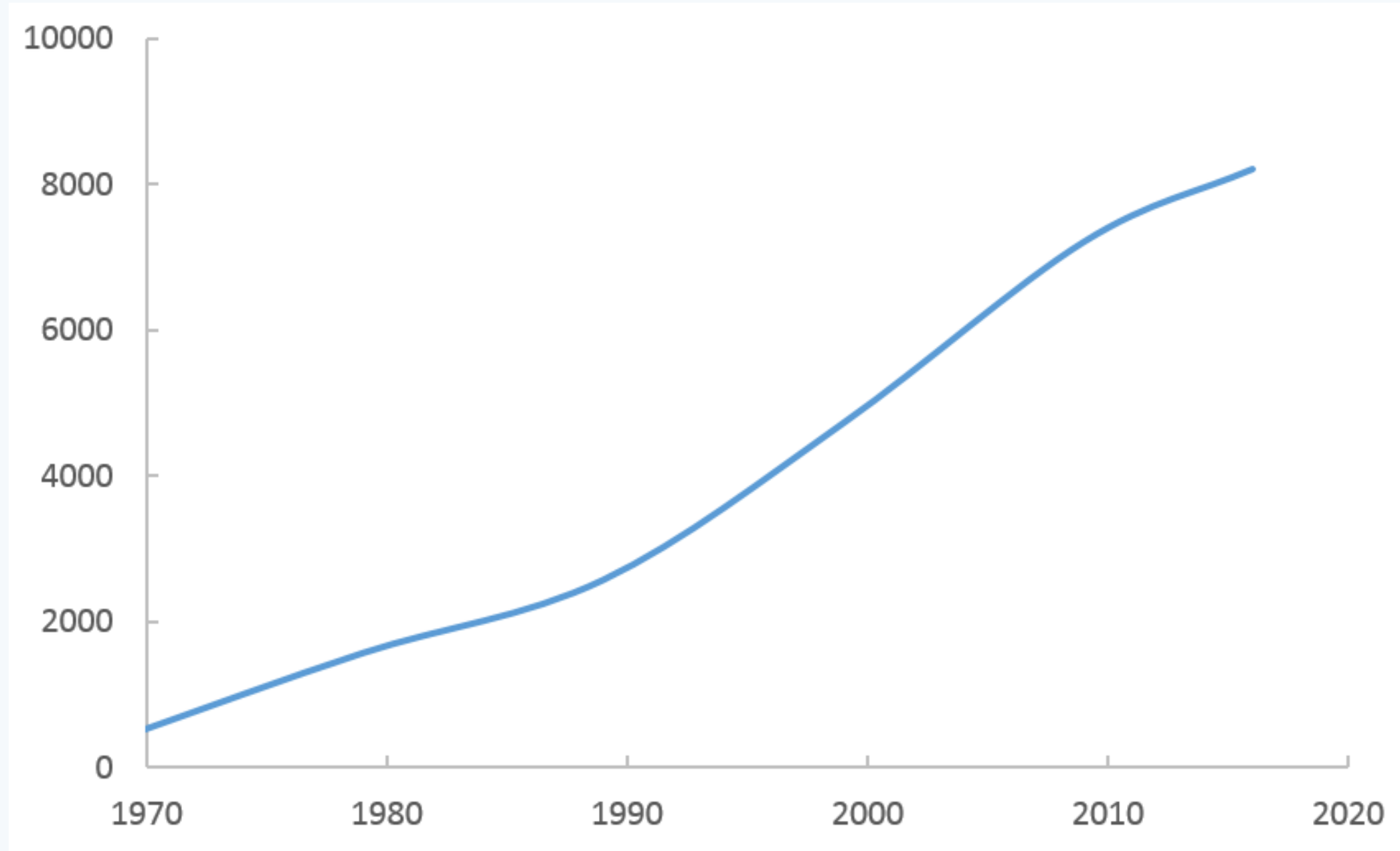
Supply

- Existing workforce and retirement of its baby boomers
- Capacity of academic and clinical training programs
- Health care policy, statutes, salaries, other factors

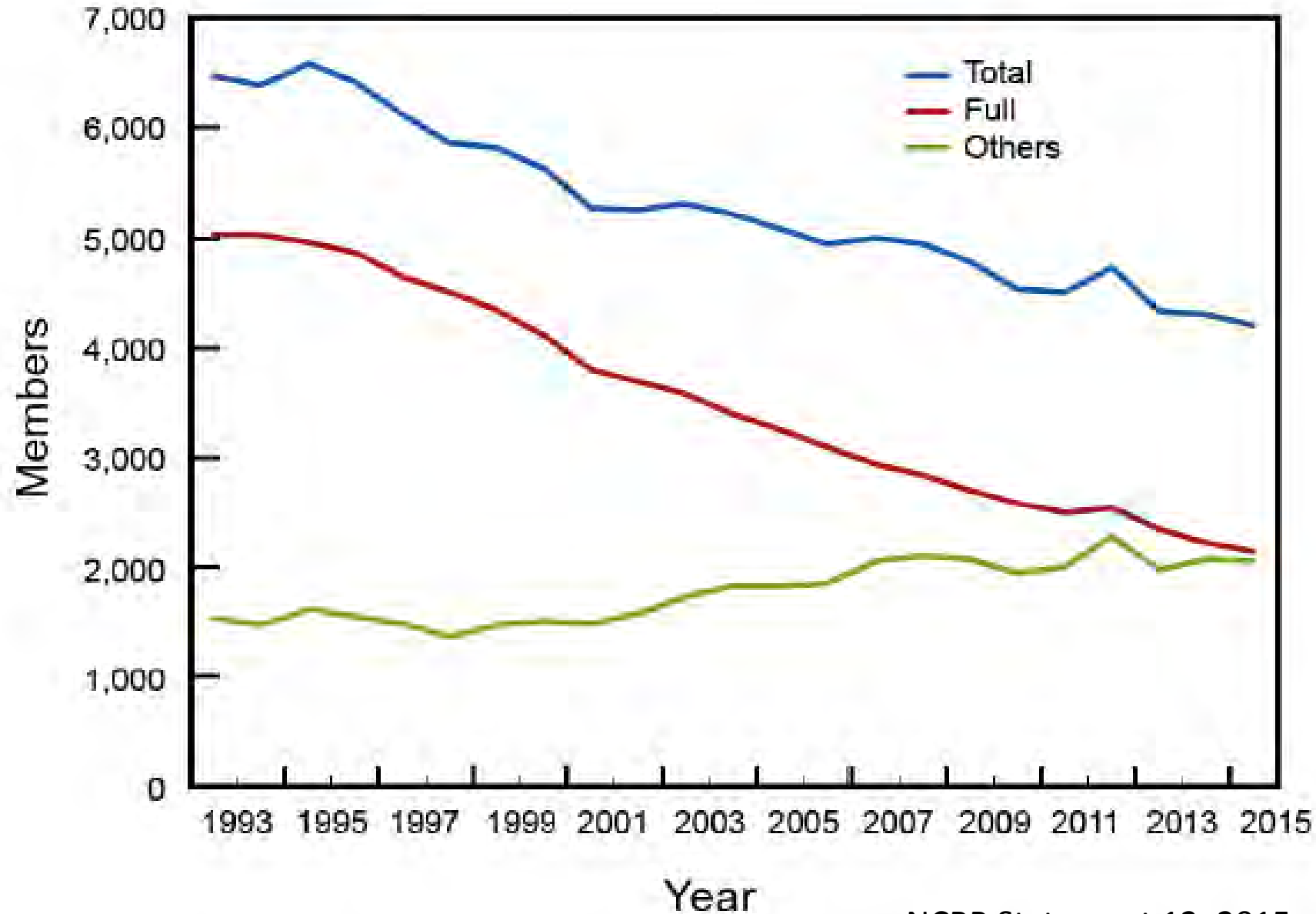
Size of Existing Radiation Workforce

Society	Current Membership	Trend
AAPM	8,205	Growing
ANS	~11,000	~Stable
HPS	<5,000	Steady decline

Membership of Am Assoc of Physicists in Medicine, 1970 to 2016



Membership of the U.S. Health Physics Society, 1993 to 2015



Doctorate Degrees (U.S. 2013)

- 52,760 in all fields
- 9,290 in physical science
- 8,963 in engineering
- In engineering & physical sciences
 - Median age at award: 30 y
 - Time to doctorate: 6.5 y
 - $\frac{3}{4}$ male, $\frac{1}{4}$ female
 - About half domestic
 - >70% white



- 169 in nuclear engineering (<2% of engineering PhDs)
- 113 in medical physics (~1% of all physical science PhDs)
- 10 in health physics (<0.2% of all physical science PhDs)

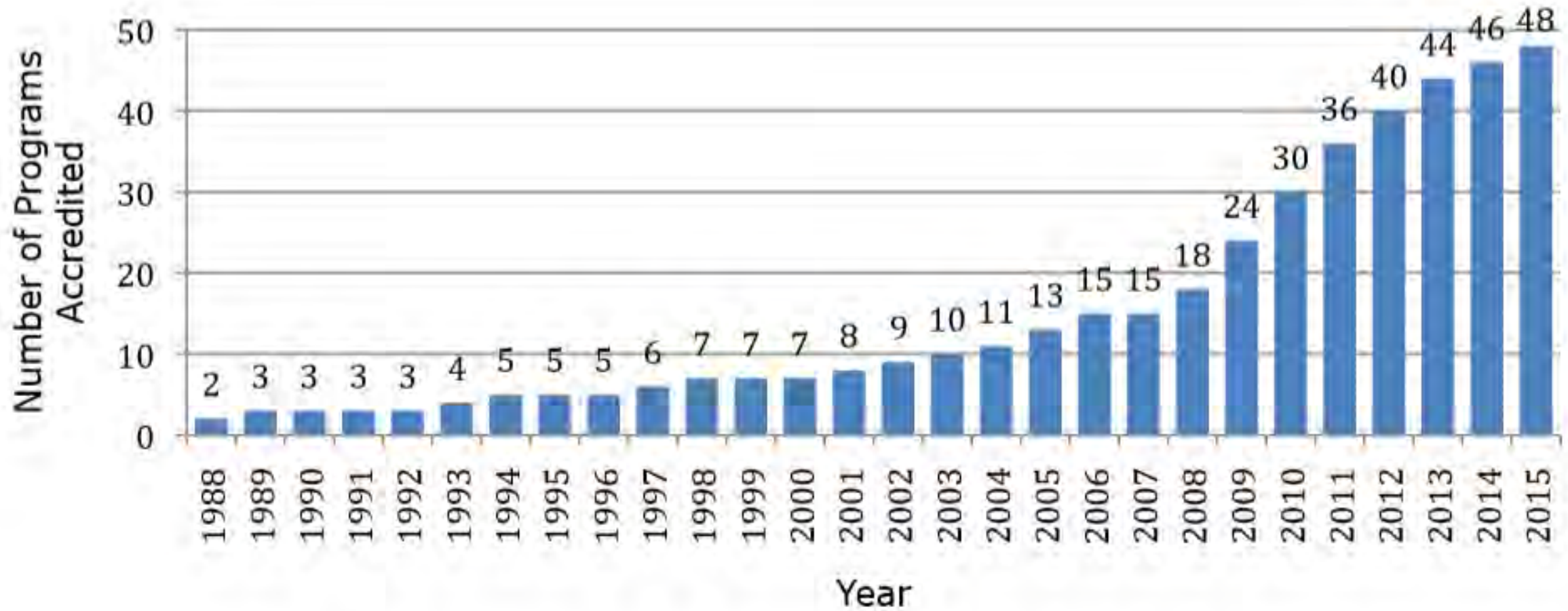
Size and Output of Medical Physics Education Programs

Degree	Programs*	Graduates/y**	Grads/y/prog
MS/MSc	43	162	4
PhD	34	113	3
Post Doc Certificate	11	9	<1

*Campep.org 2016.

**Clark, CAMPEP GEPRC Report, 2015. Data for 2013.¹¹

Growth of Medical Physics Training Programs (MS and PhD)



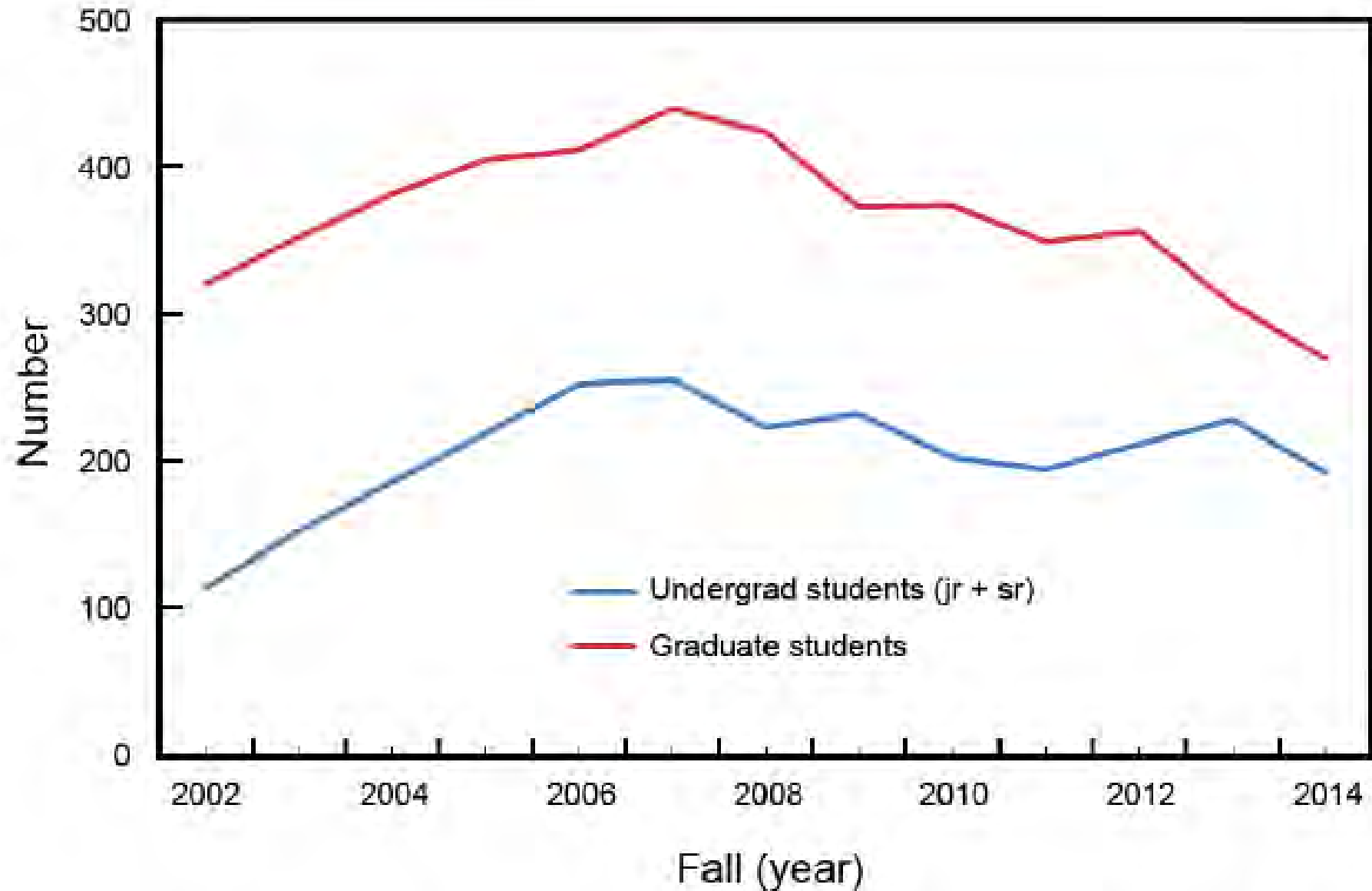
Size and Output of Health Physics Degree Programs

Degree	Programs*	Graduates/y**	Grads/y/prog
BS	13	67	5
MS	20	81	4
PhD	10	10	1

*Health Physics Education Reference Book, HPS, 2010.

**ORISE Report 75, 2015. Data for U.S. in 2014.

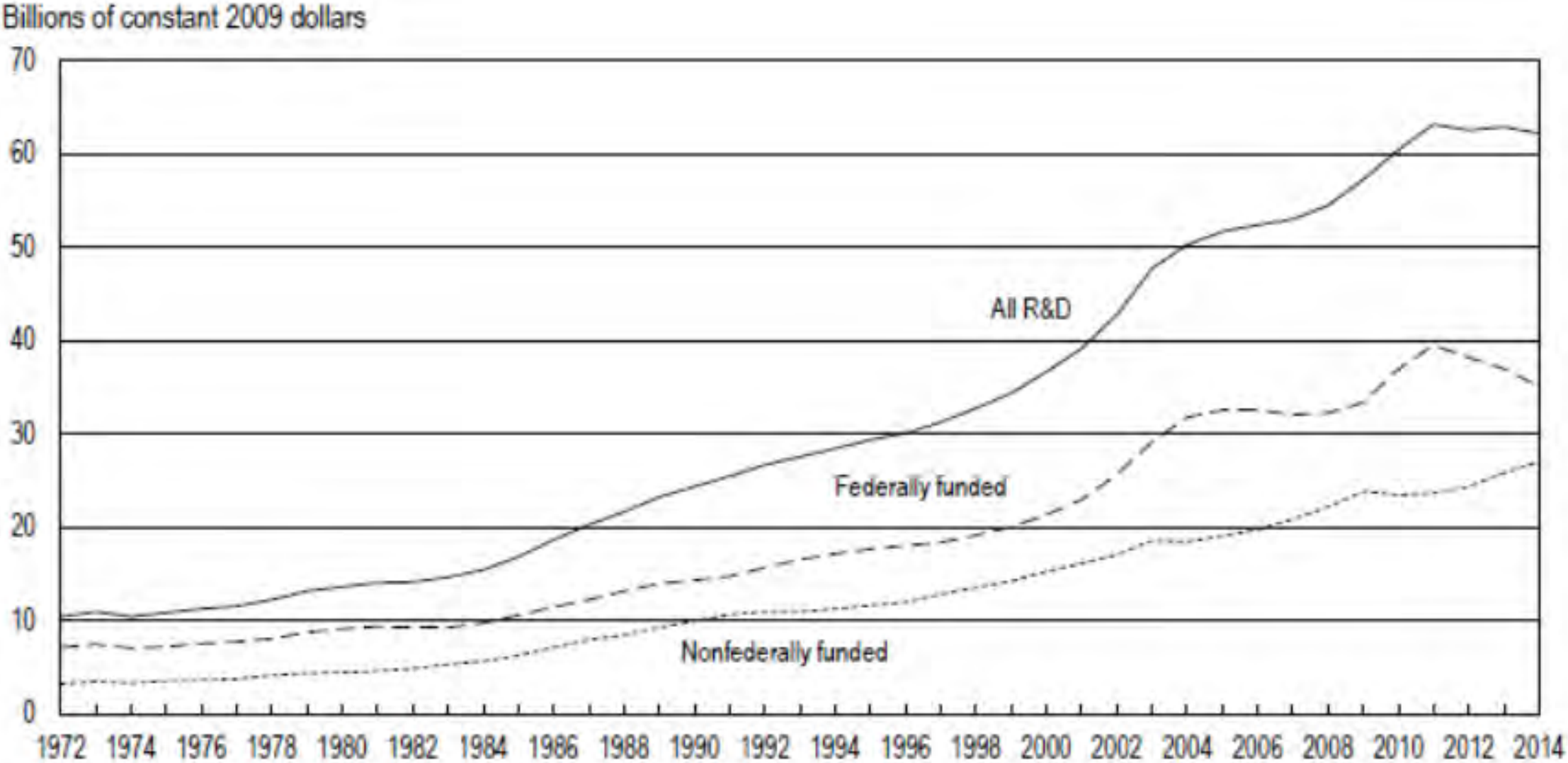
Health Physics Enrollment Trends, 2002 to 2014



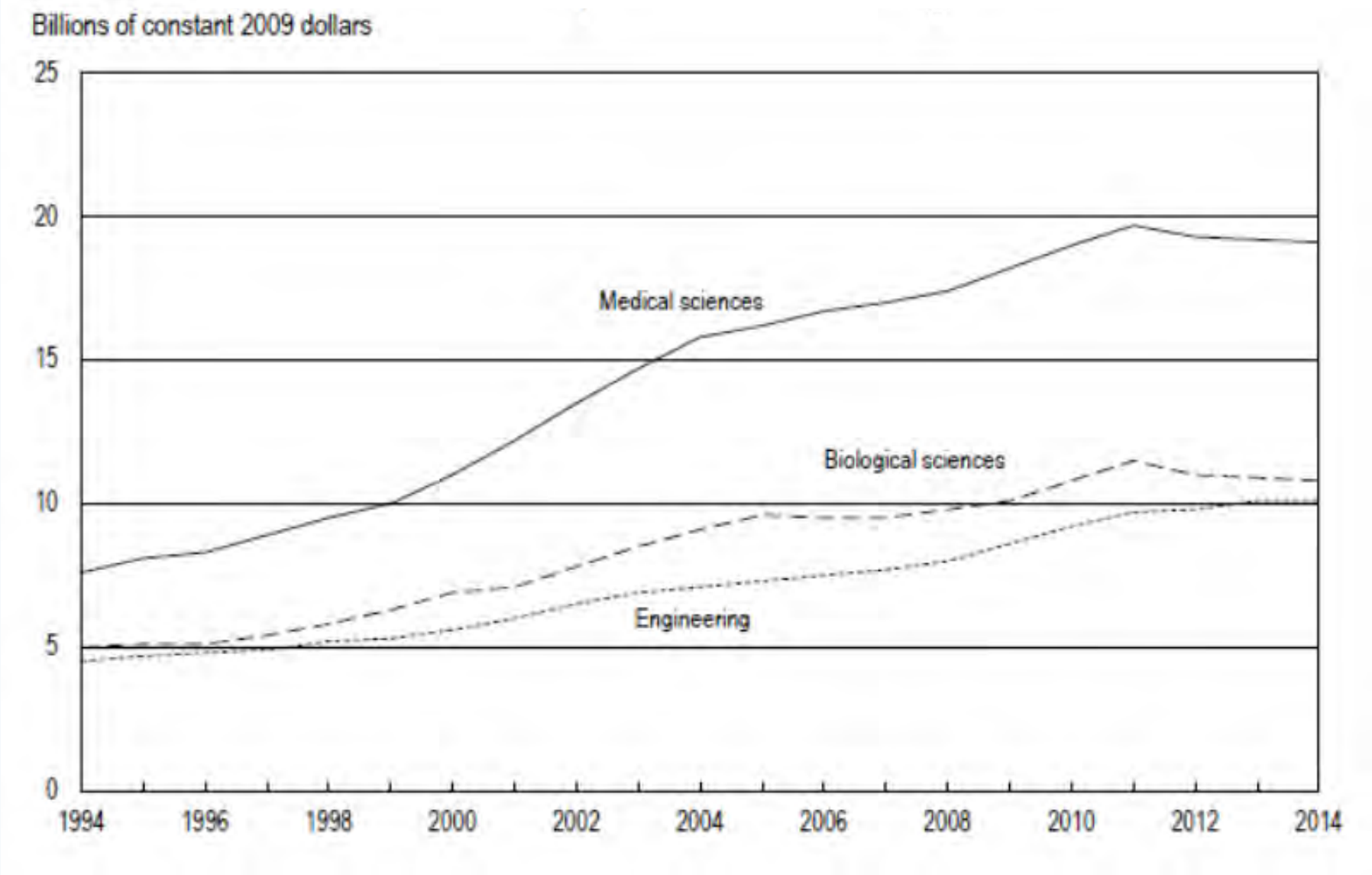
Research Funding is Broadly in Decline

- Universities depend on research and education grants to fund radiation protection and other STEM degree programs.
- Decline in federal support for research and development
 - ↓ 10% of federal budget in 1968 to about 4% now
 - ↓ 1.25% of GDP in 1977 to 0.78% in 2014

R&D Funding in U.S., 1972 - 2014



R&D Expenditures in the 3 Largest Fields



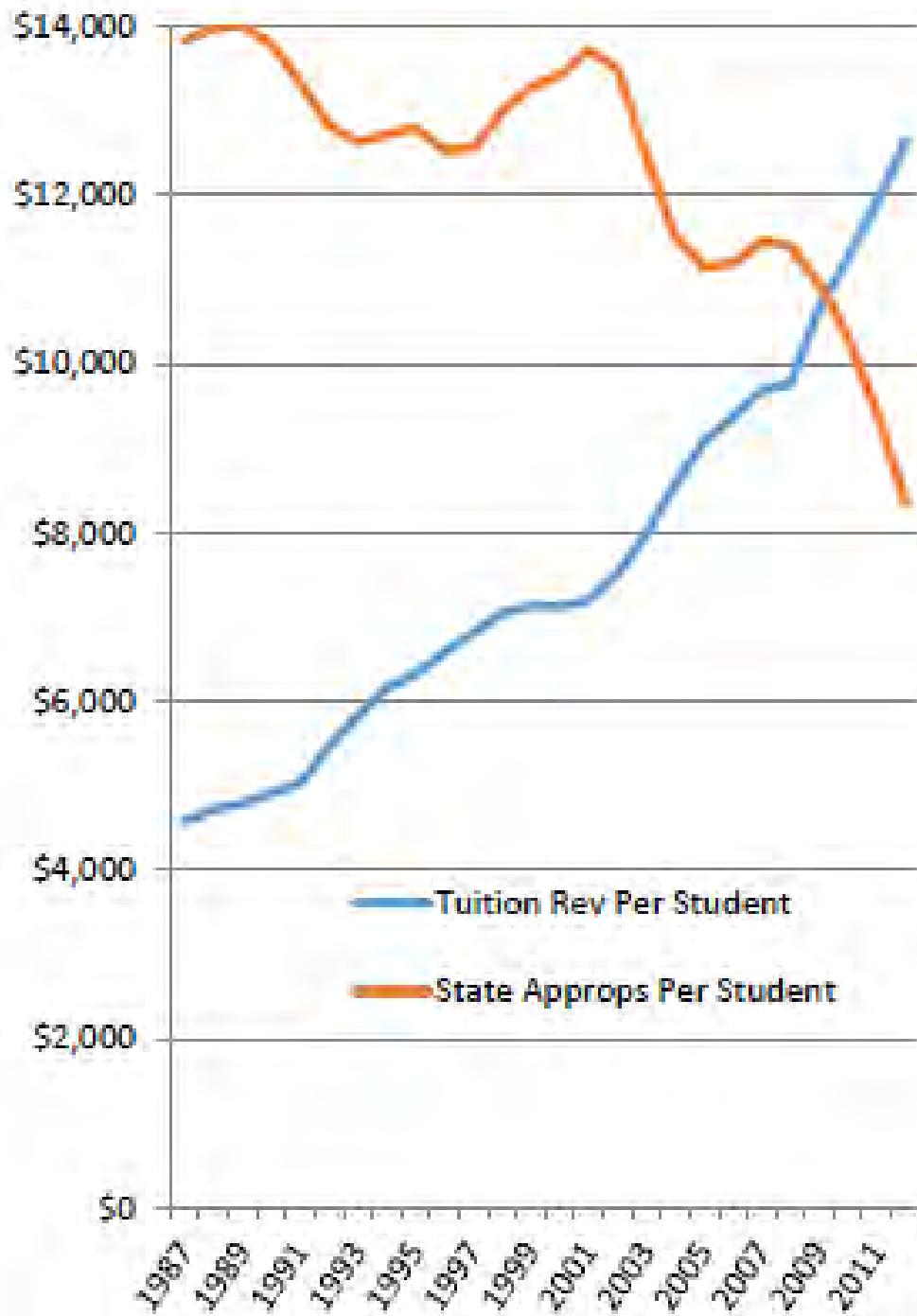
NIH Funding in Radiation Oncol/Biol/Phys (2013)

- 197 awards
- 118 held by full professors, 49 at associate prof, 27 assistant prof.
- 80% radiation biology, 13% had a physics topic, 8% clinical investigations.
- *Only 9 individual training grants!*
- Only 18 institutions had 3 or more investigators with active NIH funding.
- Critical-mass problem for research groups.
- Low-renewal rates “jeopardizing the establishment of long-term programs.”
- “The overall state of NIH funding in radiation oncology raises great concern. Many academic radiation oncology departments have already become “service departments, where novel research is limited and little or no translational research occurs.”
- **“... radiation oncology is underfunded by NIH and that the current level of support does not match the relevance of radiation oncology ...”**

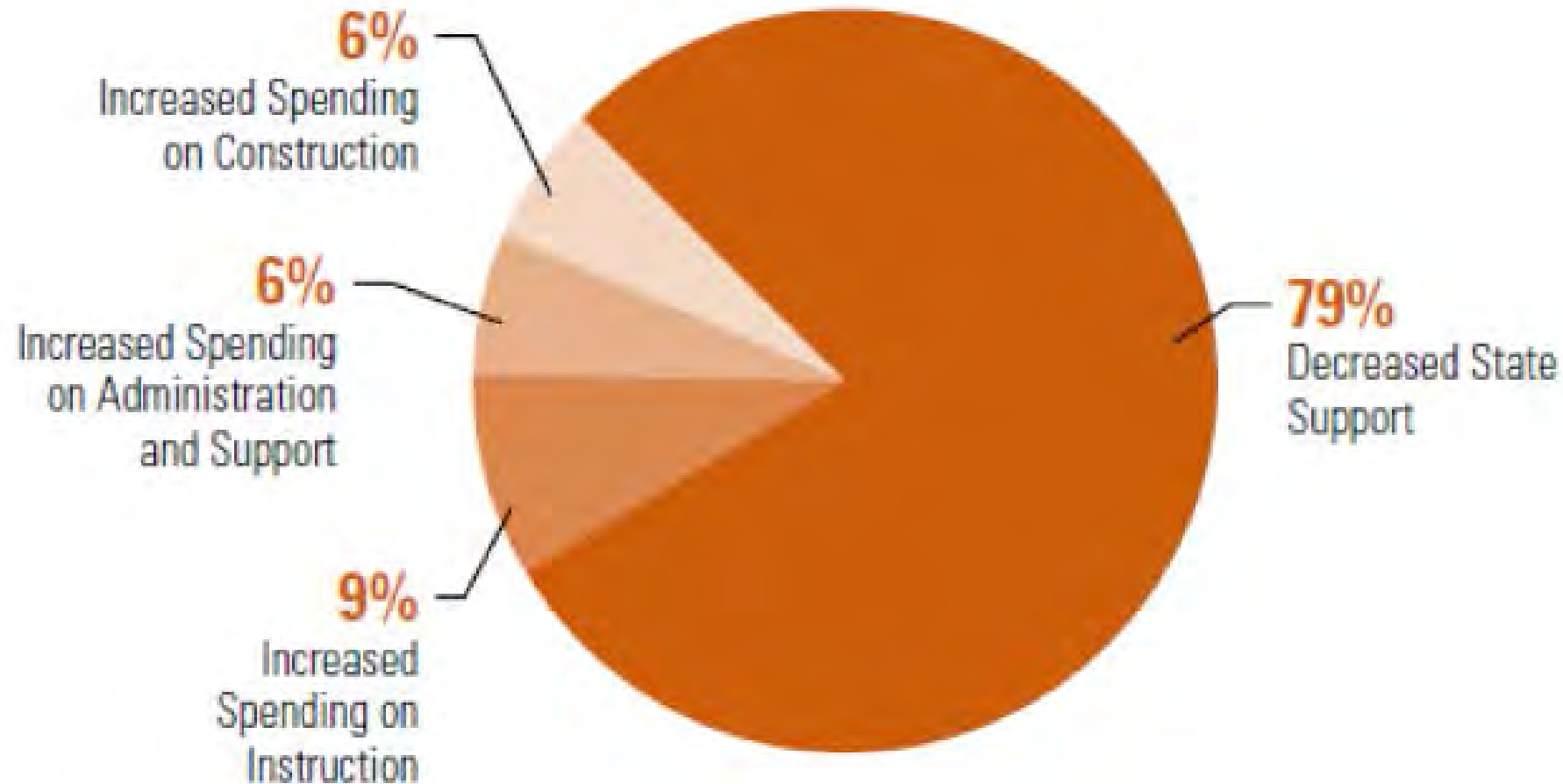
Federal Research Funding for Health Physics

- Pre 2000: Atomic Energy Commission, Public Health Service, DOE
- 2005: Congress appropriated money to DOE NE for a health physics fellowship and scholarship
- 2007: DOE ceased funding the Congressionally authorized DOE - NE health physics fellowship and scholarship program after only two fiscal years of funding the programs at minimal levels.
- 2008: Congress transferred appropriations for a Nuclear Education Program, including health physics programs, to the NRC. “Not only has the NRC ably administered this program but also it has brought needed assistance to both students and academic programs at colleges and universities throughout the entire country.”

Trends in Tuition and State Support



Causes of Rising Tuition at Public Research Universities 2001-2011



Source: Robert Hiltonsmith, *Pulling Up the Higher-Ed Ladder: Myth and Reality in the Crisis of College Affordability* (New York: Demos, 2015), <http://www.demos.org/sites/default/files/publications/Robbie%20admin-bloat.pdf>.

Professional versus Scientific Activities

- 2008: Increasing emphasis on licensure, certification, MOC
- 2014: 2 y residency required for eligibility for board certification
- Recent decline in post-doctoral training



“I chose this theme because I feel that AAPM has drifted a bit from its scientific roots; many of us (myself included) need to rejuvenate our enthusiasm as scientists. And we, as an organization, need to recognize that science is at the core of what we do.

... I humbly suggest that one of the most important survival strategies that we collectively can adopt is to get better at what we do as scientists.”

John M. Boone
2015 AAPM President


Summary of Outlook for Medical Physics

- Absolute cancer incidence increasing ~20%/decade.
- Large uncertainty in future health care economics and breakthroughs in science and medicine. Hard to predict utilization of radiation and demand for medical physicists.
- Underfunding of research appears likely to continue.
- Supply and demand appear to be in balance *for the short term*.

The Changing Roles of State Health Physicists

Ruth E. McBurney, CHP
Conference of Radiation Control Program Directors

Topics

- ▶ Regulatory Programs in the States
 - ▶ Scope of work of State Health Physicists
 - ▶ How the scope has changed over time
 - ▶ Workforce needs
 - ▶ Guidance, education, and training needs
- 

State Regulatory Programs

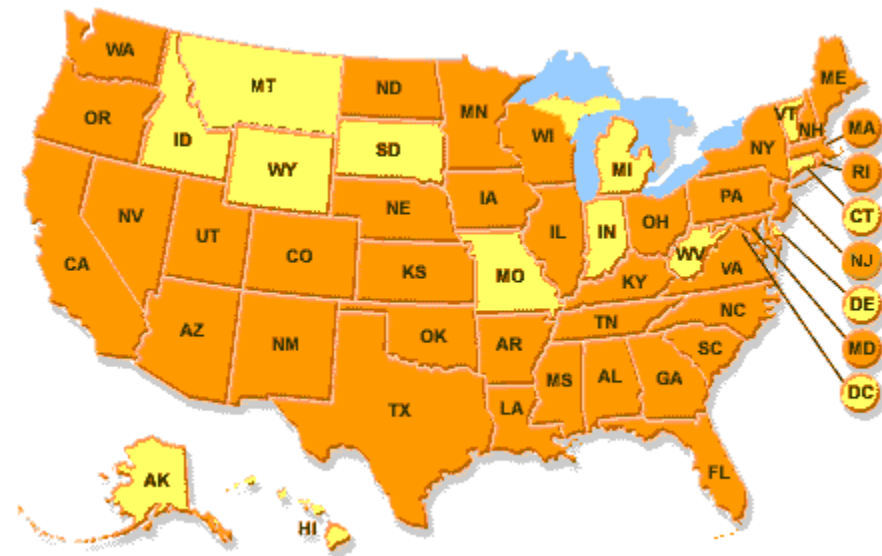
- ▶ Responsible for all Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)
- ▶ Use of x-ray machines and nonionizing radiation machines



State Regulatory Programs for Radioactive Material

State radiation control programs regulate:

- ▶ Nonreactor radioactive material in non-federal facilities in 37 Agreement States
- ▶ 86 percent of the nonreactor licenses in the United States
- ▶ All current commercial low-level waste sites



State Regulatory Programs

- ▶ Offsite emergency planning and response at nuclear power plants
- ▶ Incident investigations such as:
 - Lost or stolen sources
 - Smelting of sources at scrap facilities
 - Transportation incidents involving radioactive material



Changes in Scope of State Health Physicists' Role

- ▶ Radioactive material regulation:
 - Source security requirements
 - Alternate technologies for high activity radiation sources
 - Financial security



- Complex decommissioning issues more prevalent

Changes in Scope of State Health Physicists' Role: Emergency Response

- States within Emergency Planning Zones of Nuclear Power Plants
 - Accident assessment with plume modeling
 - Recommendations to decisionmakers for protection of the public
 - Protective action guidance
- Preparation for RDDs and INDs



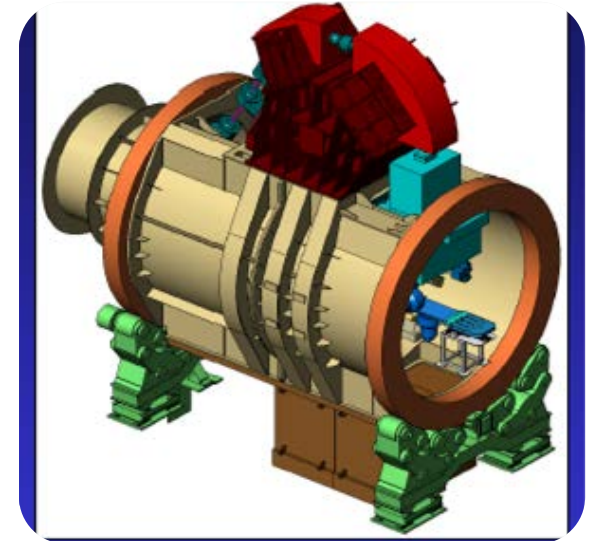
Topoff 2 Exercise, Portland, OR

Three
Mile
Island



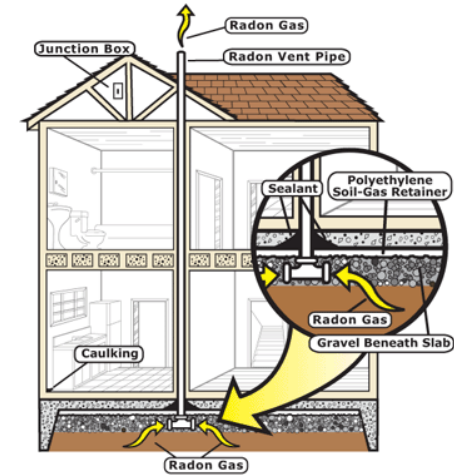
Changes in Scope of State Health Physicists' Role: Radiation Machines

- ▶ New technologies for diagnostic and therapeutic x ray
 - Proton therapy
 - Mixed radioactive material and x-ray modalities, such as PET-CT and SPECT-CT (requiring knowledge of both or different inspectors and permitting staff); mixed radioactive material and MRI (*e.g.*, ViewRay)
 - New issues regarding medical event reporting
- ▶ Training on radiation protection for new and blended technologies is expensive for state personnel




Additional State Health Physicist Responsibilities

- ▶ Nonionizing radiation
- ▶ Radon
- ▶ Certification of technologists
- ▶ Radiochemistry
 - Some states do not have dedicated radiochemistry laboratories
 - In those cases, the state health physicists either must be trained in radiochemistry or work with other chemists to train them on radioactivity analysis.



Workforce Needs

- ▶ Replacement hiring for impending “Baby Boomer” retirements
 - ▶ Staff development and training
 - ▶ Keeping up with the ever-changing technologies and radiation protection issues
 - ▶ Fair salaries and benefits to slow the revolving door of state health physicists
 - ▶ Surge capacity for emergency response at the state and local level
- 

Role of CRCPD in Addressing Training and Knowledge Transfer: Tools

- ▶ Training on new technologies (along with sponsoring professional societies)
- ▶ Tools and training for emergency response emerging issues
- ▶ White papers and regulatory guidance
- ▶ Model state regulations



Role of CRCPD in Addressing Training and Knowledge Transfer: Forums and Methods

- Annual conferences
- Web-based training
- Workshops
- Committee products



Conclusion



- The roles of state health physicists has evolved rapidly, especially in the past few years.
- New issues involving TENORM, new radiation machine technologies, source security, and emergency response call for increased knowledge transfer and consistent regulatory guidance.
- CRCPD, its federal partners, and associated societies provide forums for these issues to be addressed and to provide training on emerging issues and technologies.

Commercial Nuclear Power Industry Assessing/Meeting the RP Workforce Needs

NCRP Annual Meeting
April 11, 2016

Jerry W. Hiatt, CHP
Certified Health Physicist
Sr. Project Manager
Radiation & Materials Safety



NUCLEAR ENERGY INSTITUTE

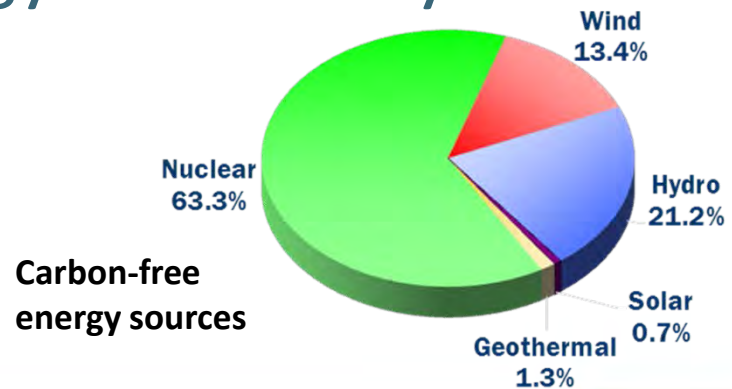
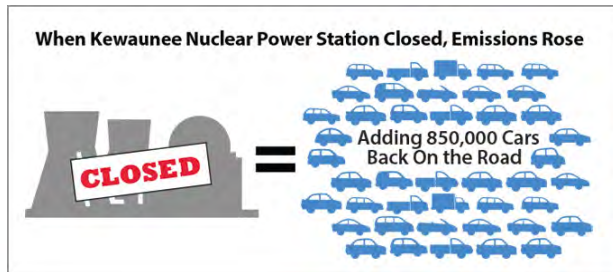
nuclear. clean air energy.

Purpose

- Describe industry's Workforce Strategy Development initiative
- Provide overview of industry workforce surveys
- Examine overall industry age distribution
- Discuss industry supply and demand forecast
- Summarize status of health physicist and radiation safety technician positions

Nuclear Energy Institute

- The Nuclear Energy Institute is the industry's policy organization
- Broad mission — foster the beneficial uses of nuclear technology in its many forms



NEI, with member participation...

- develops policy on *key legislative and regulatory* issues affecting the industry;
- serves as a *unified industry voice* before the U.S. Congress, executive branch, regulators;
- provides a forum to *resolve technical and business issues* for the industry; and
- provides accurate and timely *information* on the nuclear industry to members, policymakers, the news media and the public.



Work Force Strategy

NEI's Work Force Working Group

Chair Sam Belcher, FENOC

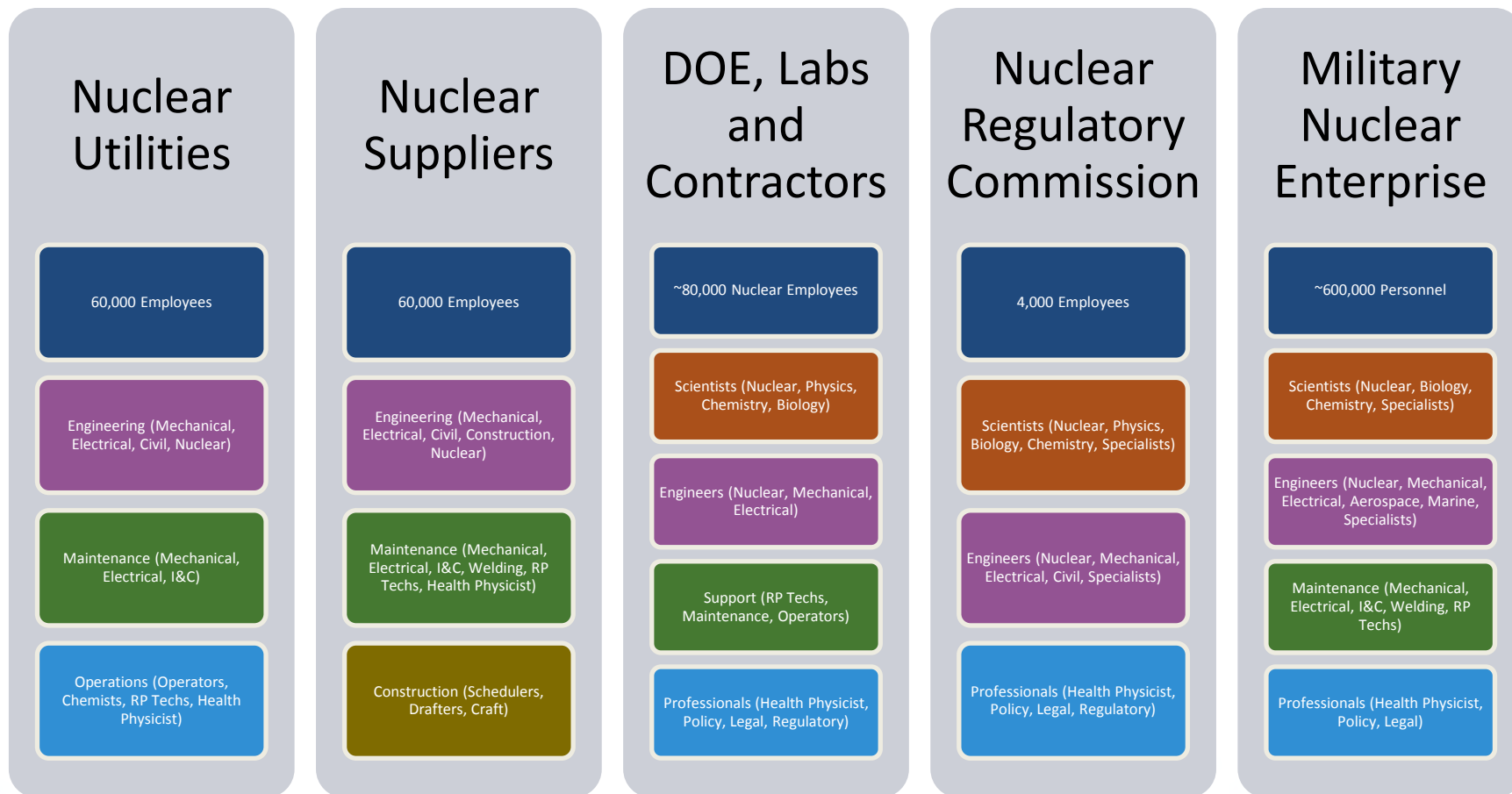
Elizabeth McAndrew-Benavides, Senior Manager, NEI

Center for Energy Workforce Development	Nuclear Human Resource Group	Outreach & Professional Development	Organizational Effectiveness Working Group	Nuclear Pipeline Programs	Institute of Nuclear Power Operations	Nuclear Energy Institute	Electric Power Research Institute
<ul style="list-style-type: none">• Career Awareness• Workforce Development/ Education• Workforce Planning• Surveys• Broader Utility Focus	<ul style="list-style-type: none">• Talent Acquisition• HR Metrics• Knowledge Transfer	<ul style="list-style-type: none">• American Nuclear Society• North American Young Generation• U.S. Women in Nuclear• HPS	<ul style="list-style-type: none">• Leadership Development• Mid-Career Development• Organizational Effectiveness Benchmarking and Support	<ul style="list-style-type: none">• NEDHO• NMAP• Military• NUCP	<ul style="list-style-type: none">• Technical Training• Leadership Training• Plant Training Accreditation• NUCP Co-Management	<ul style="list-style-type: none">• NUCP Co-Management• Federal Education Appropriations• Workforce Survey• Tie to NSIAC• Workforce Policy	<ul style="list-style-type: none">• STE Process

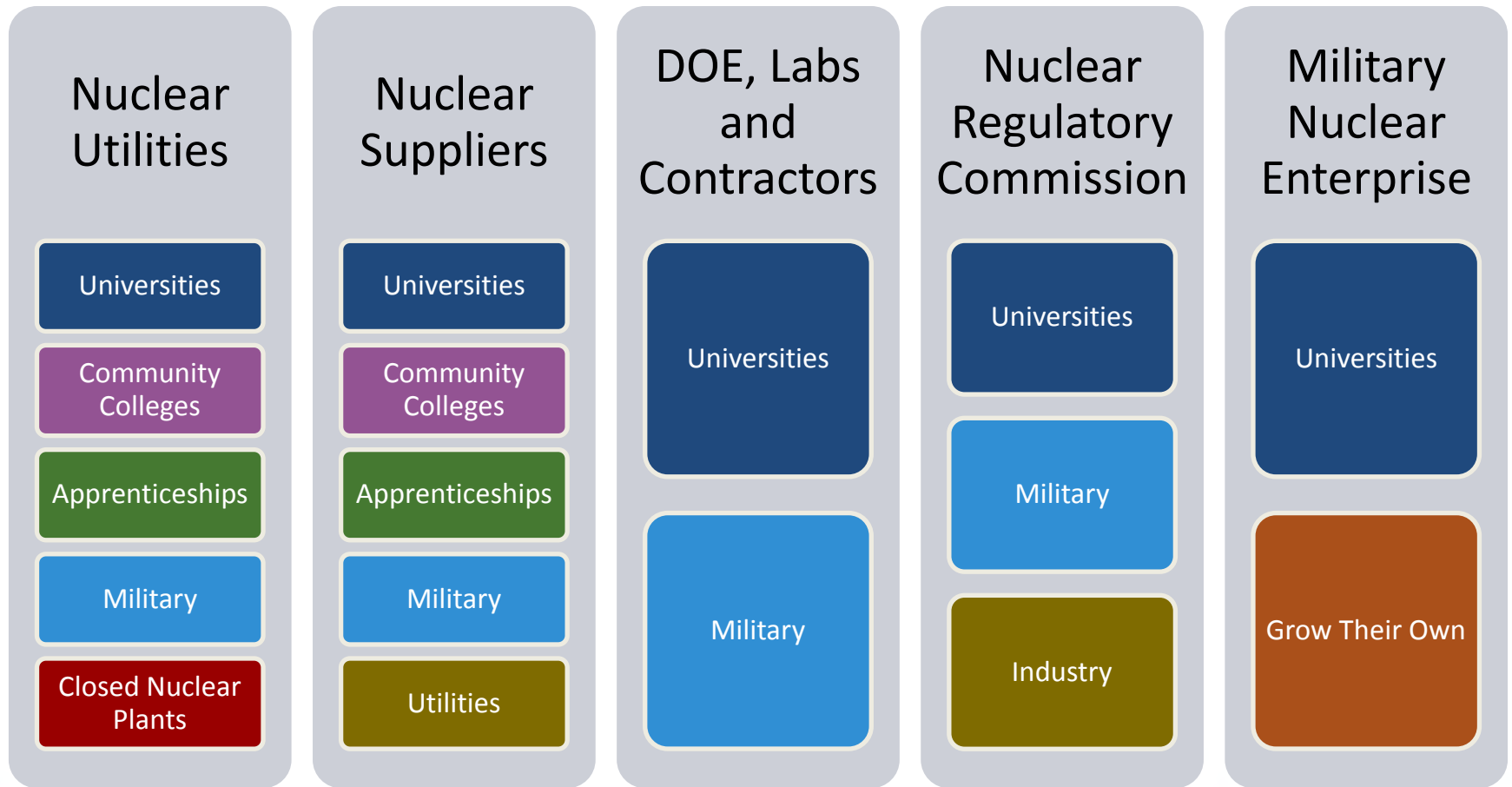
Communicating efforts to ensure industry has the right people, at the right times in the right places.



U.S. Nuclear Sector Workforce Needs



U.S. Nuclear Sector Pipelines

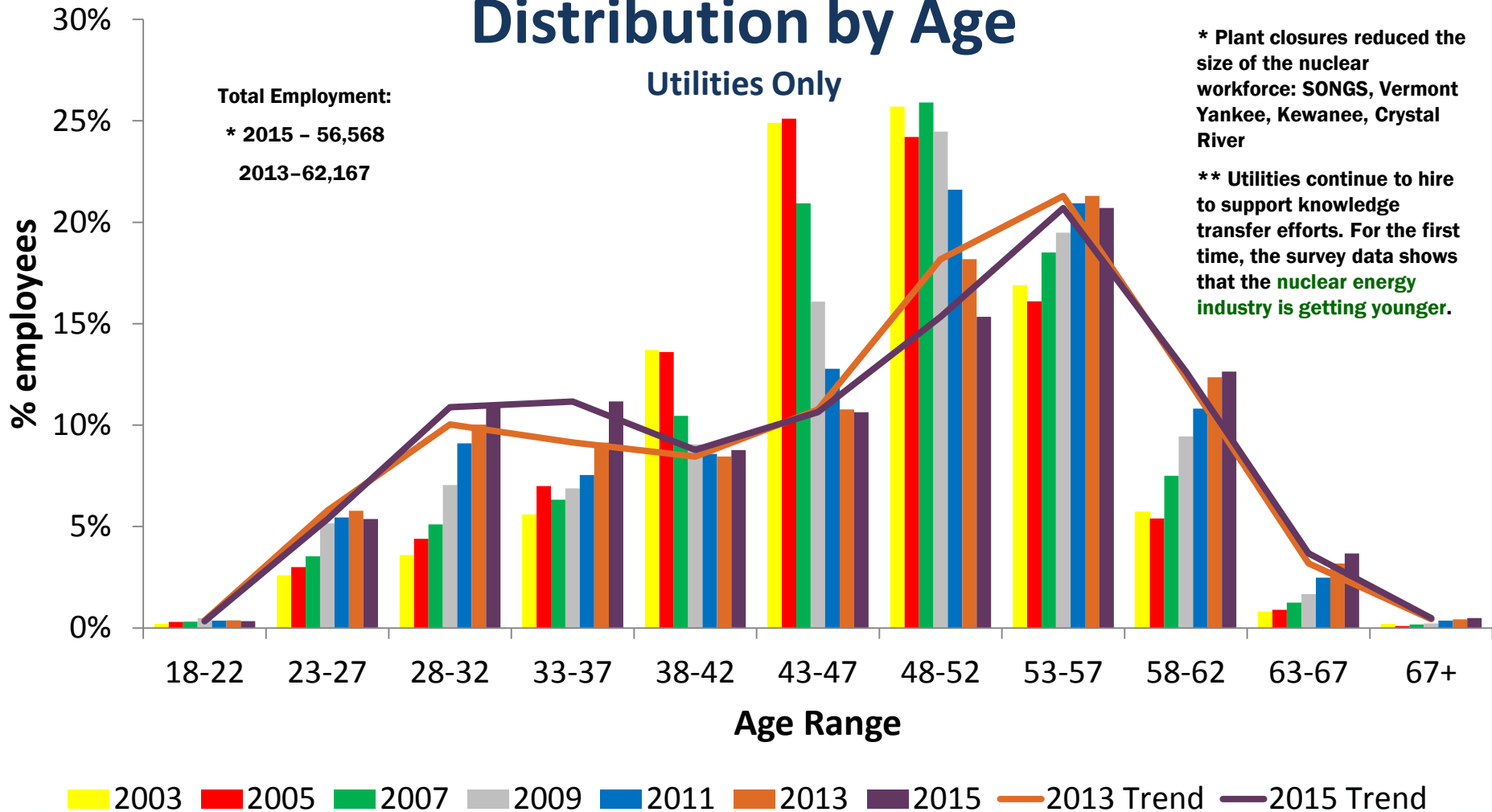


NEI 2015 Workforce Survey Participation

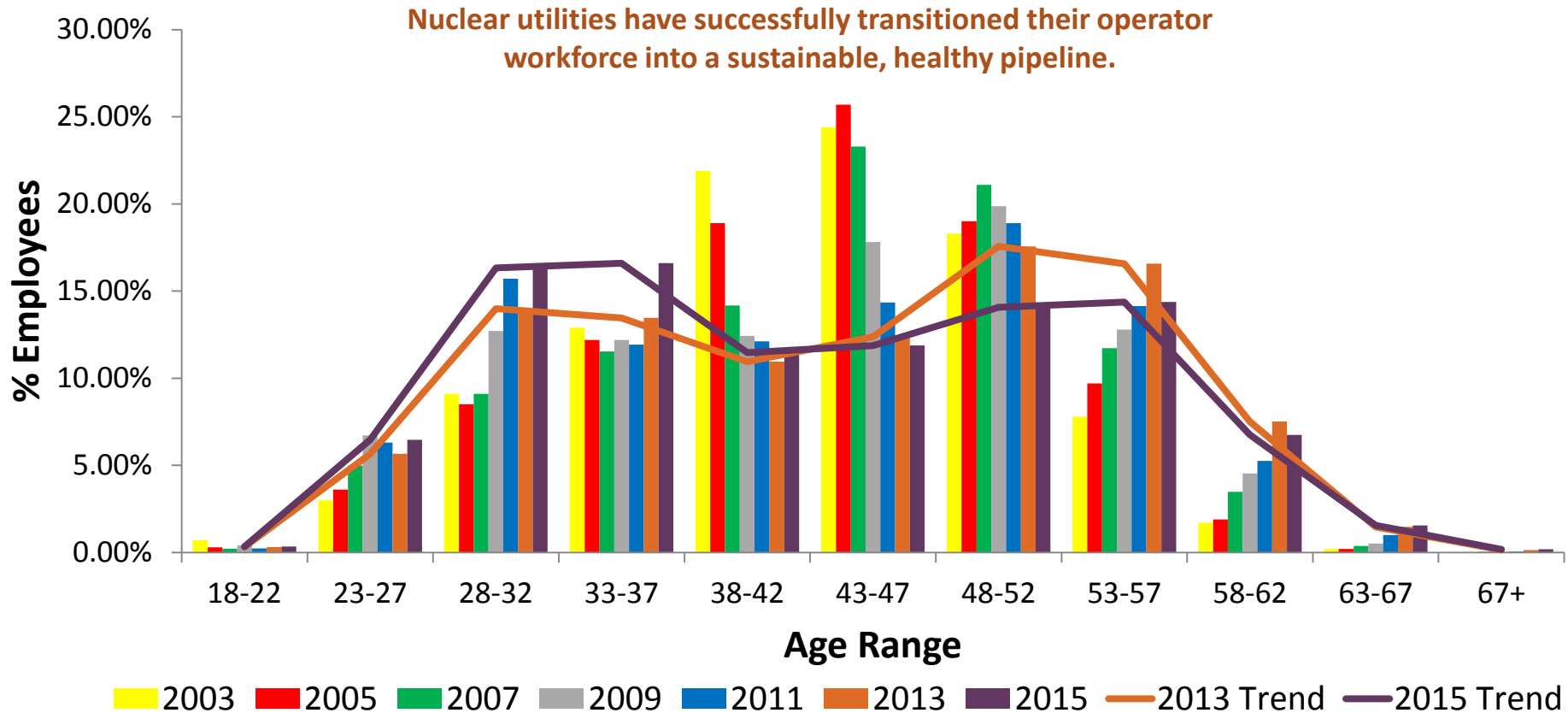
- 23 utilities supplied data
- Data represents 100% of utility employees
- AREVA, Babcock & Wilcox, Cameco USA, Day & Zimmermann, Fluor, GE Hitachi, Holtec, NAC International and Westinghouse



Nuclear Industry Employment Distribution by Age



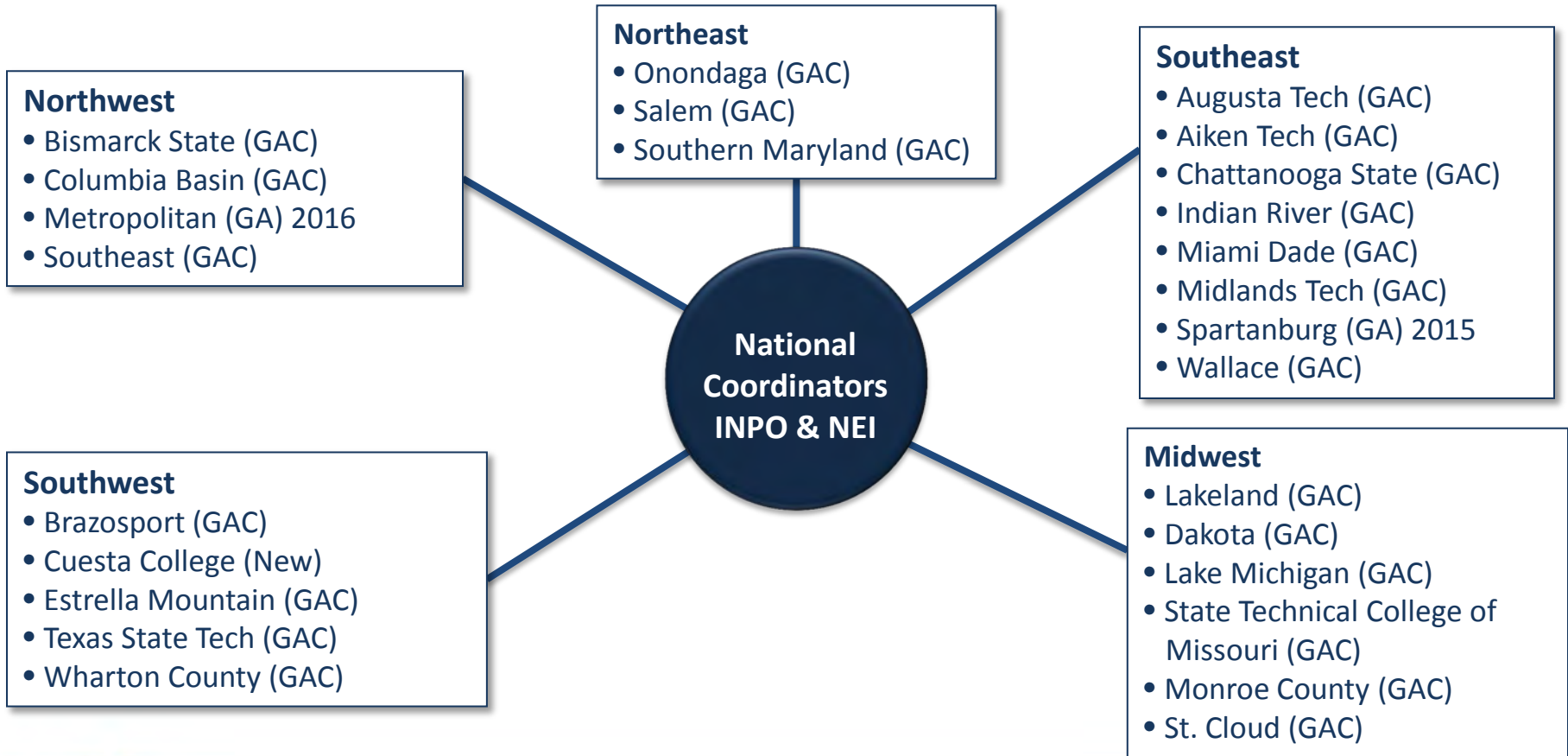
Nuclear Generation Operations Distribution by Age



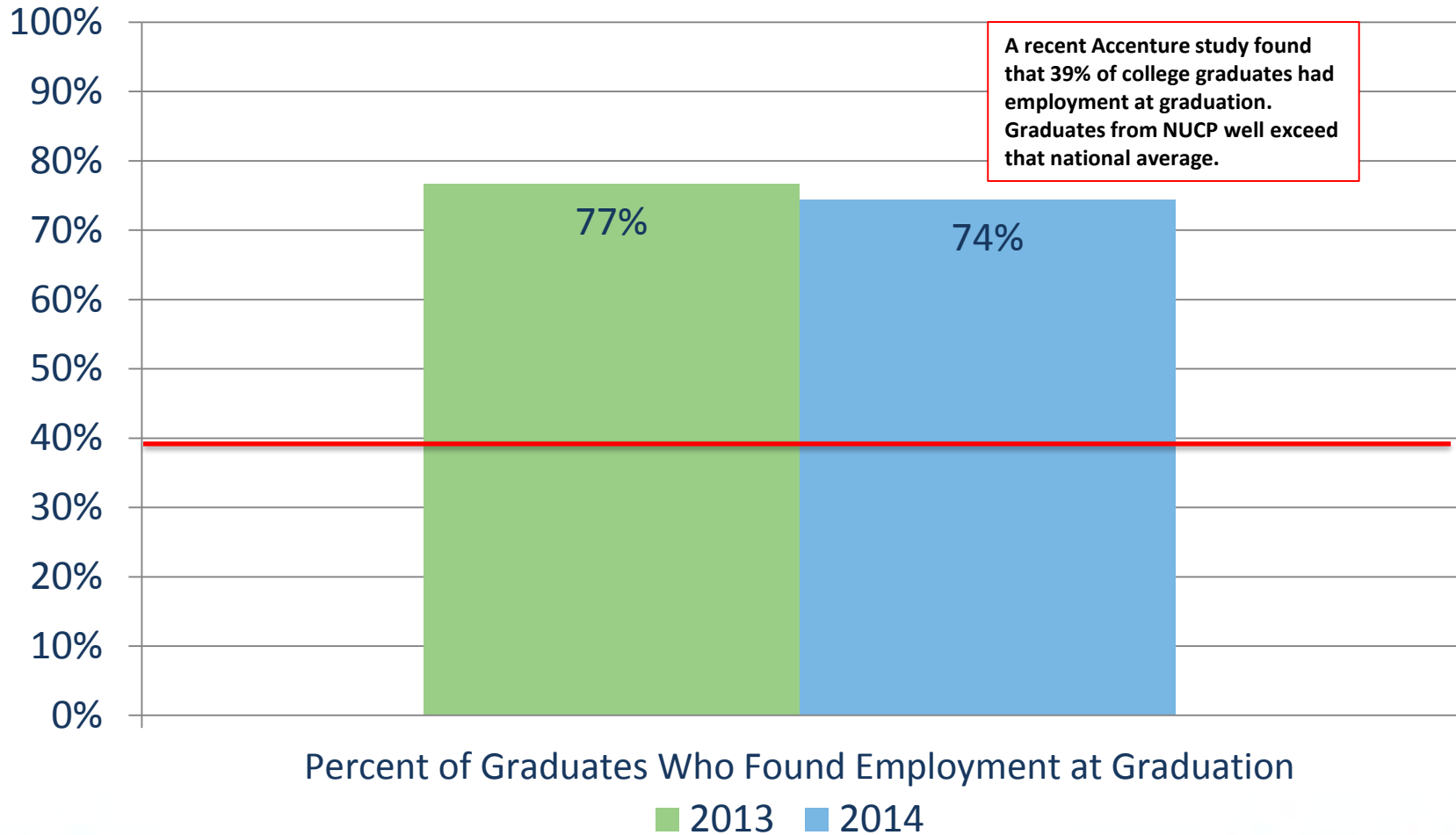
Nuclear Uniform Curriculum Program

October 2015

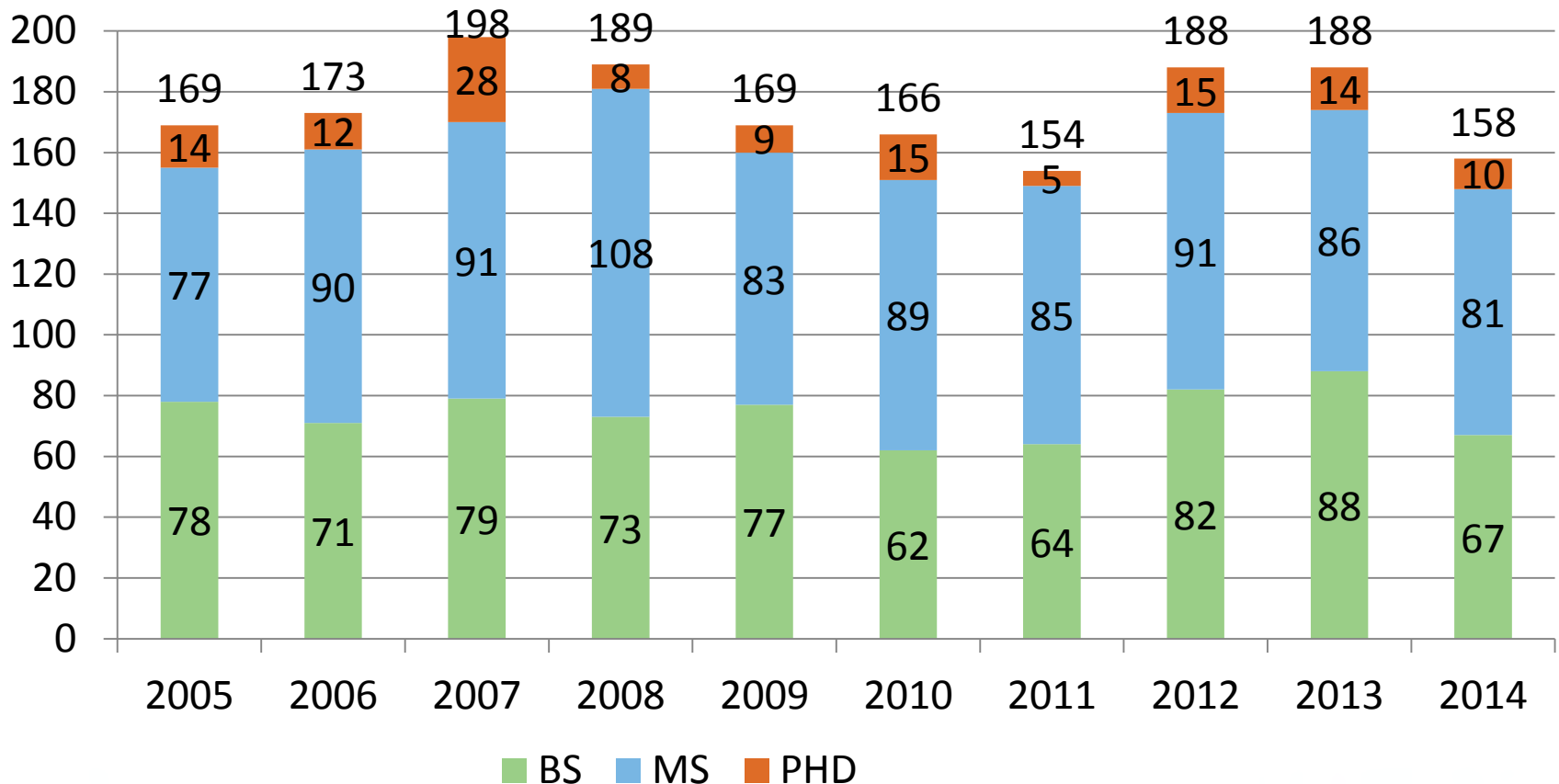
G – Gap Analysis Submitted **A** – AOU Submitted **C** – Challenge Board Completed **Date** – Challenge Board Planned



NUCP Graduation Placement



Total U.S. Health Physicist Graduates



Summary – Technician Positions

- No major issue for utility positions – a result of the industry focus on growth
 - NUCP graduates successfully filling openings
 - In 2014 — **5% of RP Workforce** NUCP grads (began in 2009)
 - Shut-down sites & supplemental work force are also a source
- Supplemental positions are a challenge
 - Experience required per ANSI criteria (2 y)
 - Shorter outage lengths result in up to 6 y needed to achieve required experience
 - Utilities hire from the supplemental pool



Summary – Health Physicists

- Clearly recognize that the work-force is aging
 - Data indicates one of oldest specialties
 - Average of approx. 5 health physicist per operating unit
 - Currently hiring approximately 30 health physicist per year
- Resources are not at a critical level in the industry at this point
 - Deferred retirements
 - Shut-down sites provide additional individuals
 - Colleges graduates fill positions
 - Consultants fill short-term open positions
- Positions will continue to be closely monitored
- Knowledge transfer programs are a critical element to continued success



Education or Training – Does it Matter?

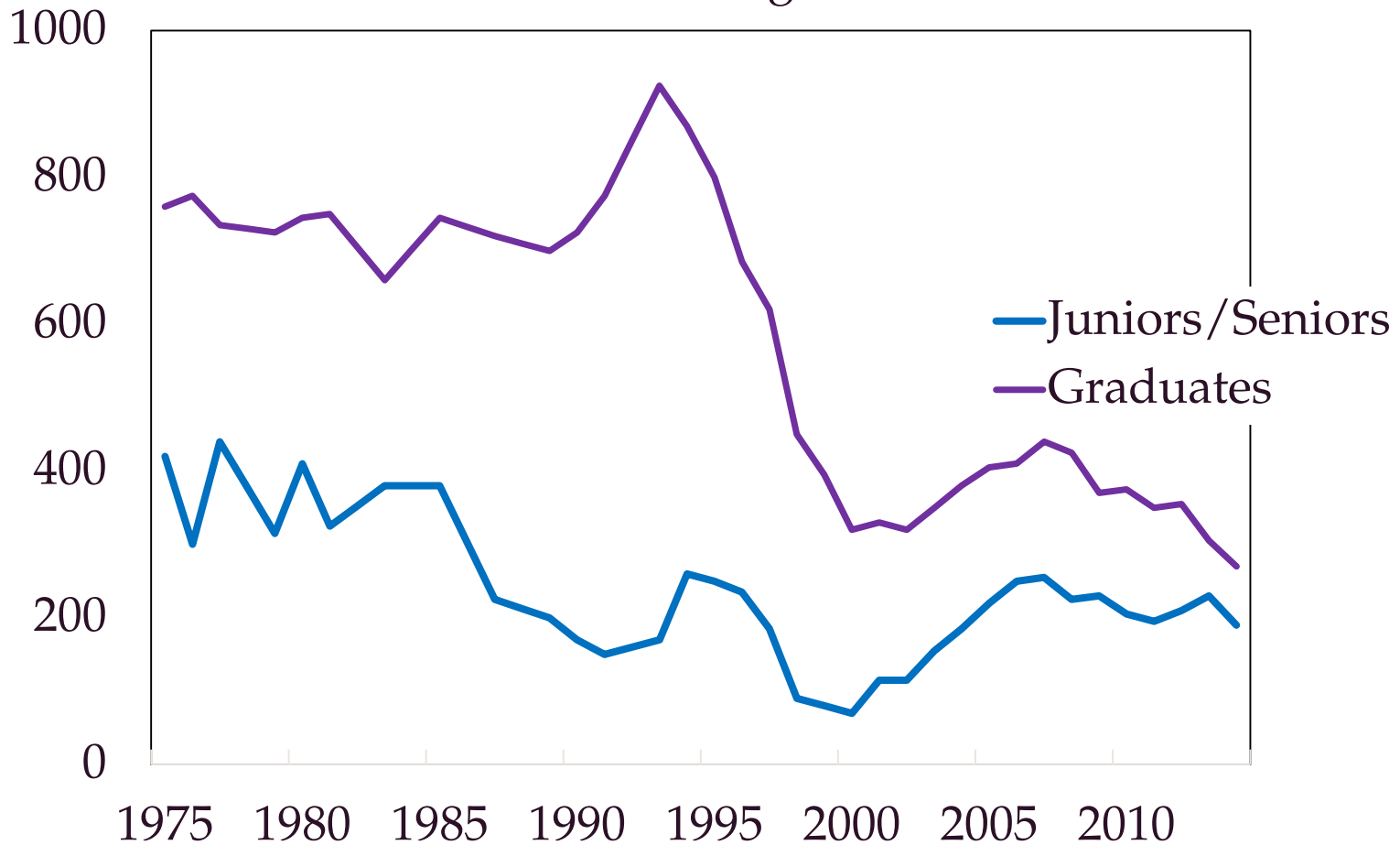
Kathryn Higley, PhD, CHP

Professor and Head, School of Nuclear Science
and Engineering

Oregon State University

Declining Enrollments

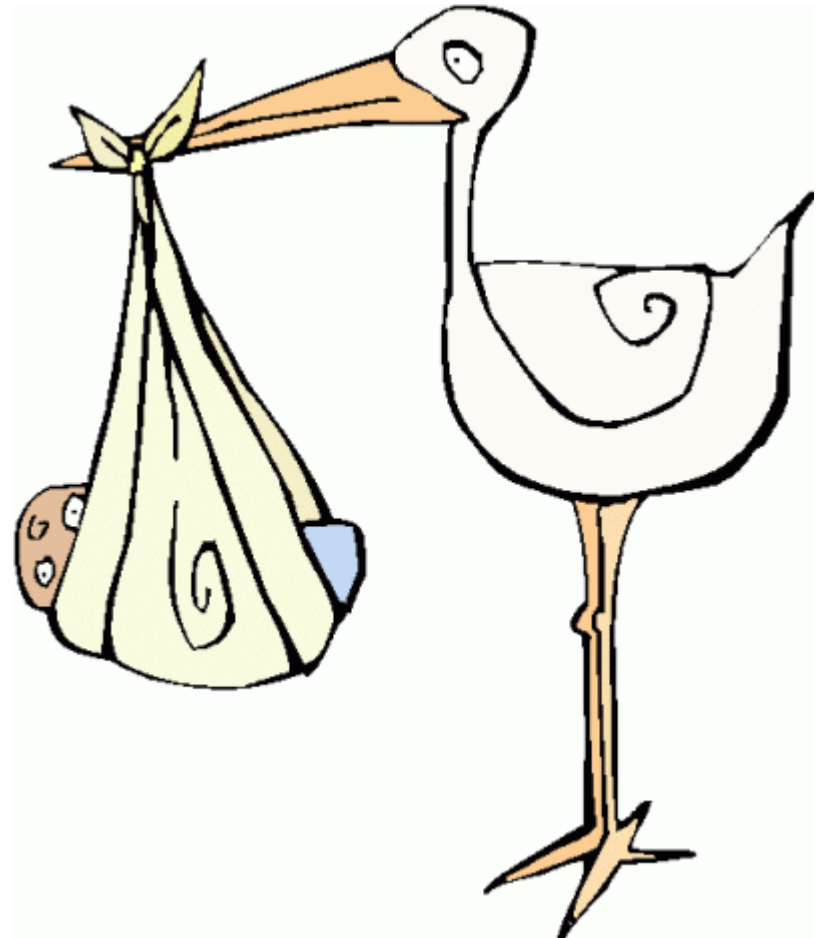
US Academic Institutions – HP Enrollments
1975 through 2014



Fewer Health Physicists – no big deal – market forces will provide sufficient capacity.....?

Permit me to digress

How are health
physicists made?



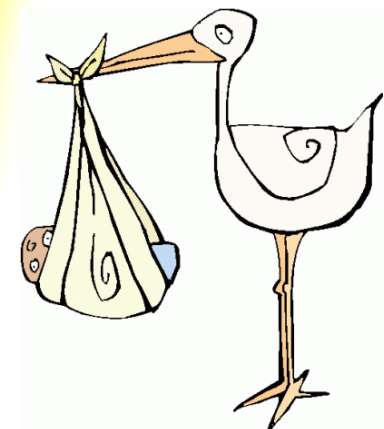
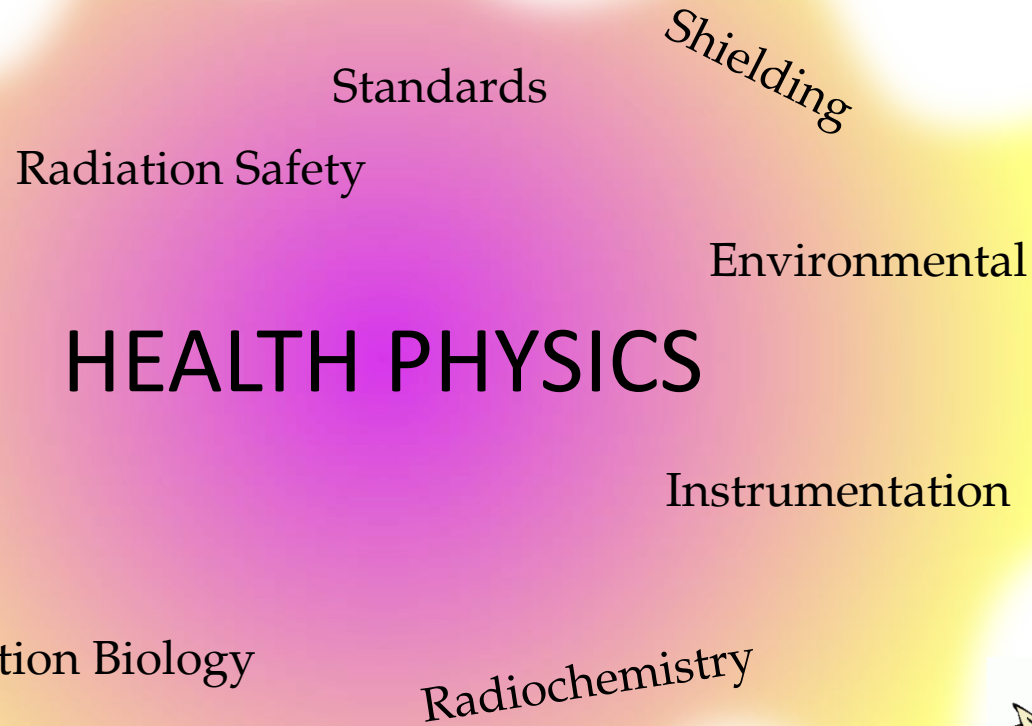
A diffuse, ill-defined field

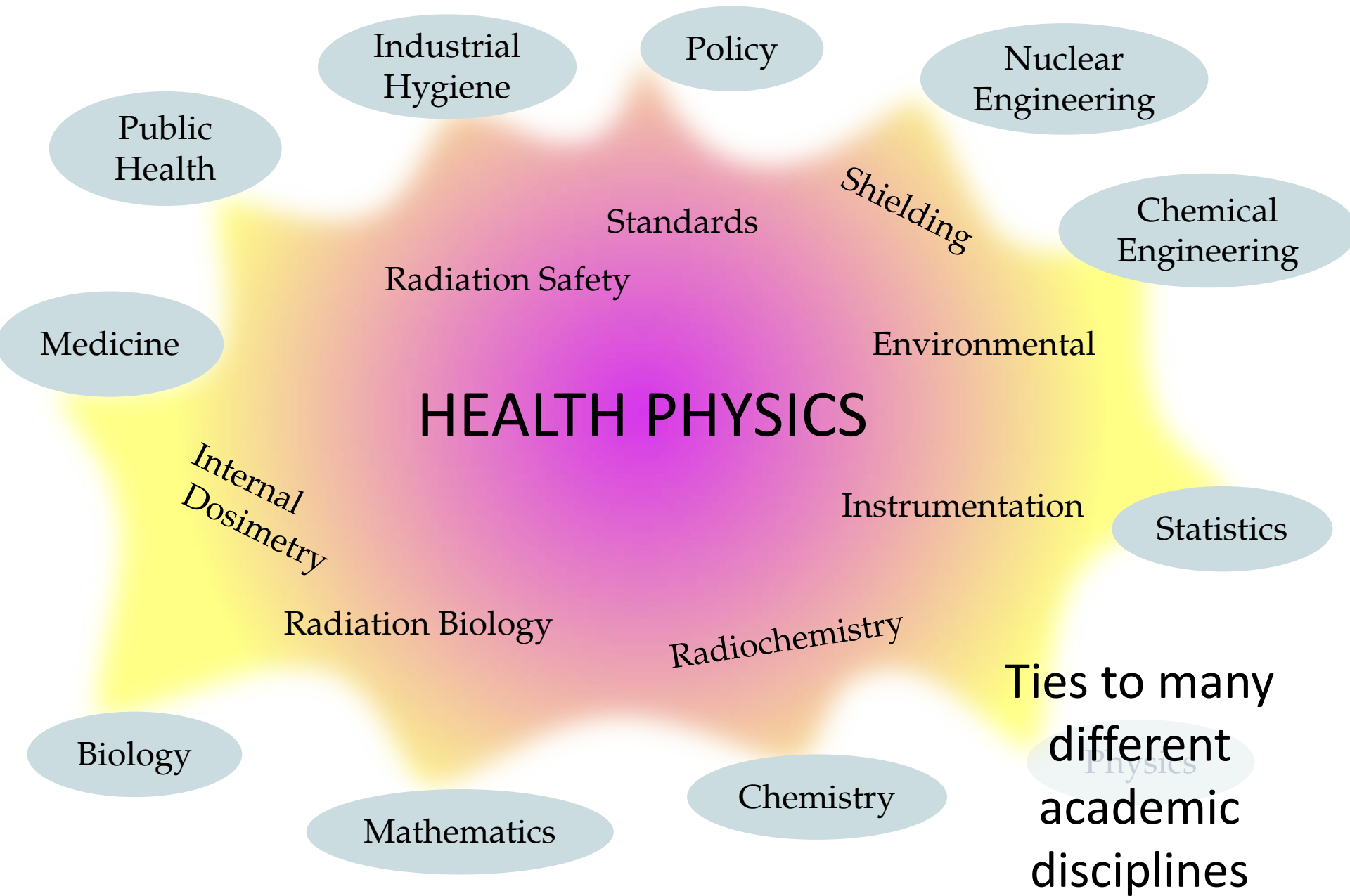


HEALTH PHYSICS

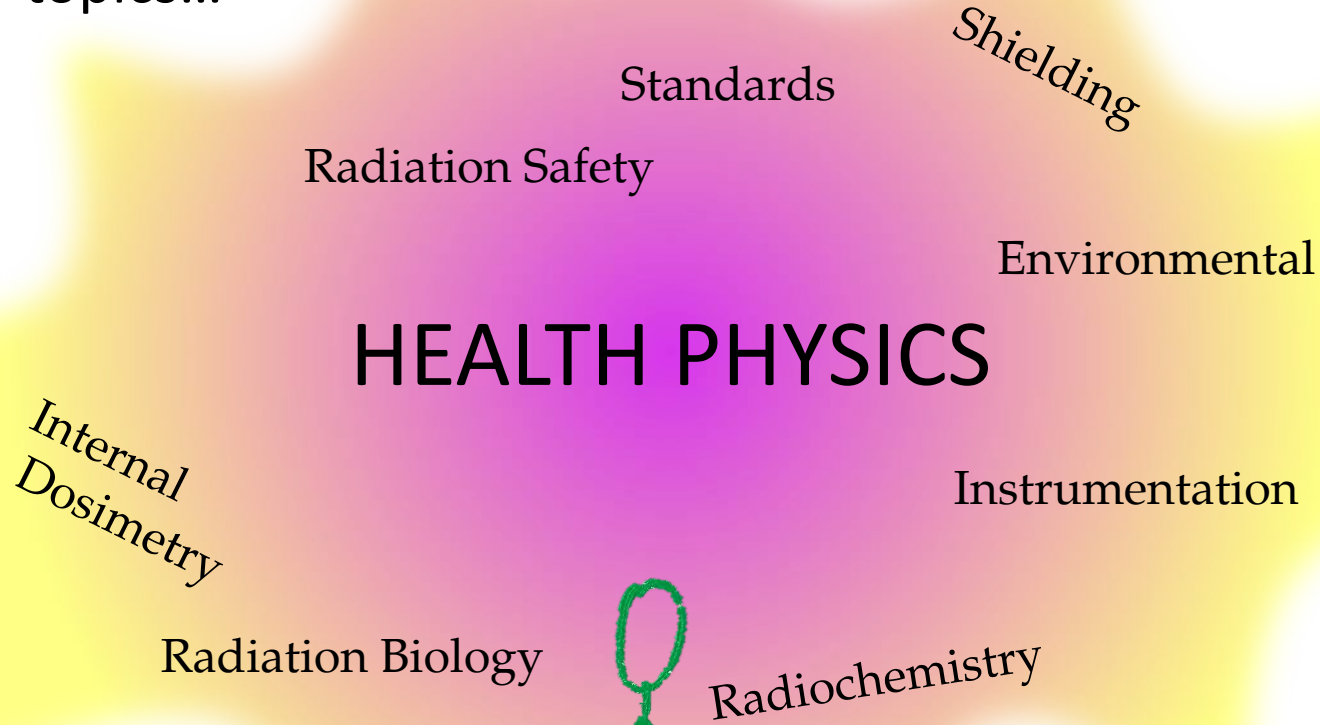
Many different
specializations

HEALTH PHYSICS

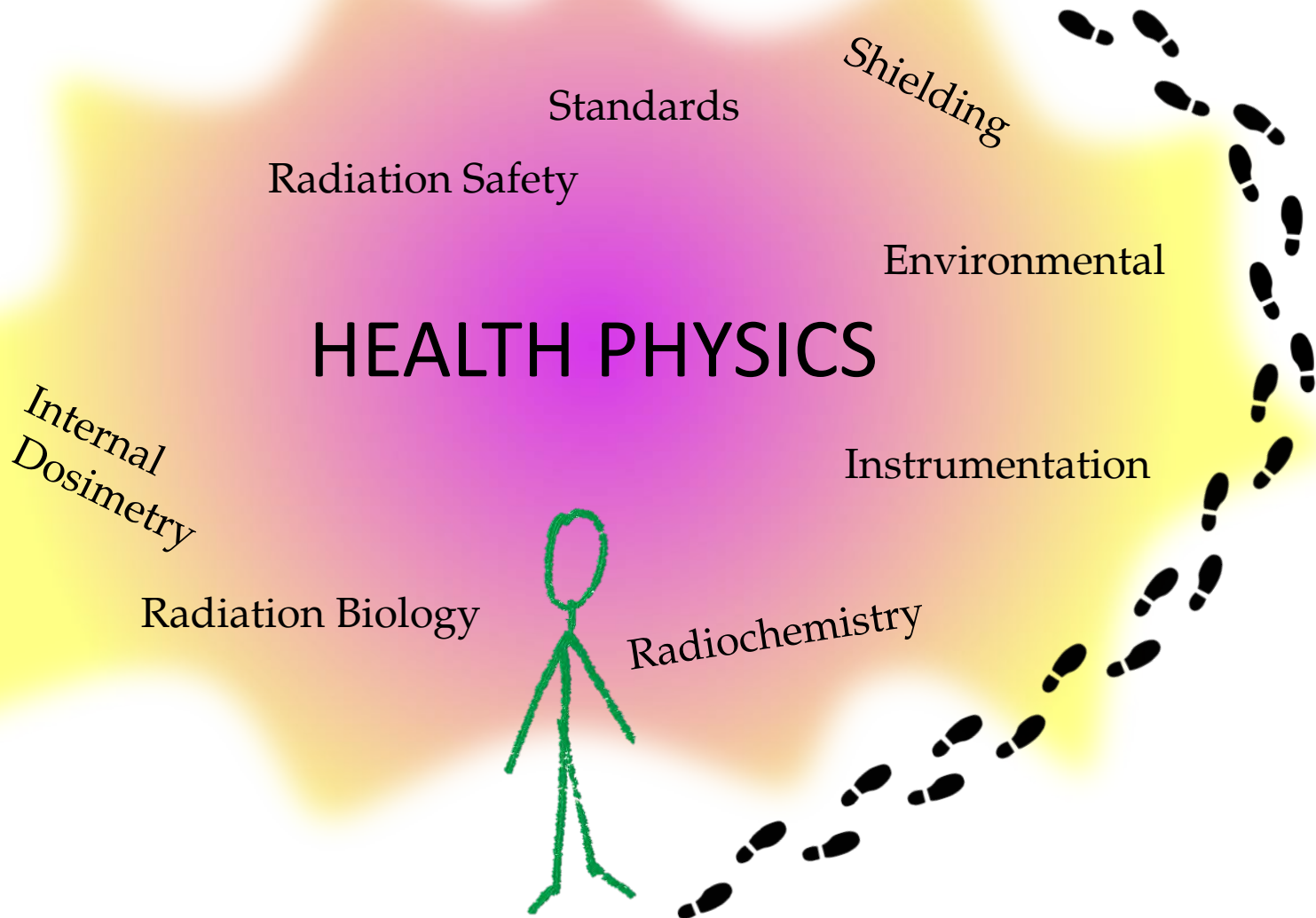




A student can be educated
in some or all of these
topics...



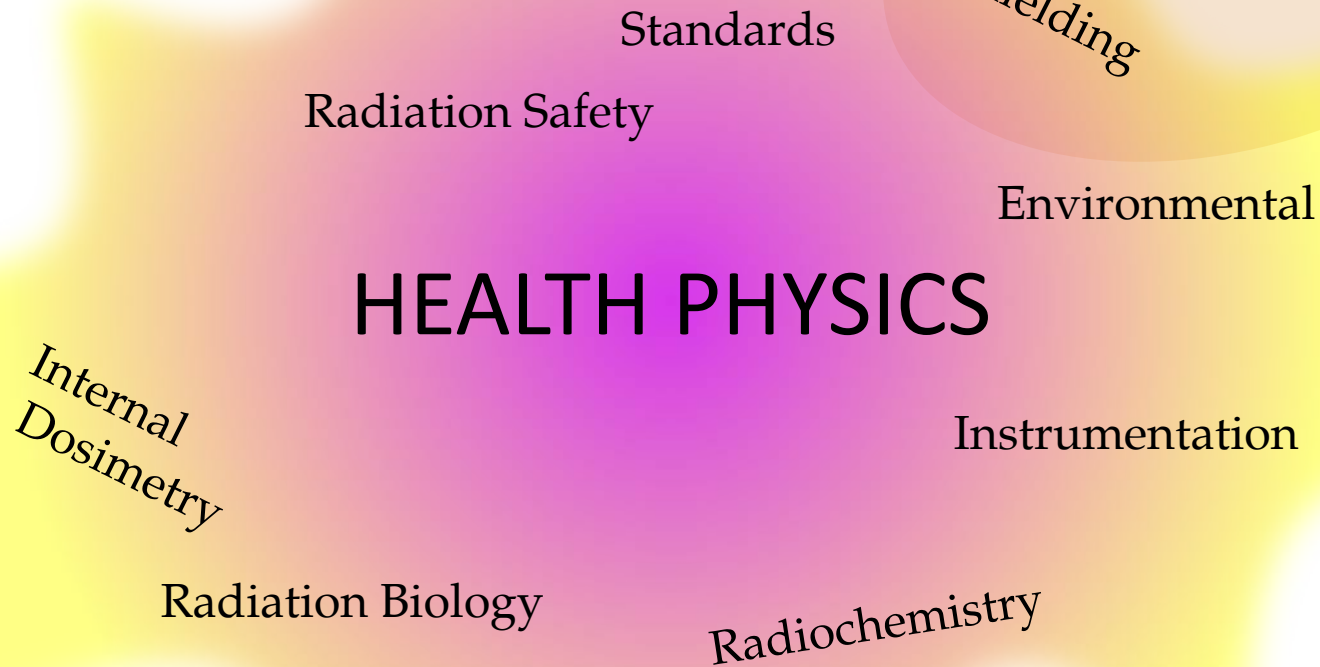
And with the right education, a student can move between these specializations as the employer's need evolves



But what if the individual you've hired doesn't have broad health physics education?

And you still need a health physicist?

Many disciplines overlap
with health physics



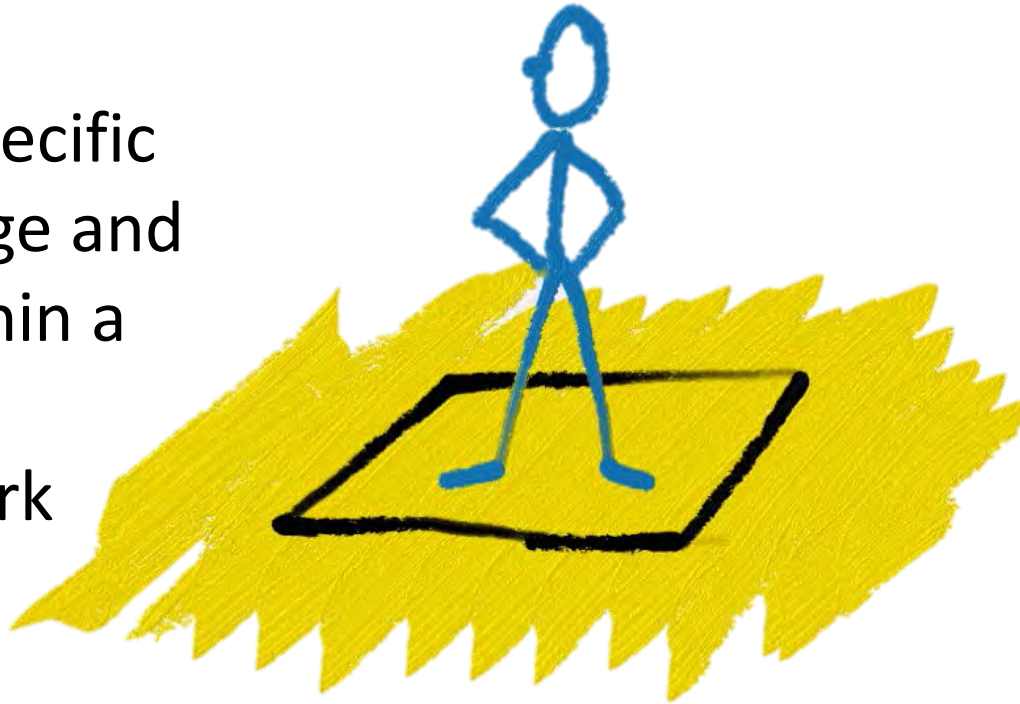
So if you have someone with
“*health physics-like*” education –
can you create a health physicist?

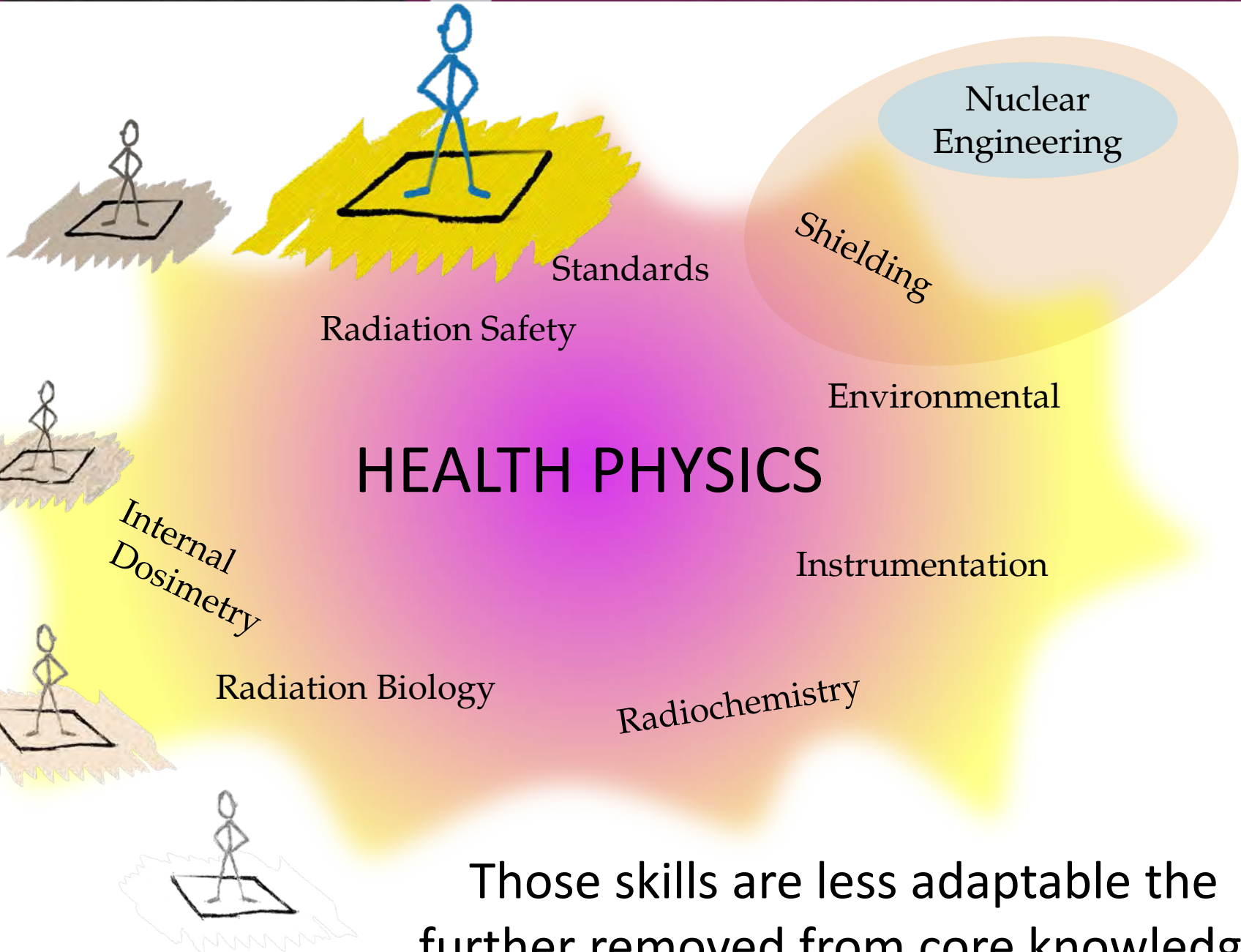
Is training the answer?



What Does Training Accomplish?

Instills specific knowledge and skills within a defined framework





Nuclear Engineering

Shielding

Environmental

Instrumentation

HEALTH PHYSICS

Standards

Radiation Safety

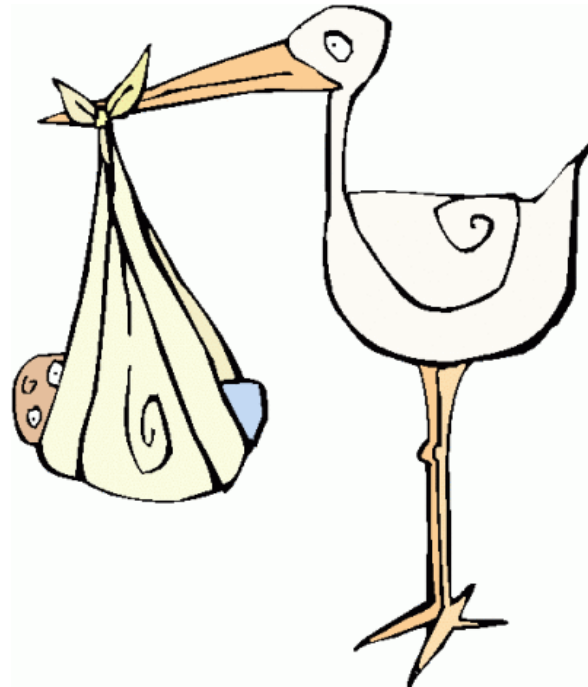
Internal Dosimetry

Radiation Biology

Radiochemistry

Those skills are less adaptable the further removed from core knowledge

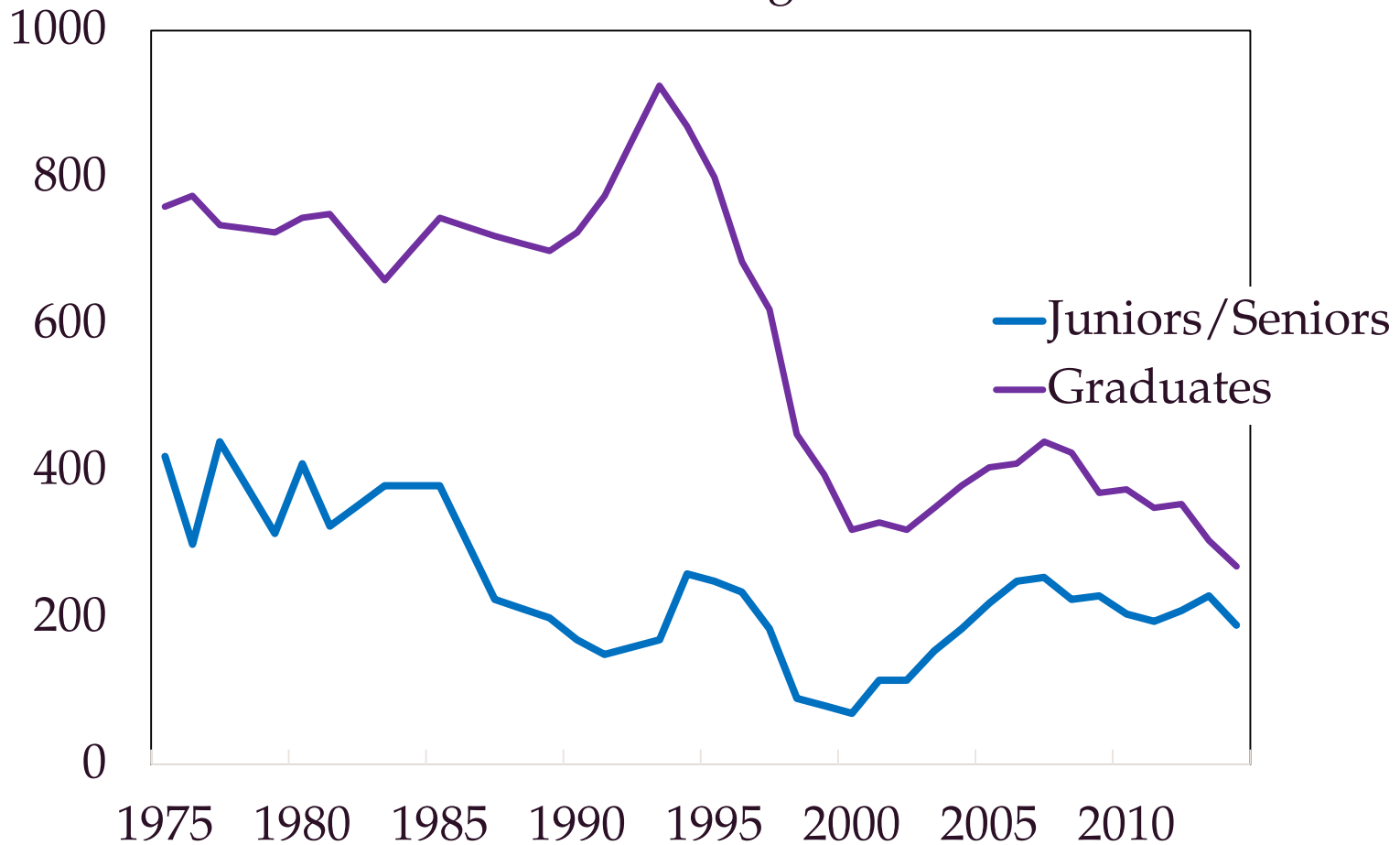
Training may, but likely will not, fill the need for well rounded, knowledgeable health physicists



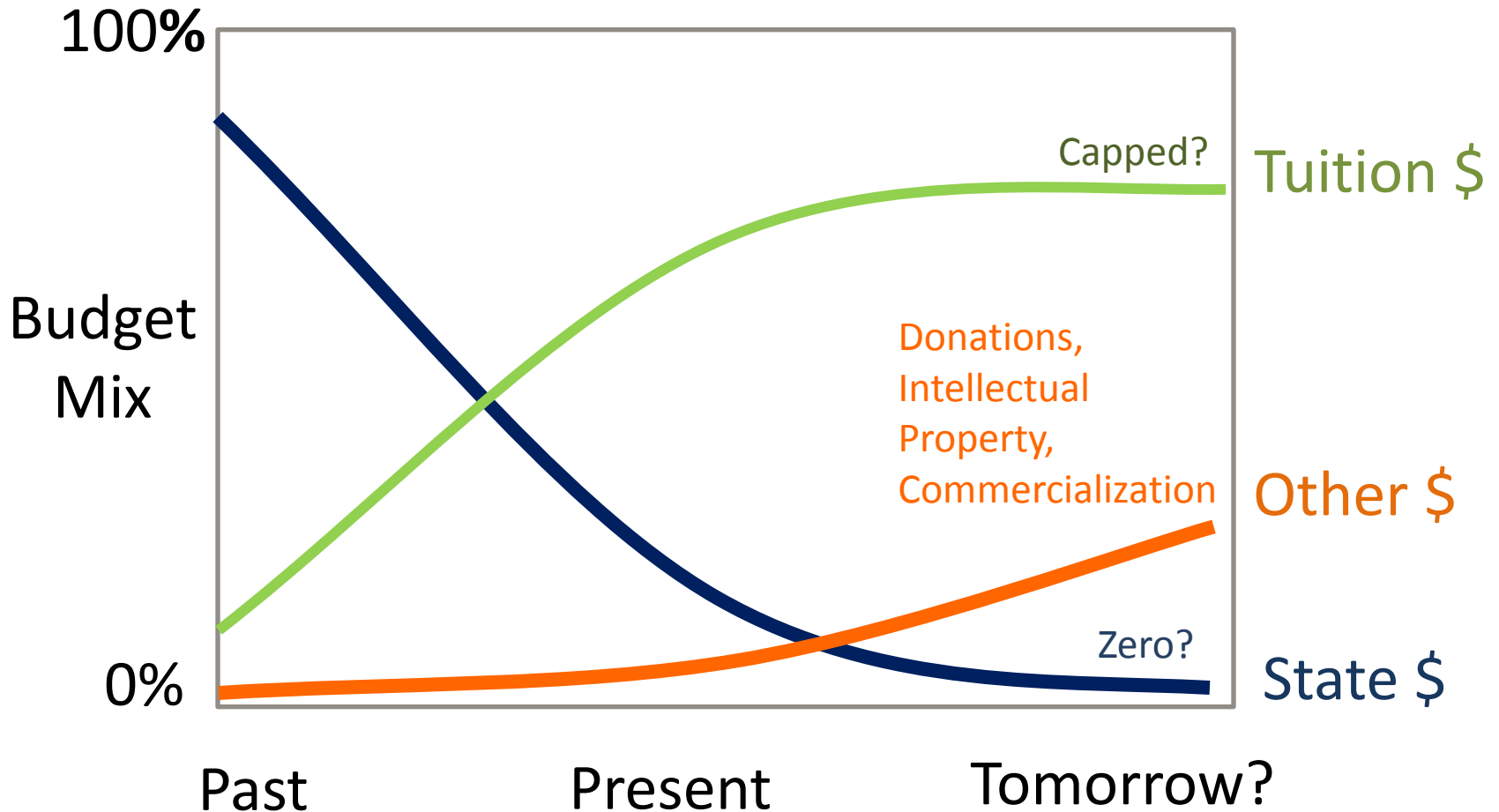
You still need educated health physicists- particularly when something goes wrong...

Declining Enrollments

US Academic Institutions – HP Enrollments
1975 through 2014

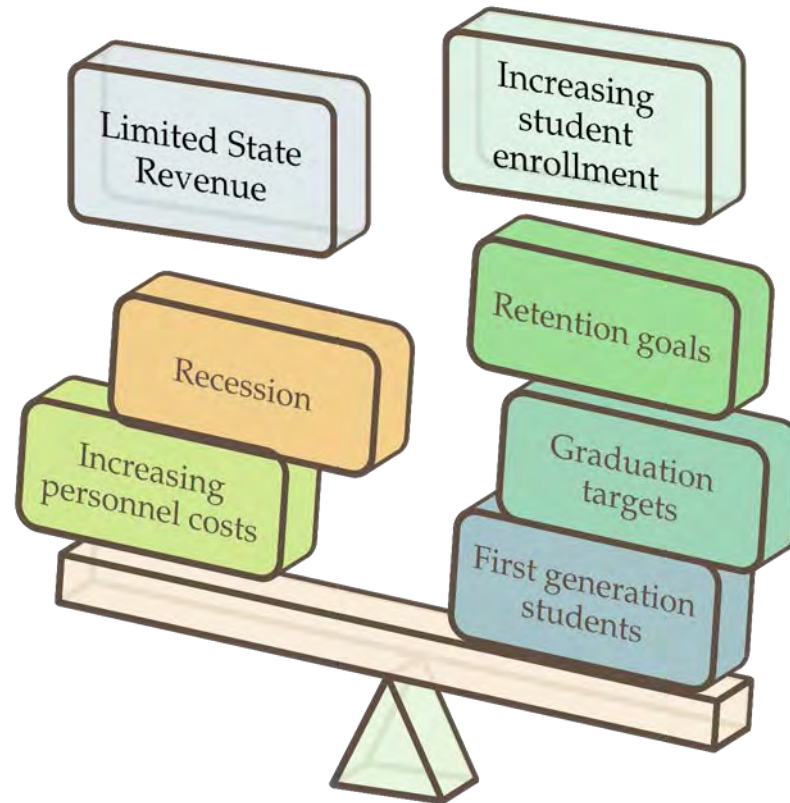


Enrollments and Shifting Revenue Streams in Higher Ed



*Conventional wisdom: Undergraduate programs bring in tuition \$; Graduate programs lose \$

Higher Ed: Resource Constraints & Competing Needs



- Tough decisions about priorities in Higher Ed are taking place
 - What investments are essential?
 - Where should we cut spending to support essential needs?
 - Where does support for small programs fit?

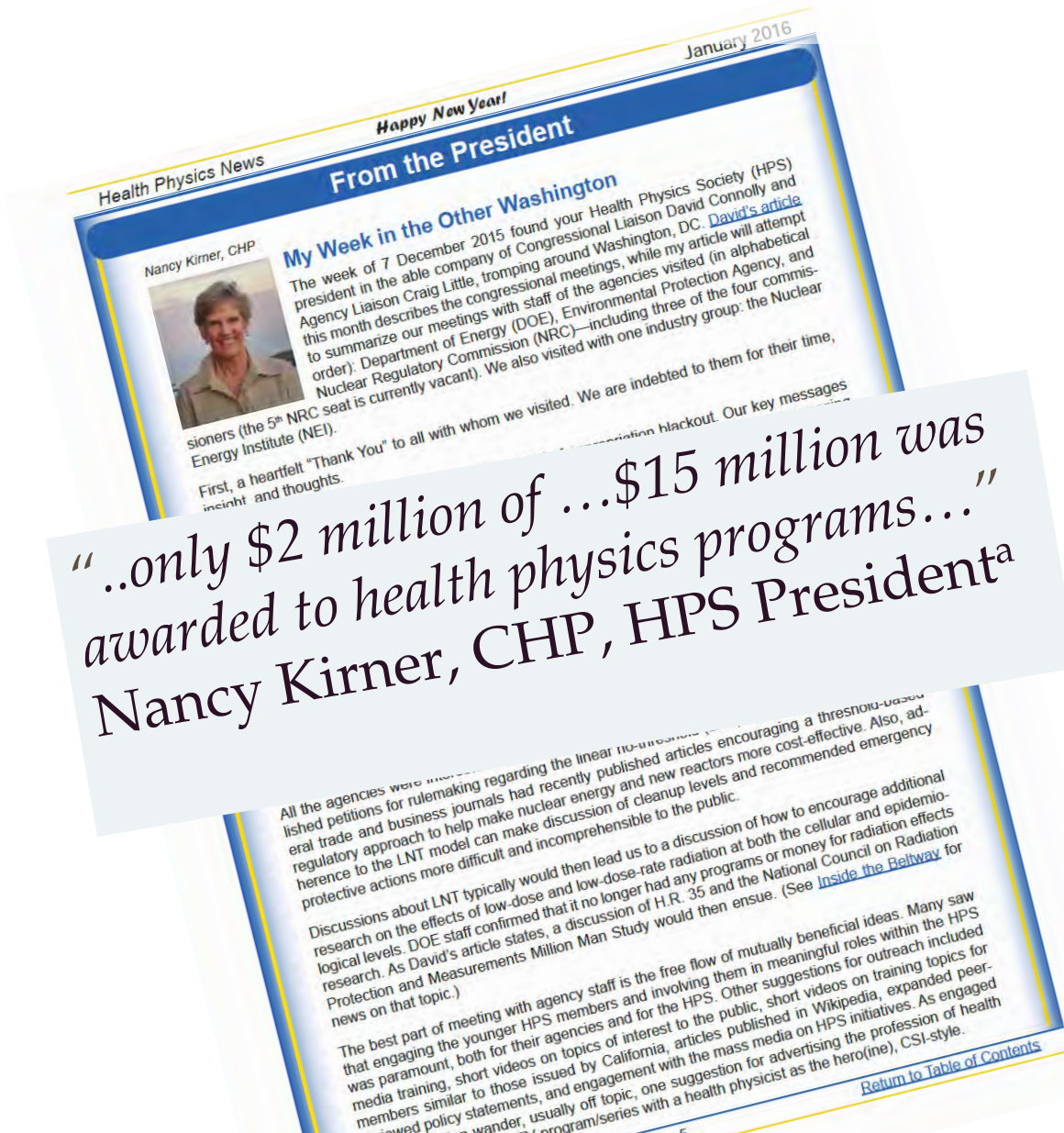


HP Programs, Degrees, and Reality: 2014



- BS programs
 - Programs ~ 13
 - Degrees: 67
 - 5 students / program
 - Maximum: 18
- MS programs
 - Programs ~ 20
 - Degrees: 81
 - 4 students / program
 - Maximum: 22
- PhD programs
 - Programs ~ 17
 - Degrees: 10
 - 1/2 student / program
 - Maximum 2

Declining Support for Health Physics Academic Research



^aUS DOE Integrated University Programs funding, 2015

Is This Sustainable? AY 2014

- Only 8 institutions graduated HP PhDs – none graduated more than 2
- Only 3 institutions graduated more than 10 MS students
- Only 3 institutions graduated more than 10 BS students
- Higher Education is shifting to a ROI model
- HP programs are not financially sustainable

WHAT ARE OUR OPTIONS IN ACADEMIA?

- Collaborate, evolve or perish?
 - Share courses
 - Joint degrees
 - Pooled curriculum
- Examples –
 - Interuniversity doctoral consortium in New York¹
 - Joint doctoral program in Montreal
- Resistance is expected
 - Threat to autonomy – hallmark of Higher Education
- Create academic leagues for research universities?

¹Jonathan R. Cole, *Building a New Research-University System*, January 17, 2016, *The Chronicle of Higher Education* <http://chronicle.com/article/Building-a-New/234906>

What about Radiation Protection Societies?

Can They Play a Role?

Health Physics Society

Specialists in Radiation Safety • Founded 1956 • <http://hps.org>

- Provide a necessary voice to marshal support
- ~~Lobby~~ Inform
- Clarify who are health physicists
- Provide guidance to Academia on core competencies for health physicists
- Accredit / approve programs? (Alternative to ABET?)



What About Federal Agencies?

Can They Help?

.....time for another digression

Office of Personnel Management - Jobs

Classification & Qualifications

General Schedule Qualification Standards

Nuclear Engineering Series, 0840



VS

Classification & Qualifications

General Schedule Qualification Standards

Health Physics Series, 1306

Classification & Qualifications
GENERAL SCHEDULE QUALIFICATION STANDARDS

All Professional Engineering Positions, 0800

Individual Occupational Requirements

Basic Requirements:

Degree, professional engineering. To be acceptable, the curriculum must: (1) be in a school of engineering with at least one curriculum accredited by the Accreditation Board for Engineering and Technology (ABET) as a professional engineering curriculum, or (2) include differential and integral calculus and courses (more advanced than first-year physics and chemistry) in five of the following seven areas of engineering science or physics: (a) statics, dynamics, (b) strength of materials (stress-strain relationships), (c) fluid mechanics, hydraulics, (d) thermodynamics, (e) electrical fields and circuits, (f) nature and properties of materials (relating particle and aggregate structure to properties), and (g) any other comparable area of fundamental engineering science or physics such as optics, heat transfer, soil mechanics, or electronics.

RELATED INFORMATION

Associated Group Standard
Use the Group Coverage Qualification Standard for Professional and Scientific Positions for this series in conjunction with the Individual Occupational Requirements described below.

Note:
An applicant who meets the basic requirements as specified in A or B above may qualify for positions in any branch of engineering unless selective factors indicate otherwise, or unless he/she qualifies under the provisions of G.2 related to the EIT examination or BET degree.

Additional Experience and Training Provisions for Graduates of Professional Engineering Curricula:

1. Superior academic achievement at the baccalaureate level in a professional engineering curriculum is qualifying for GS-7.
2. Individuals can be converted noncompetitively to a GS-7 position if they complete all the requirements of a Federal baccalaureate level student-trainee program, including 1040 hours of work experience, 320 hours of which was at the GS-5 level.
3. A combination of superior academic achievement and 1 year of appropriate professional experience is qualifying at GS-6.
4. Applicants with an engineering degree who have appropriate experience as a technician equivalent to grade GS-5 or higher may have such experience credited for grade GS-7 only on a month-for-month basis up to a maximum of 12 months.
5. Successful completion of a 5-year program of study, or at least 180 semester hours (equivalent to a bachelors degree in

Classification & Qualifications
GENERAL SCHEDULE QUALIFICATION STANDARDS

Health Physics Series, 1306

Individual Occupational Requirements

Basic Requirements:

A. Degree, natural science or engineering that included at least 30 semester hours in health physics, engineering, radiological science, chemistry, physics, biology, mathematics, and/or calculus.

B. Combination of education and experience – courses as shown in A above, plus appropriate experience or other education, or certification as a health physicist by the American Board of Health Physics, plus appropriate experience and other education that provided an understanding of sciences applicable to health physics comparable to that described in paragraph A.

RELATED INFORMATION

Associated Group Standard
Use the Group Coverage Qualification Standard for Professional and Scientific Positions for this series in conjunction with the Individual Occupational Requirements described below.

Engineer

Health Physicist

Requires graduation from an ABET accredited program, or PE / EIT and a bunch of other stuff

Requires 30 hours of science classes, *maybe some HP ones*

Recommendations

- Revise OPM classifications and qualifications for HPs more in line with Engineering professions
 - Minimum credit hours
 - Coursework
 - Approved academic program
- Mandate advanced degrees and/or certification for jobs with substantial radiation safety management or assessment responsibility
- Federal programs with substantial radiation safety obligations must carve out funds for academic research



INPO

- Promotes the highest levels of safety and reliability in the operation of commercial nuclear power plants.
- Establishes performance objectives, criteria and guidelines for the nuclear power industry

INPO and the nuclear industry must

- Require accreditation of health physics professionals
- Support knowledge transfer through
 - Internships
 - Partner with academic institutions
 - Encourage faculty experience

What is the Future?

- Without specific steps, Health Physics as a discipline will be relegated to a subspecialty footnote within other academic programs
- If it survives at all
- The broad, interdisciplinary education that is the hallmark of great health physicists will be lost.
- Training can help fill employer needs – but ***it is not sufficient***
- ***We are a victim of our own successes in minimizing accidents and controlling doses.***

But Wait a Minute

- For many decades people came into health physics through other disciplines:
 - Chemistry
 - Nuclear Engineering
 - Industrial Hygiene....
- There used to be a robust health physics community where they could share and learn fundamentals
- That community is now fragmented
- Consequently, the vibrant, after-college learning environment has been decimated.

Niche Knowledge at Risk

ASSURING A FUTURE U.S.-BASED
Nuclear and Radiochemistry Expertise



**Is there a Crisis in Nuclear
Radiochemistry Education**

Heino Nitsche

University of California at
Berkeley
and
Lawrence Berkeley National
Laboratory

ANS Embedded Topical Meeting- Isotopes for Medicine
Education
Anaheim, CA, June 11, 2003
Invited presentation

LAWRENCE BERKELEY NATIONAL
LABORATORY

THE FUTURE of UNIVERSITY NUCLEAR ENGINEERING PROGRAMS

and

UNIVERSITY RESEARCH & TRAINING REACTORS

Michael L. Corradini, Chair
Associate Dean, College of Engineering
University of Wisconsin, Madison

Marvin L. Adams, Professor
Nuclear Engineering Department
Texas A&M University

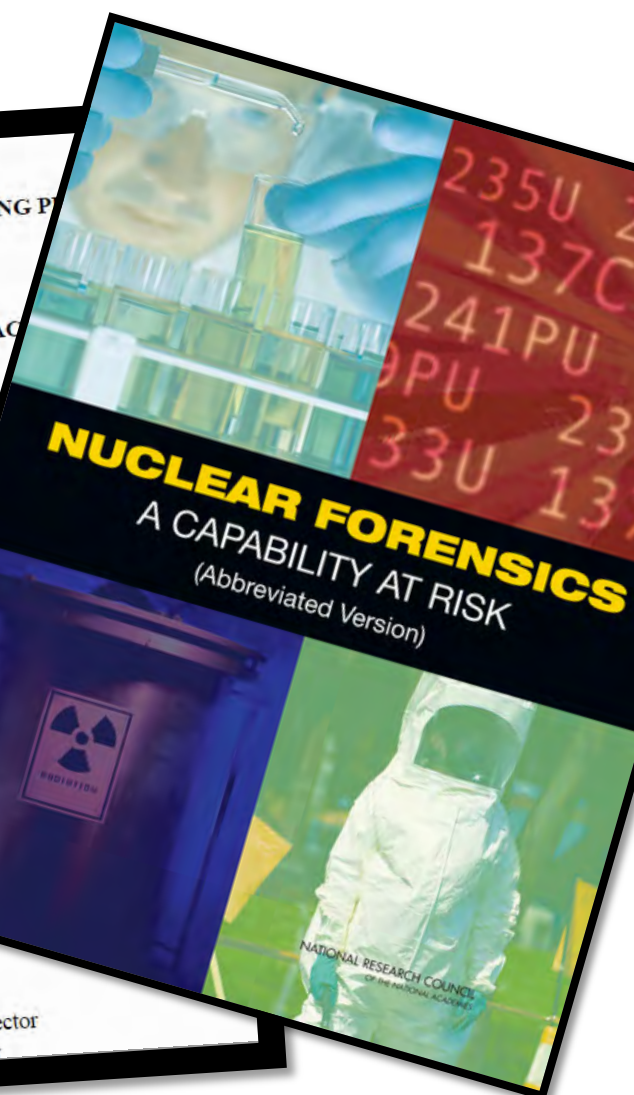
Donald E. Dei, Chief Physicist
United States Naval Nuclear Program

Tom Isaacs, Senior Scientist
Lawrence Livermore National Laboratory

Glenn Knoll, Professor
Department of Nuclear Engineering
University of Michigan, Ann Arbor

Warren F. Miller
Senior Advisor to the Laboratory Director
Los Alamos National Laboratory

NUCLEAR FORENSICS
A CAPABILITY AT RISK
(Abbreviated Version)



(Mis)Informed Policies & Standards?

[7590-01-P]

NUCLEAR REGULATORY COMMISSION
10 CFR Part 20

[Docket Nos. PRM-20-28, PRM-20-29, and PRM-20-30; NRC-2015-0057]
Linear No-Threshold Model and Standards for Protection Against Radiation

AGENCY: Nuclear Regulatory Commission.

ACTION: Petition for rulemaking; notice of docketing and request for comment.

SUMMARY: The U.S. Nuclear Regulatory Commission (NRC) has received three petitions for rulemaking (PRM) requesting that the NRC amend its "Standards for Protection Against Radiation" regulations and change the basis of those regulations from the Linear No-Threshold (LNT) model of radiation protection to the radiation hormesis model. The radiation hormesis model provides that exposure of the human body to low levels of ionizing radiation is beneficial and protects the human body against deleterious effects of high levels of radiation. Whereas the LNT model provides that radiation is always considered harmful, there is no safety threshold, and biological damage caused by ionizing radiation (essentially the cancer risk) is proportional to the amount of radiation exposure to the human body (response linearity).
Submitted by Carol S. Marcus, Mark L. Miller, and Mohan Doss (the
February 13, 2015, and February 24, 2015, respectively.
February 20, 2015, February 27, 2015, and
PRM-20-28, PRM-20-29, and PRM-
to determine

- Linear No-Threshold
- Epigenetics and long term risks
- Individual human radiosensitivity
- High LET radiation and human space flight
- Dose calculation system
 - Whole body / Critical Organ
 - Whole body / dose equivalent / effective dose equivalent
 - Equivalent dose / effective dose
 - Detriment
 -

Suggested Solutions

- Cooperation and cash
 - Academic programs must cooperate with each other
 - Industry and government must support academic programs
 - Continue scholarships, fellowships and internships
 - ***Add research set asides for academic programs***
- Recognition and respect
 - Designate certain expertise (HP and others) '**areas of strategic national need**' – somethings should be outside the budget model
- Regulation and retention
 - Reclassify Health Physicist in OPM system
 - Broaden coursework requirements in order to be considered a HP.
 - NRC (and other equivalent organizations) mandate stricter education and or licensure for certain jobs

Conclusions

- Specific steps are needed to retain Health Physics as an academic discipline
- Health Physics represents a strategic national need
- It is in peril
- No single action will save it.
- Multiple actions must be taken, and soon
 - Cooperation and cash
 - Recognition and respect
 - Regulation and retention

ACKNOWLEDGEMENTS

- Recognize these mentors (and many more)
 - Ron Kathren
 - Jack Corley
 - Joe Soldat
 - Gene Schreckhise
 - Ward Whicker
- And these colleagues (and many more)
 - Bruce Napier
 - Bill Kennedy
 - Dan Strom
 - John Boice

Estimating Cancer Risks at Very Low Doses



Epidemiologist



Radiobiologist

*What can be done?
Who can do it?*



Animal researcher

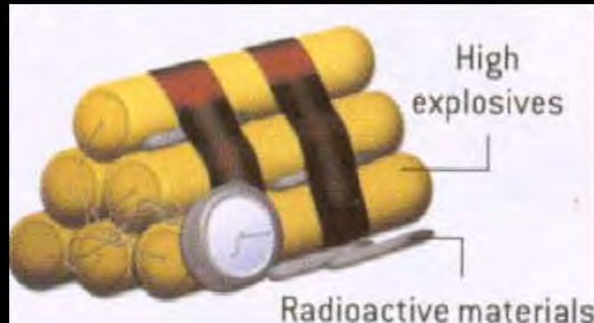


Statistician

David J. Brenner
Center for Radiological Research
Columbia University

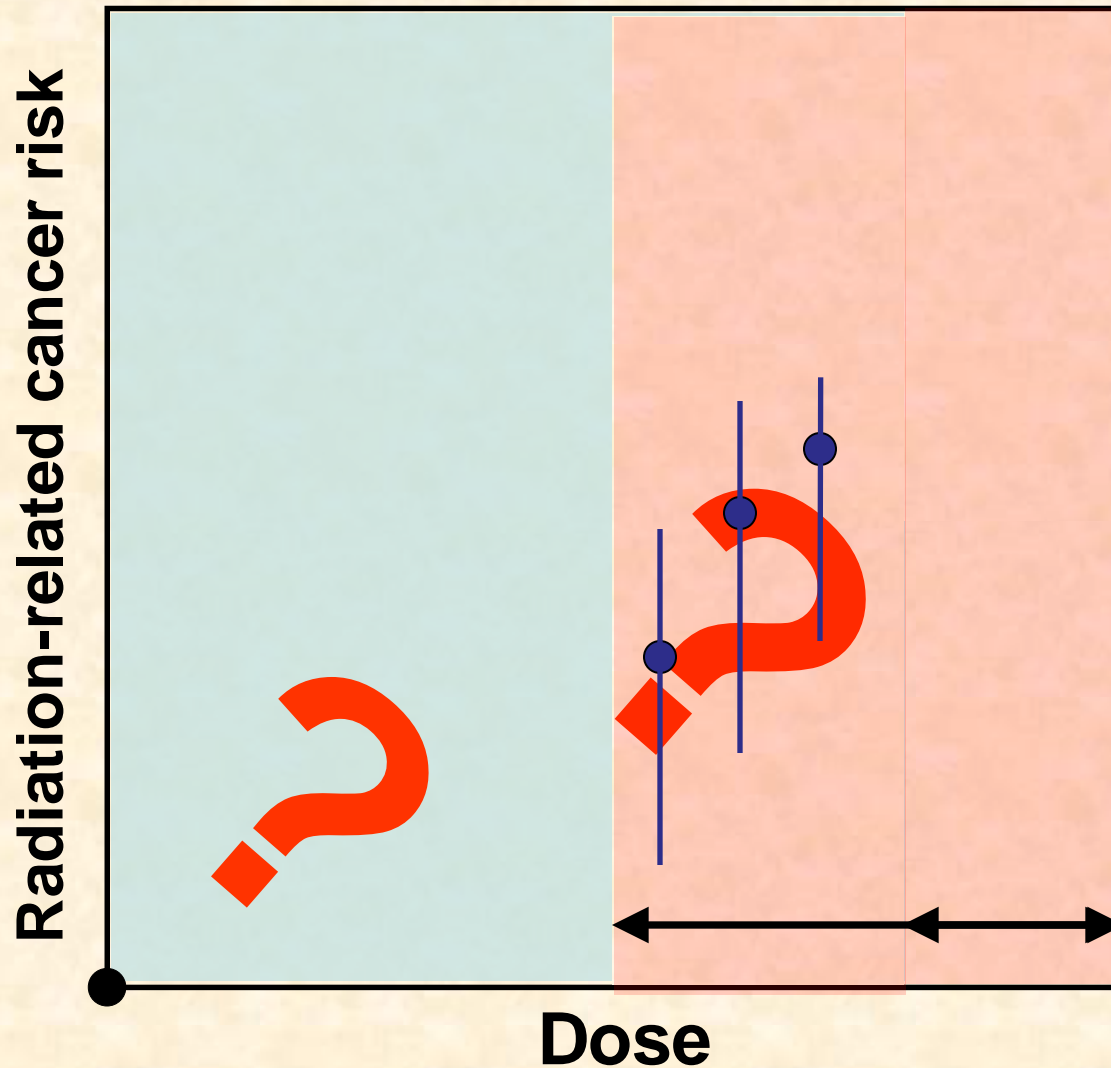
djb3@columbia.edu

Why are we interested in the effects of low doses of ionizing radiation?

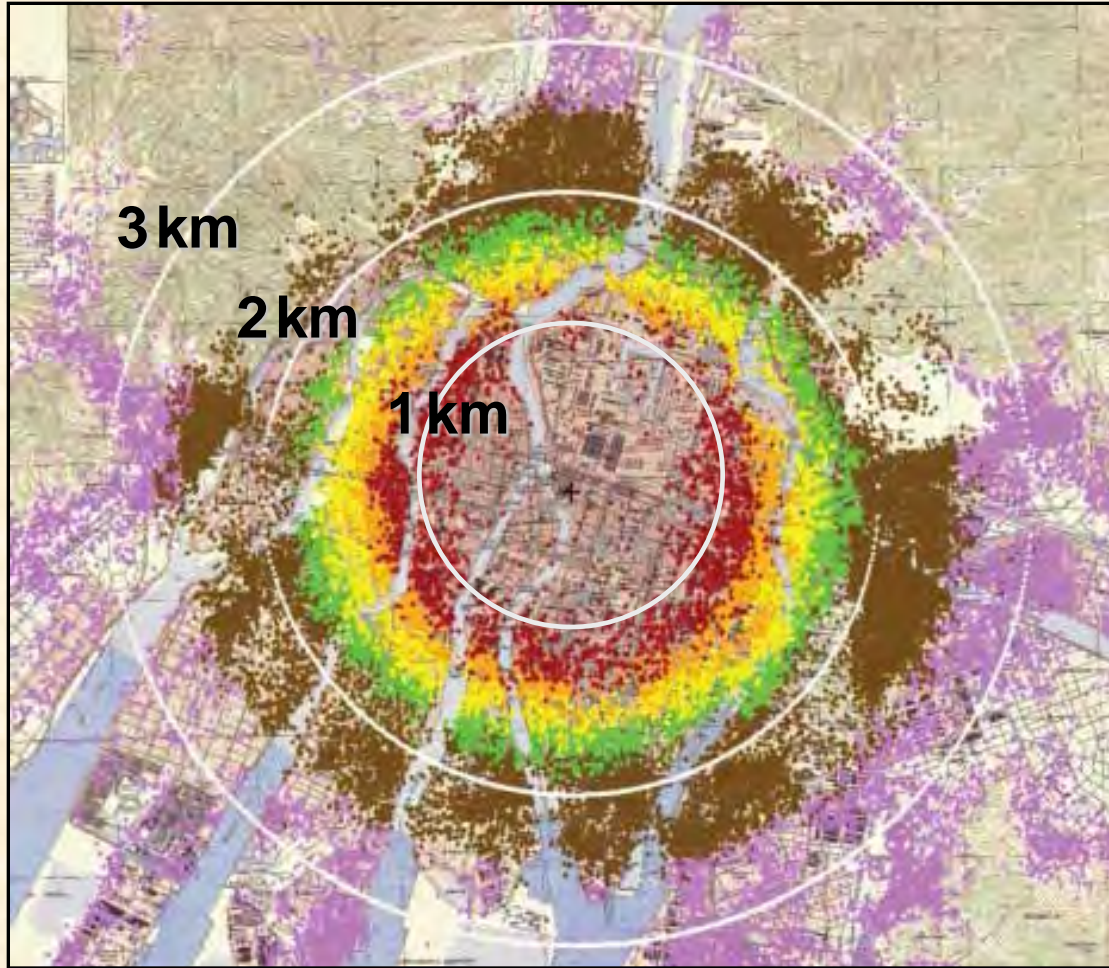


Low Radiation Doses....

We don't have the cancer risk data



What we know about the cancer risks associated with low doses of ionizing radiation



Brown dots: Individuals exposed to between 5 and 100 mGy (n~25,000)

At present we can't go that much lower in dose

Three studies of mortality in radiologists

STUDY	Relative Risk	
Matanowski (US)	1.2	Statistically significant increase
Berrington (UK)	0.68	Statistically significant decrease
Carpenter (UK)	1.03	No significant change

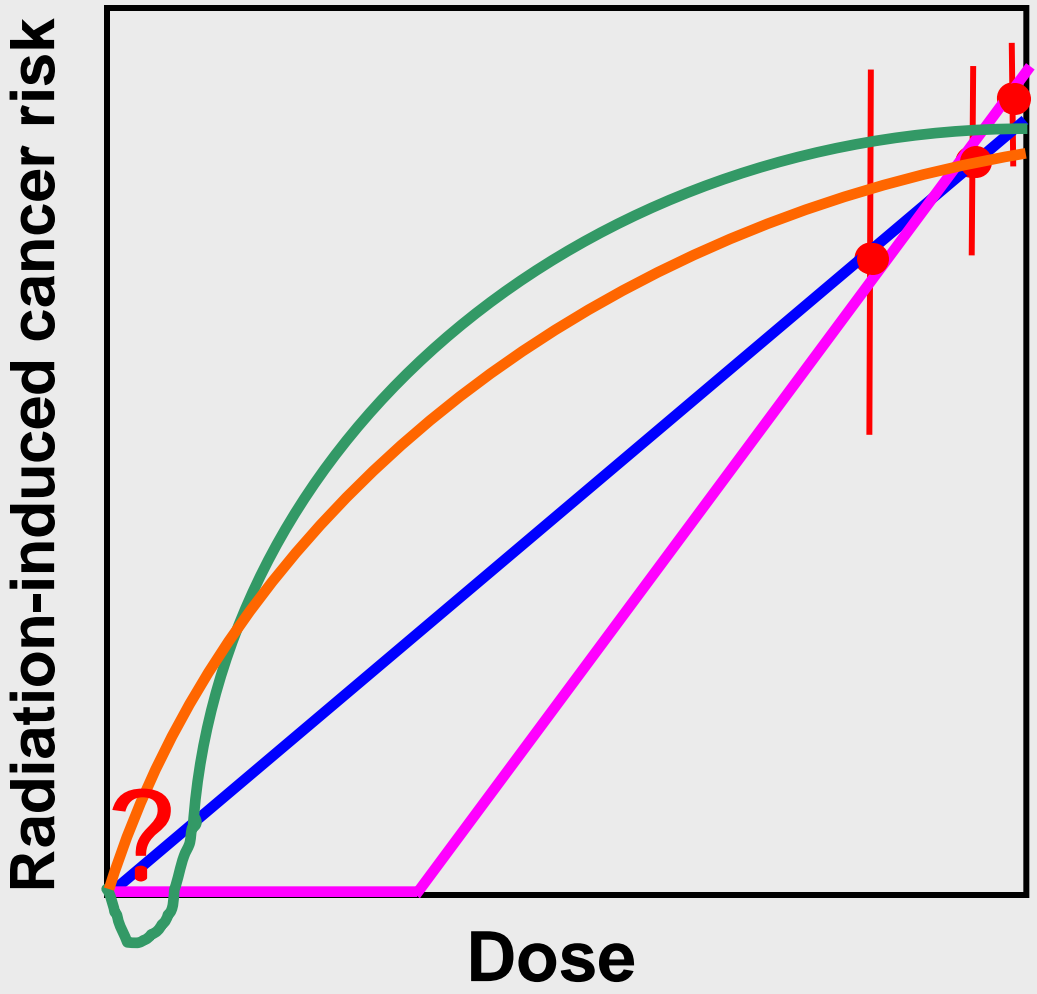
Why can't we get useful information from epidemiological studies at still lower doses?

- **~40% of any study population will get cancer anyway**
- **At very low doses, looking for very small excess risks on top of this 40% cancer background requires huge epidemiological studies**

At present we have to either scale or extrapolate the cancer risks we need, based on higher-dose epidemiological data

- **To lower doses**
- **To different radiation qualities**
- **To different dose rates**
- **To populations with different radiation sensitivities**
 - **Different ages**
 - **Different genetic sensitivities**

The most appropriate methodology to extrapolate measured radiation-induced cancer risks to very low doses?

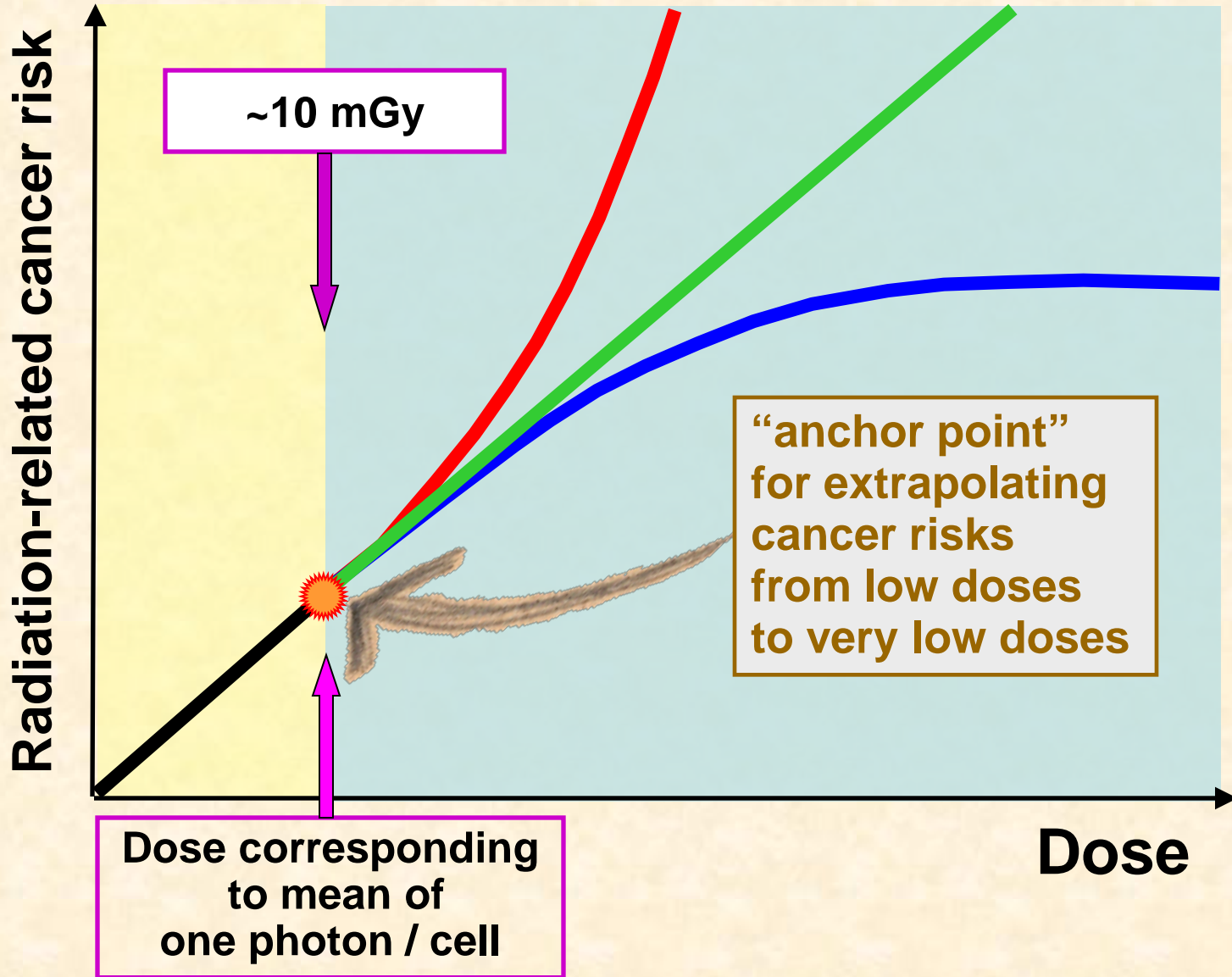


Can laboratory radiobiology studies help?



Not directly... we have no proven laboratory systems for quantifying radiation-induced cancer risks in man

The Biophysical Argument



Toward estimating risks in the sub mGy range:

The Big Need #1

1. **Epidemiological evaluation of cancer risks specifically in the 10 mGy (1 rad) region**
 - ✓ **Optimize the epi study**
 - ✓ **Radiation biomarkers**

Eur J Nucl Med Mol Imaging
DOI 10.1007/s00259-015-3303-3



Gene signature of the post-Chernobyl papillary thyroid cancer

Oncogene (2015) **34**, 3917–3925
© 2015 Macmillan Publishers Limited All rights reserved 0950-9232/15
www.nature.com/onc

ORIGINAL ARTICLE

CLIP2 as radiation biomarker in papillary thyroid carcinoma

Am. J. Hum. Genet. 72:1162–1170, 2003

Past Exposure to Densely Ionizing Radiation Leaves a Unique Permanent Signature in the Genome

The biophysical argument makes a number of implicit / explicit assumptions that can and should be questioned



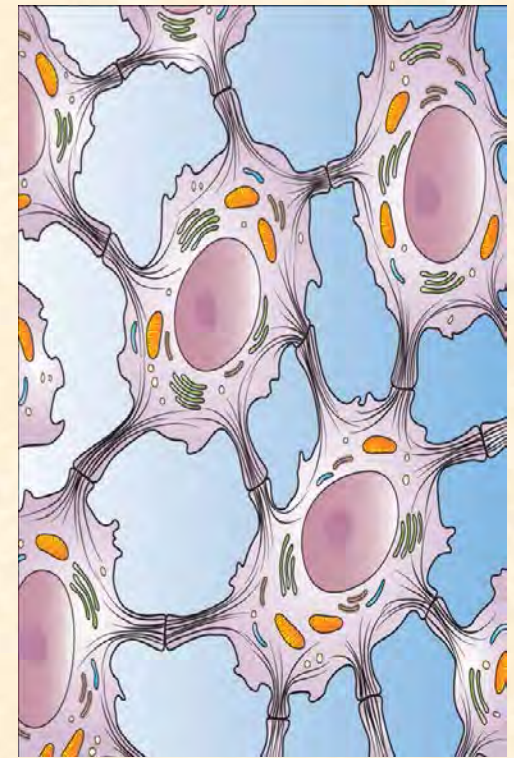
The biophysical argument makes a number of implicit / explicit assumptions that can and should be questioned



DNA repair



Immuno-surveillance



Cell-to-cell communication

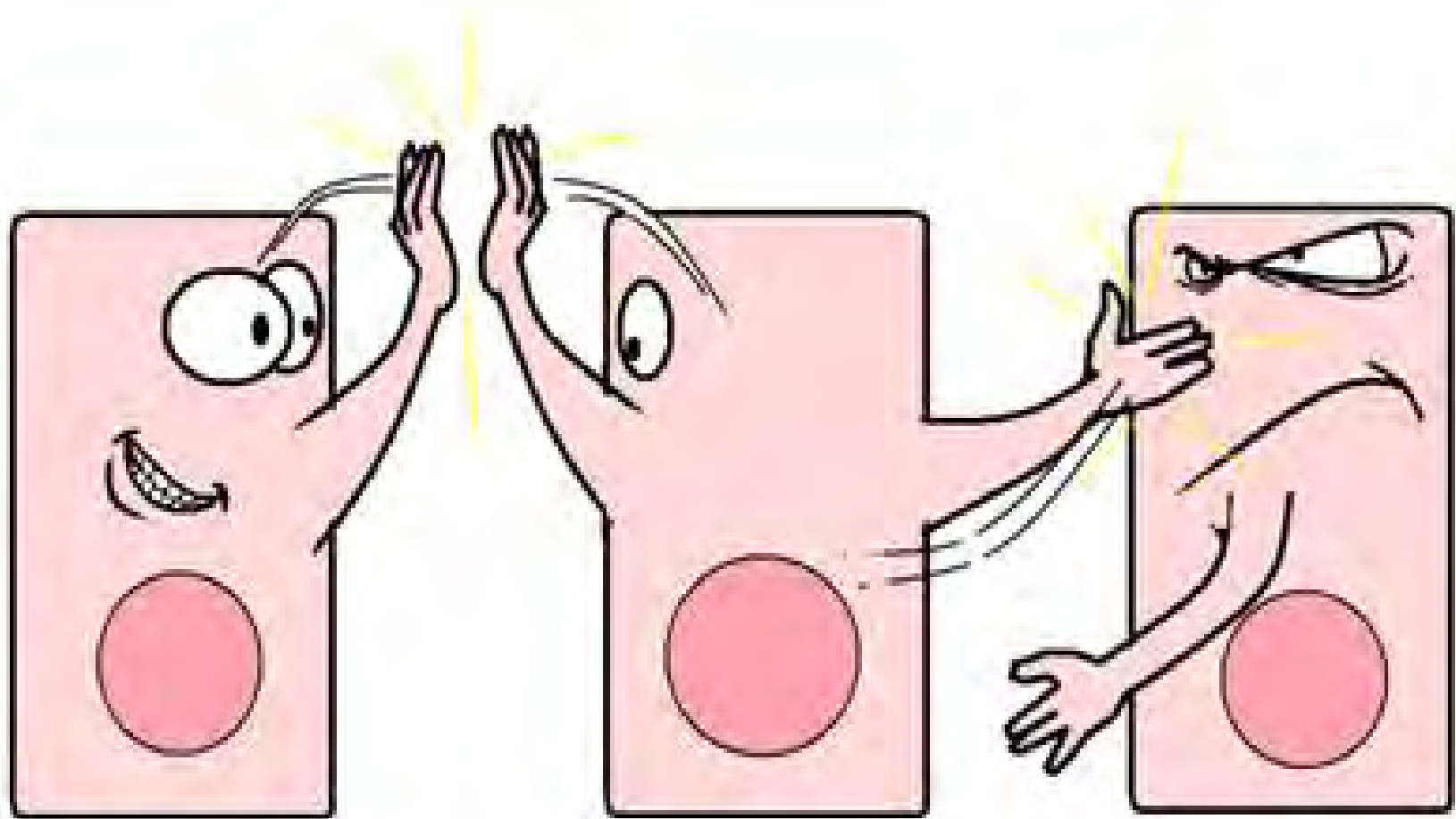
Laboratory radiobiology studies can help us
help us critically test these assumptions



The significance of inter-cellular communication for radiation-induced cancer

- ❖ **The biophysical argument refers to the development of tumors from damage in independently developing single cells**
- ❖ **Are radiation-carcinogenic processes counteracted / amplified by inter-cellular communication mechanisms?**

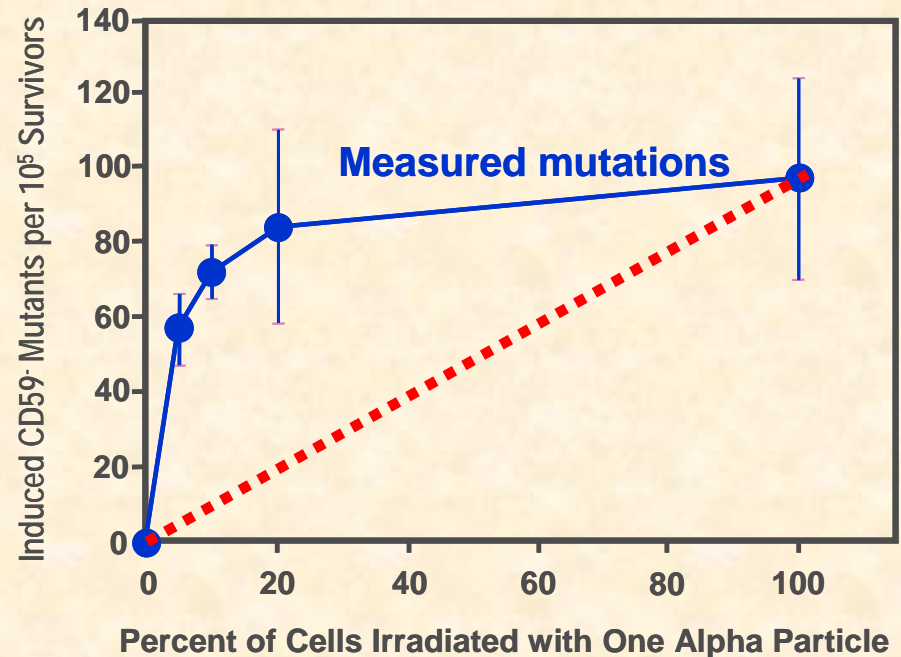
We don't know enough about the significance of cell-to-cell communication in radiation carcinogenesis



Cells in tissue certainly talk to each other, but what are the implications for low-dose risks?

- The most quantified radiation-related inter-cellular response is the bystander effect

- Where bystander responses have been quantitated, they have shown saturation



- In such cases, extrapolating linearly from low to very low doses could underestimate the risk

Toward estimating risks in the sub mGy range:

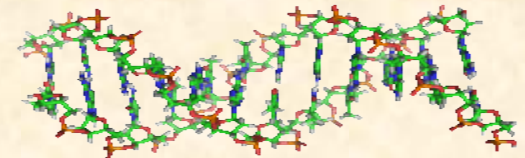
The Big Need #2

1. **Epidemiological evaluation of cancer risks specifically in the 10 mGy (1 rad) region**
2. **Understanding the significance of multi-cellular effects in radiation carcinogenesis**
 - **Are bystander effects relevant for radiation carcinogenesis?**

Who gets radiation-induced cancer?

- Irradiated populations typically show small increase in cancer risks

- Are these cancers random stochastic events... the roll of the dice?
- Or are they largely confined to radiosensitive sub-groups?



Genetic predisposition for the development of radiation-associated meningioma: an epidemiological study

Pazit Flint-Richter, Siegal Sadetzki

Lancet Oncol 2007;8:403-410

Summary

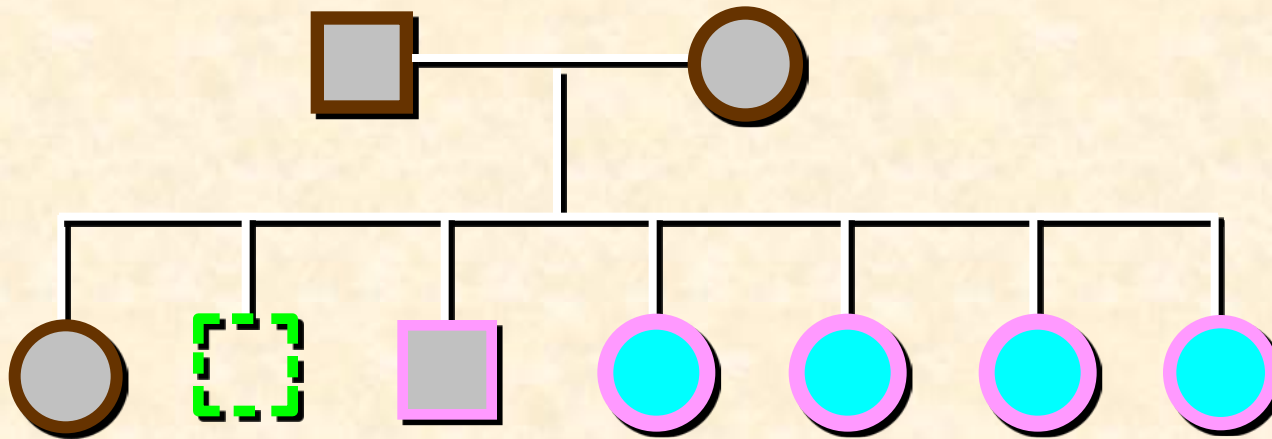
Background Ionising radiation is an established risk factor for meningioma, yet less than 1% of irradiated individuals develop this tumour. Familial aggregation of meningioma is rare. We aimed to assess whether genetic factors can modify the risk for meningioma formation after the initiating effect of radiation, by comparison of the frequency of meningiomas in families that included irradiated and unirradiated siblings.

Methods This study was based on a larger epidemiological, genetic case-control study, and included 525 families that were divided according to irradiation and disease status of each of the family's index participant: 160 had radiation-associated meningioma (RAM); 145 were irradiated and did not develop meningioma; 85 had meningioma with no previous history of irradiation; and 135 were unirradiated and did not develop meningioma. Data were collected by questionnaires.

Findings We found additional first-degree relatives with meningioma in 17 families (11%) in the RAM group, whereas only between one and two such families (1%) were found in the other groups ($p < 0.0001$). All meningiomas seen in the families of the RAM group were in irradiated participants. Also, 22 families (10%) in the RAM group had members with cancers in irradiated sites (including head, neck, and chest) compared with 9 (5%) of irradiated controls ($p = 0.04$).

Interpretation This dataset of families, which included irradiated and unirradiated, and also affected and unaffected family members, created a natural experiment. Our results support the idea that genetic susceptibility increases the risk of developing meningioma after exposure to radiation. Further studies are needed to identify the specific genes involved in this familial sensitivity to ionising radiation. DNA repair and cell-cycle control genes, such as the ataxia-telangiectasia gene, could be plausible candidates for investigation.

Family #1 (Origin: Morocco)



 Irradiated

 Unirradiated

 Status unknown

 Meningioma

 No meningioma

Inter-Individual Radiosensitivity: Radiation Carcinogenesis

- **Almost all the radiation-associated cancers occurred in a very few families**
- **Genetic susceptibility appears to markedly increase the risk of radiation-associated meningioma (but not the risk of meningioma in general)**
- **If this were generally true in radiation carcinogenesis, radiation safety limits would be too strict for most people, and not strict enough for a few people**

Toward estimating risks in the sub mGy range:

The Big Need #3

1. Epidemiological evaluation of cancer risks specifically in the 10 mGy (1 rad) region
2. Understanding the significance of multi-cellular effects in radiation carcinogenesis
3. Understanding the significance of inter-individual radiosensitivity in radiation carcinogenesis
 - Studies with outbred mice?
 - Large scale screening of radiosensitivity?

How should we deal with major uncertainties in estimated radiation-induced risk?



Le doute n'est pas un état bien agréable, mais l'assurance est un état ridicule

- ❖ Right now, we can't provide accurate, defensible estimates of the individual or population risks associated with large numbers of people exposed to low radiation doses
- ❖ What we can do is provide upper-limit risk estimates:

“The low-dose risks can't be more than 'x', because if they were, then such large risks would have been seen in past low-dose epidemiological studies”

Upper-limit risk estimates: Fukushima

- **(Almost) everyone agrees that the individual radiation-related cancer risks as a result of Fukushima are extremely small**
 - **Despite this there is huge anxiety and skepticism in Japan about individual / personal radiation-related risk**
 - **One of the main reasons is the “mixed messages” that the public gets from different scientists with different views**
 - **Using upper-limit risk estimation is a way round these uncertainties, and also provide us with a reasonable and appropriately conservative basis for societal risk-benefit analyses**

Toward estimating risks in the sub mGy range:

The Big Need #4

1. Epidemiological evaluation of cancer risks specifically in the 10 mGy (1 rad) region
2. Understanding the significance of multi-cellular effects in radiation carcinogenesis
3. Understanding the significance of inter-individual radiosensitivity in radiation carcinogenesis
4. Generating upper-limit risk estimates

Toward estimating risks in the sub mGy range:

The Big Needs

1. Epidemiological evaluation of cancer risks specifically in the 10 mGy (1 rad) region
2. Understanding the significance of multi-cellular effects in radiation carcinogenesis
3. Understanding the significance of inter-individual radiosensitivity in radiation carcinogenesis
4. Generating upper-limit risk estimates



Developing a Radiation Protection Hub

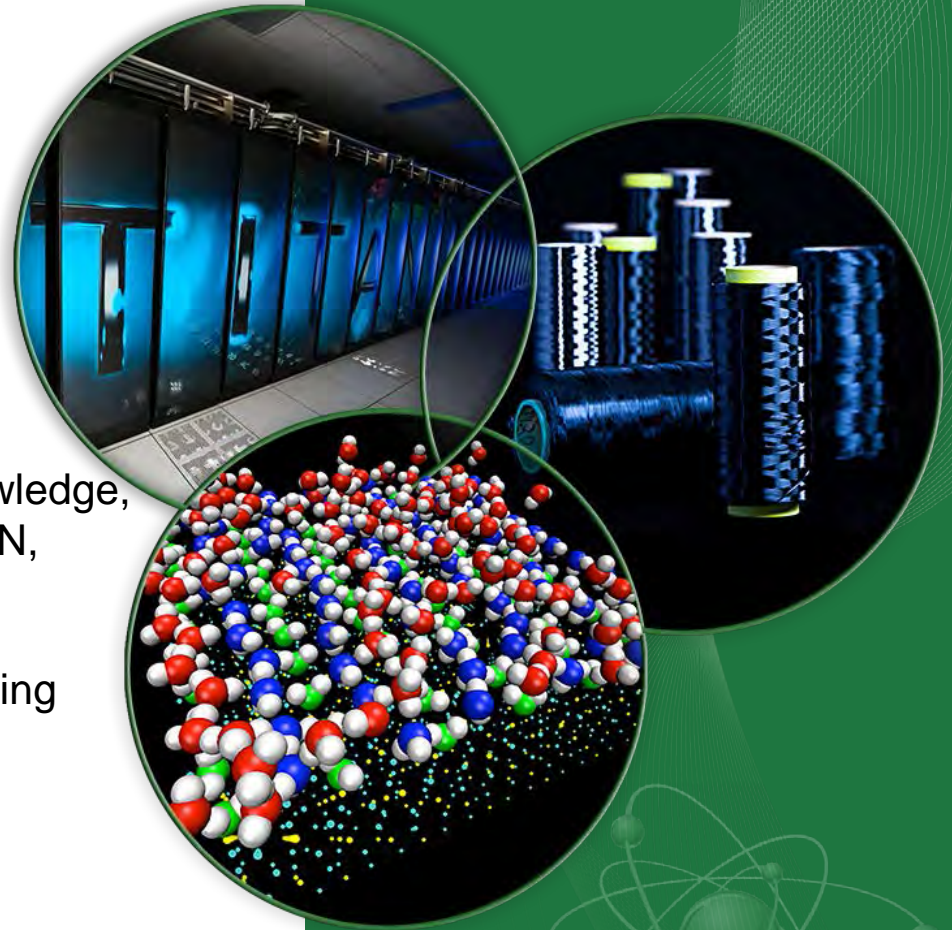
Nolan E. Hertel

Director, Center for Radiation Protection Knowledge,
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Professor, Nuclear and Radiological Engineering
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Atlanta, GA 30332-0745
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2016 National Council On Radiation Protection &
Measurements Annual Meeting, April 11-12, 2016.

“Meeting the Needs of the Nation for Radiation Protection”



Where are the Radiation Professionals (WARP)?

- NCRP Statement No. 12, December 17, 2015
 - Looming shortage of radiation professionals represents a serious threat to the United States
 - Scientific leadership is being lost
 - Competition in world markets is affected
 - Protection of our citizens and country diminished
 - Restore significant **federal** and state funding for scholarships, **fellowships**, and **faculty research**

More Activities Advocated by the NCRP Statement

- Reinvigorate partnerships among universities, government, and the private sector to ensure undergraduate and graduate programs are adequately resourced to support the training and qualification of radiation professionals, **including those who will educate the next generation**
- Establish a Joint Program Support Office (JPSO) for radiation professionals in the federal civil service to **manage utilization and career development** of personnel more effectively
- Establish basic and advanced competency profiles to serve as guidance upon which to base the education, training, qualification and appropriate use of radiation professionals.

More from NCRP Statement

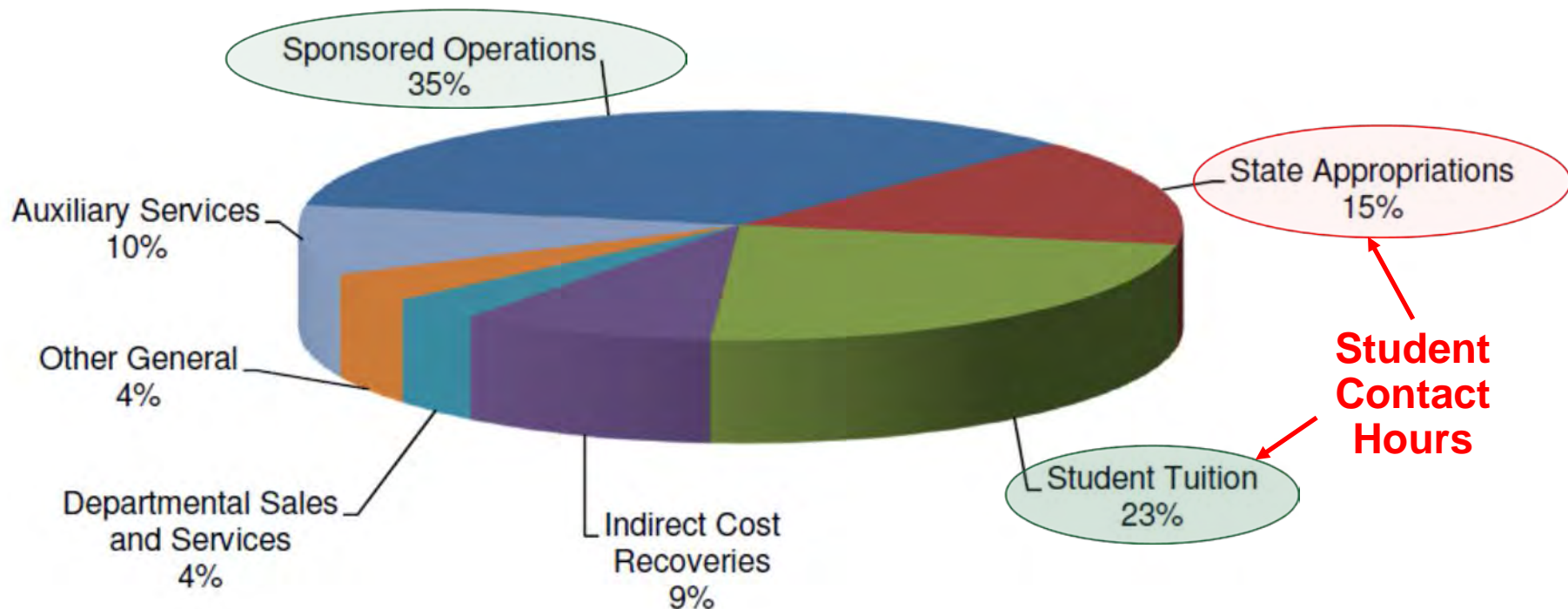
- Monitor trends in the supply of and demand for radiation professionals.
- Establish basic and advanced competency profiles to serve as guidance upon which to base the education, training, qualification and appropriate use of radiation professionals. Public health, radiation safety, emergency preparedness, and the environment are all at risk. The clarion call to act is now!

The Crisis in Radiation Protection (My viewpoint and somewhat anecdotal)

- Radiation protection research groups have largely been disbanded or dramatically reduced in size.
- Low level of funding in in radiation protection research areas for academic programs and national labs.
 - We are conservatively overestimating doses, etc.?
 - We know all we need to know?
- Moving towards the elimination of Health Physics and Radiation Protection Programs at “Major” Research Universities
 - Less of an impact on 2 y and 4 y degree schools, colleges, and universities

The Challenge – Business Models of the 21st Century

Typical Revenue Stream for a Major “Research” University (and all graduate degree granting institutions want to be a major research university)



Reality for Research Universities

- Student Contact Hours are revenue streams
 - Enrollment numbers in HP/RP/RE degree programs and related programs don't yield enough contact hours to defend their existence
 - Regional needs may keep programs alive
 - Number of Faculty historically are rather small and graying
- Research grants and contracts are revenue streams
 - Publish or Perish still exists, but faculty in Engineering with less than \$300k-\$400k per year in research expenditures are considered substandard
 - Where do HP/RP faculty go for that level of sustainable funding?

Challenges for 4 y Programs

- Decreased state appropriations and therefore increasing student tuition revenue has at least an equal impact on undergraduate programs as it does on graduate programs.
- Increasing competition from other STEM disciplines for students.
- Scholarship money is not proving to be enough of an incentive to bring students into radiation protection.
- They want confidence that employment will be there and that internships exist for them now.
- And a significant chunk of industry is still not very aggressive in their hiring practices.

Realities for Radiation Protection Research at National Laboratories

- National Labs largely now work on specific contracted tasks for federal agencies, no more “blanket” grants
 - Every hour must be billable
 - Ballpark fully burdened cost of a scientist \$420k+ per year
- Retirements without full replacement
 - Some have retired because they could no longer cover their salaries
 - In some cases, this also impacts operational HP programs at the labs

ORNL Center for Radiation Protection Knowledge – A Recognition of the National Need

- Established in 2010 by an MOU signed by DOE, DOD, EPA, NRC, and OSHA
 - 5 y Renewal signed in 2015
 - DHHS was added to the MOU.
- The Center serves as a common resource to assist the participating agencies in the development and application of radiation dosimetry and risk assessment methodologies based on best available scientific information.
 - **Intended to help preserve U.S. expertise in radiation dosimetry**
 - **Ensure that federal radiation programs are based on best information available**

Consortium for the Advancement of Radiation Protection (CARP?)

- CRPK MOU says little about the structure of the CRPK and how it will function
- Consortium for the Advancement of Radiation Protection (CARP)
 - The CRPK or a similar organization could be used as a focal point for rebuilding the radiation protection education, training, and research efforts in the United States by forming a consortium of universities, national laboratories, industries, utilities and nonprofit organizations.
- We need a launching platform to provide the critical human resource and knowledge needs in radiation protection for the future and its challenges

Consortium

- Bring together the radiation protection research community remaining within the laboratory complex to engage in research and development as well as to participate in the training of the next generation of radiation protection professionals at all levels.
- Such a consortium could bring together the strengths of different university and laboratory programs in a strategic manner to accomplish a multifaceted research, educational and training agenda.

Consortium

- Educational experiences for undergraduate students
- Research experiences for graduate students
- Thesis/dissertation topics for graduate research assistants
- Developmental experiences for faculty members
- Post-doctoral research
- Such efforts by the CRPK mirror the ORNL mission of invigorating science through graduate and post-graduate research and education

Getting Started

- Forge a working relationship between several major research universities, academic programs and national labs to form a consortium
 - Concept similar to DOE funded “innovation hubs”
 - This concept would incorporate a greater educational and training mission
 - Secure an initial, guaranteed 5 y funding period of the consortium that would be renewable upon satisfactory performance
- The “hub” serves as a concentrated focal point to fund other entities
- Do no Harm to existing activities!

Getting Started (Cont.)

- Develop an agenda that is truly research and education driven
- At a minimum provide three activities:
 - Summer student intern programs for either research or operational radiation protection experience
 - A practicum program where new hires by DOE, their labs, and/or other federal agencies physics perform rotations at several facilities
 - Serve as a research hub for distributing funding for university and national laboratory research that advances the state of radiation protection knowledge and methods

Center for Advanced Simulation of Light Water Reactors (CASL) is a Hub Example



CASL ORGANIZATION

- **Senior Leadership Team**

- Director (ORNL)
- Deputy Director (INL)
- Chief Scientist (NCSU)

- **Technical Leadership**

- Focus Areas (FA) Leads
- Deputy FA Leads
- Project Leads
- Product Integrators.

CASL ORGANIZATION

- **Focus Area Leads** develop their project plans, budgets, and staffing to complete milestones and are responsible for integration of their Focus Area technical activities vertically and horizontally
- **Projects Leads** are responsible for all technical plans, budget, and execution within the scope of the project
- **Product Integrators** have responsibilities for driving critical applications, products, and outcomes that cross over Focus Area boundaries

CASL ORGANIZATION

- **Board of Directors** serves as both an advisory and oversight body on issues related to management, performance, strategic direction, and institutional interfaces
- **Industry Council** ensures that CASL solutions are “used and useful,” and that CASL provides effective leadership advancing the state-of-the art in the nuclear industry
- **Science Council** provides independent assessment of CASL scientific work planned and executed is of high quality and supports attaining the goals of CASL as well as performing detailed assessments of specific CASL scientific issues

Final Comments

- Is it time to pursue CARP?
- Who is the Champion?
- NCRP should play some role, at least in setting the research agenda.
- Should International Collaborations should be part of CARP?
 - Probably not much funding, but shared common interests
- Tough Decisions as everyone cannot be supported

Is CARP the correct acronym?

Some of my Friends don't think the acronym is positive sounding, but Kinky Friedman understands my approach:



"Some things are too important to be taken seriously."

Of course, it could be a trademark infringement.



We must do something to
address the future.

Should we CARP on WARP,
Do something else, OR



Meeting Regulatory Needs

Michael Weber, Director of Nuclear
Regulatory Research

11 April 2016
National Council on Radiation Protection and Measurements
Annual Meeting



Overview



- Greetings
- Dynamic Environment
- Project Aim
- Workforce planning
- Looking Forward



Change

- Unprecedented pace
- Trends
 - Cyber threat
 - Proliferation
 - Robotics
 - Workforce diversity
 - Demographics
 - Economic powerhouses
 - Financial constraints
 - Globalization
 - Political instability
 - Trust in large institutions



Convergence

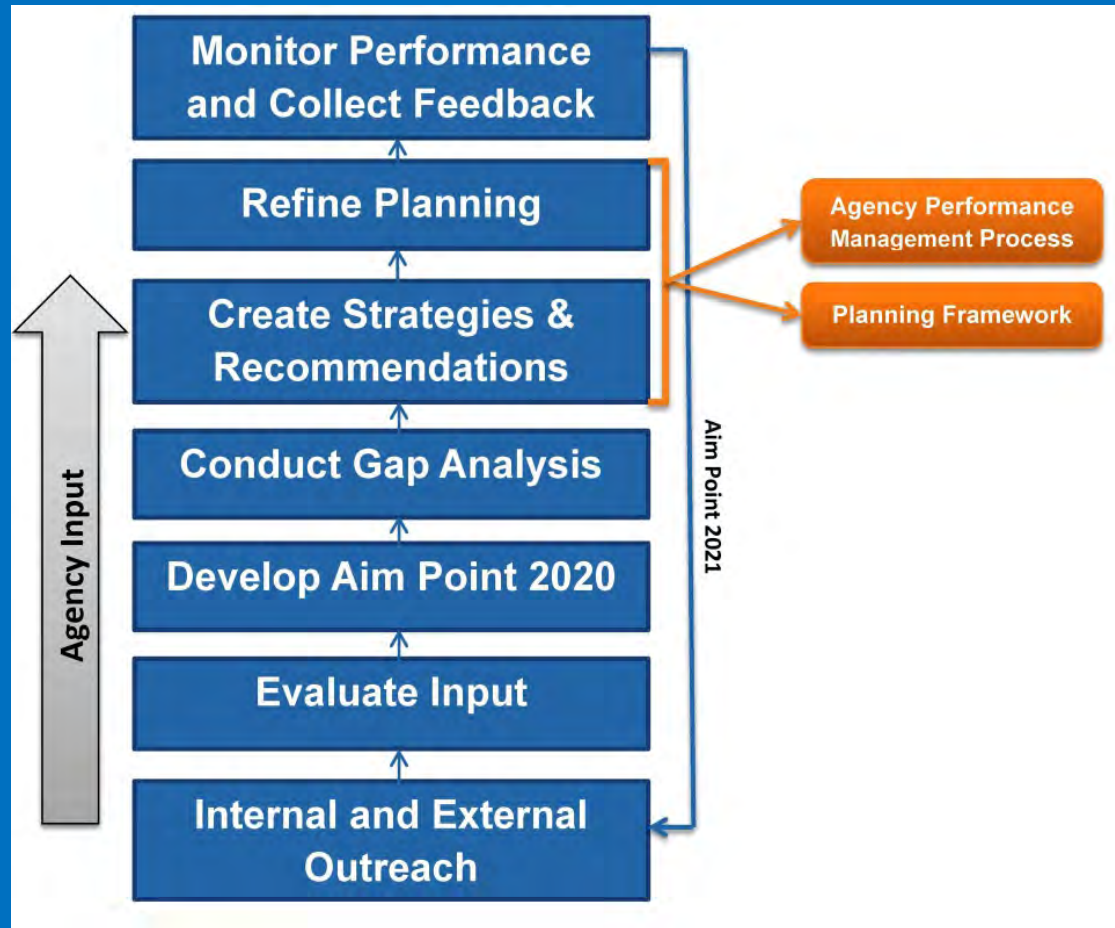
- Response to Fukushima Dai-ichi
- Nuclear licensing backlog
- Increase in annual fees
- Reduction in new nuclear demand
- Revisited waste confidence
- Restarted Yucca Mountain licensing
- Centralized corporate functions
- Shutdown and restarted government
- Constrained fiscal environment



Project Aim



Approach



Workforce Planning

- Gap analysis includes workforce planning
- NRC employs about 170 health physicists and associated radiation professionals
- Radiation protection is and will remain central to accomplishing NRC's mission



Workforce Planning

- Moeller & Ellason 1976 – 50% shortfall
- Mossman & Poston 1988 – sustained shortfall through 2005
- Health Physics Society (HPS) 2001/2005 – 55% decrease in HP graduates (1995-2002)
 - 1,050 radiation professionals in state agencies
 - Forecast growing gap in qualified workforce



HPS Survey - 2013

- HPS 2013 membership survey
 - Low response (14%)
 - 10% retire in 5 y; **51%** retire in 10 y
 - **70%** in state government
 - **52%** in federal government
 - Could be better/worse
- Will we have sufficient people to accomplish radiation safety?

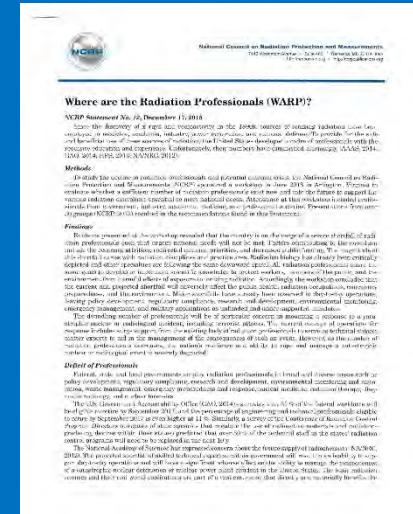
HPS Salary Survey - 2014

- New results released in December 2014
- Survey led by Stephen Bump
- Only considered responses from full-time HPs
- 20% fewer respondents in 2014 than 2013 (total = 205)
- Average salary for all HPs ~ \$104K (\$131K for all CHPs)



WARP

- Led by NCRP
- WARP - Where are the radiation professionals?
- On the verge of a severe shortfall
- Recommendations – education, research, training, monitoring, advocacy
- Workshop in July 2013
- Common challenges in staffing



NEI Workforce Survey 2015



- Included nuclear utilities and vendors
- Examined workforce needs by sector
- Current workforce is sufficient
- Coping strategies are helping
 - Deferred retirements
 - Transfers of professionals from shutdown sites
 - Knowledge transfer
 - Continued hiring and development

NEA Survey



- Nuclear industry growth will require increases in radiation professionals
- Surveyed Member State nuclear safety regulatory agencies
- Mixed trends on university programs
- Strong negative response on sufficiency of radiation protection experts
- New hires lack practical experience

Looking Forward

- Growing concerns about shortfalls in radiation professionals
- Increasing complexities and demands
- Radiation professionals needed in all sectors to accomplish safety and security
- Risk informed, performance based approaches require higher performance
- NRC is using strategic workforce planning to fulfill its nuclear safety and security mission

Thank You



Critical Issues in Knowledge Management in Domestic Radiation Protection Research Capabilities

Shaheen Azim Dewji, Ph.D.

Center for Radiation Protection Knowledge

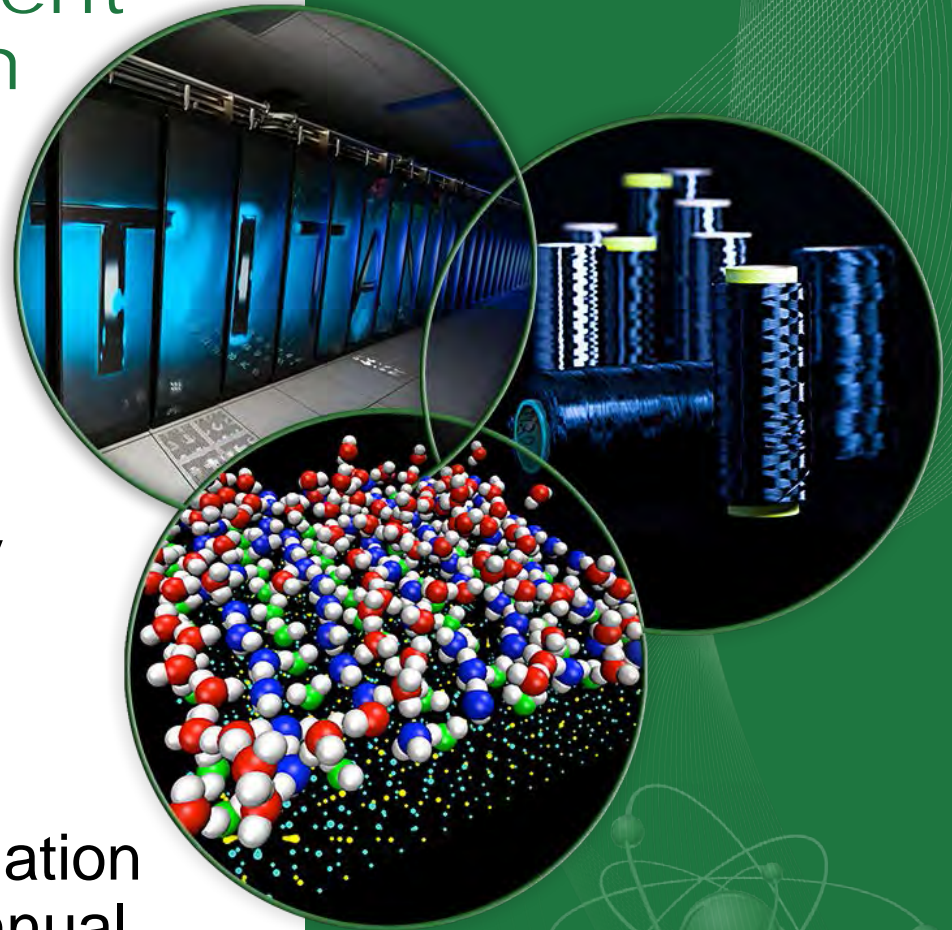
Oak Ridge National Laboratory

dewjisa@ornl.gov

Prepared for:

2016 National Council On Radiation Protection & Measurements Annual Meeting

11-12 April 2016

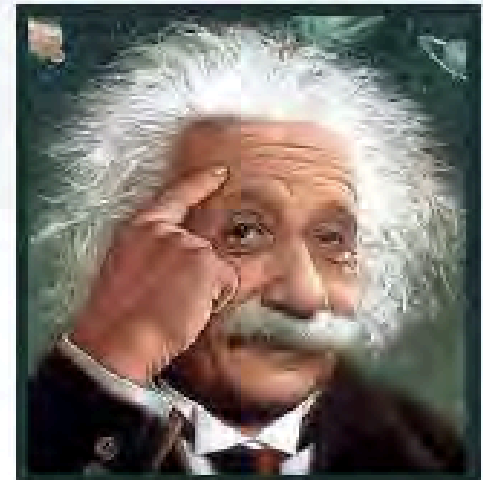


Outline

- Center for Radiation Protection Knowledge
 - Oak Ridge National Laboratory
 - History and Legacy
 - Mission Objectives
- What is Nuclear Knowledge Management (NKM)
 - “4R” Paradigm
 - Objectives
 - Components
- Radiation Protection NKM Methodology
- CRPK Proposed NKM Initiative

**“Knowledge is experience;
everything else is information.”**

Albert Einstein



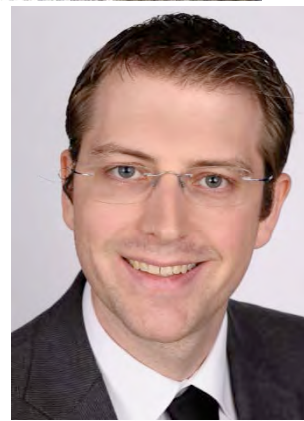
Center for Radiation Protection Knowledge



<http://crpk.ornl.gov/>

Top:

Nolan Hertel (JFA, Georgia Institute of Technology)
Keith Eckerman (Emeritus)
Rich Leggett (R&D Scientist)
Clay Easterly (Consultant)
Richard Ward (Consultant)



Middle: Michael Bellamy (ORNL, R&D Engineer)
Shaheen Dewji (ORNL, R&D Engineer)
Mauritius Hiller (ORNL, R&D Engineer)
Derek Jokisch (JFA, Francis Marion U)



Bottom: Ken Veinot (Consultant)
Pat Scofield (ORNL)
Scott Schwahn (ORNL)

Center for Radiation Protection Knowledge: Value to Radiation Protection Stakeholders

1. Provide infrastructure and resources to continue to provide services in radiation protection and dosimetry
 - Retain expertise to conduct fundamental R&D domestically
2. Collaborate and communicate across organizational boundaries
3. Capture critical knowledge before it is lost to create organizational memory
4. Facilitate the decision making process
5. Create sustainable KM system in radiation protection

Current State of Radiation Protection Knowledge

- In 2002: Health Physics Society identified severe atrophy of talent was occurring in the field of health physics
- NCRP created the **WARP (Where Are the Radiation Professionals)** Initiative
 - Assessed “front-end” of the human capital pipeline in university education and training
 - Little done to address loss of expertise associated with the loss of professionals on “back-end”/retirement-end
- Need to preserve radiation protection knowledge that may be lost due to the growing retirements in radiation protection
- **Knowledge management** in radiation protection is high priority
 - **Must be addressed immediately before the expertise is irreplaceably lost**

What is Nuclear Knowledge Management (NKM)?

- NKM is an **integrated, systematic approach** applied to all stages of the nuclear knowledge **cycle**, including its **identification, sharing, protection, dissemination, preservation and transfer**.
- It affects and relates to:
 - Human resource management,
 - Information and communication technology,
 - Process and management approaches,
 - Document management systems, and
 - Corporate and national strategies.

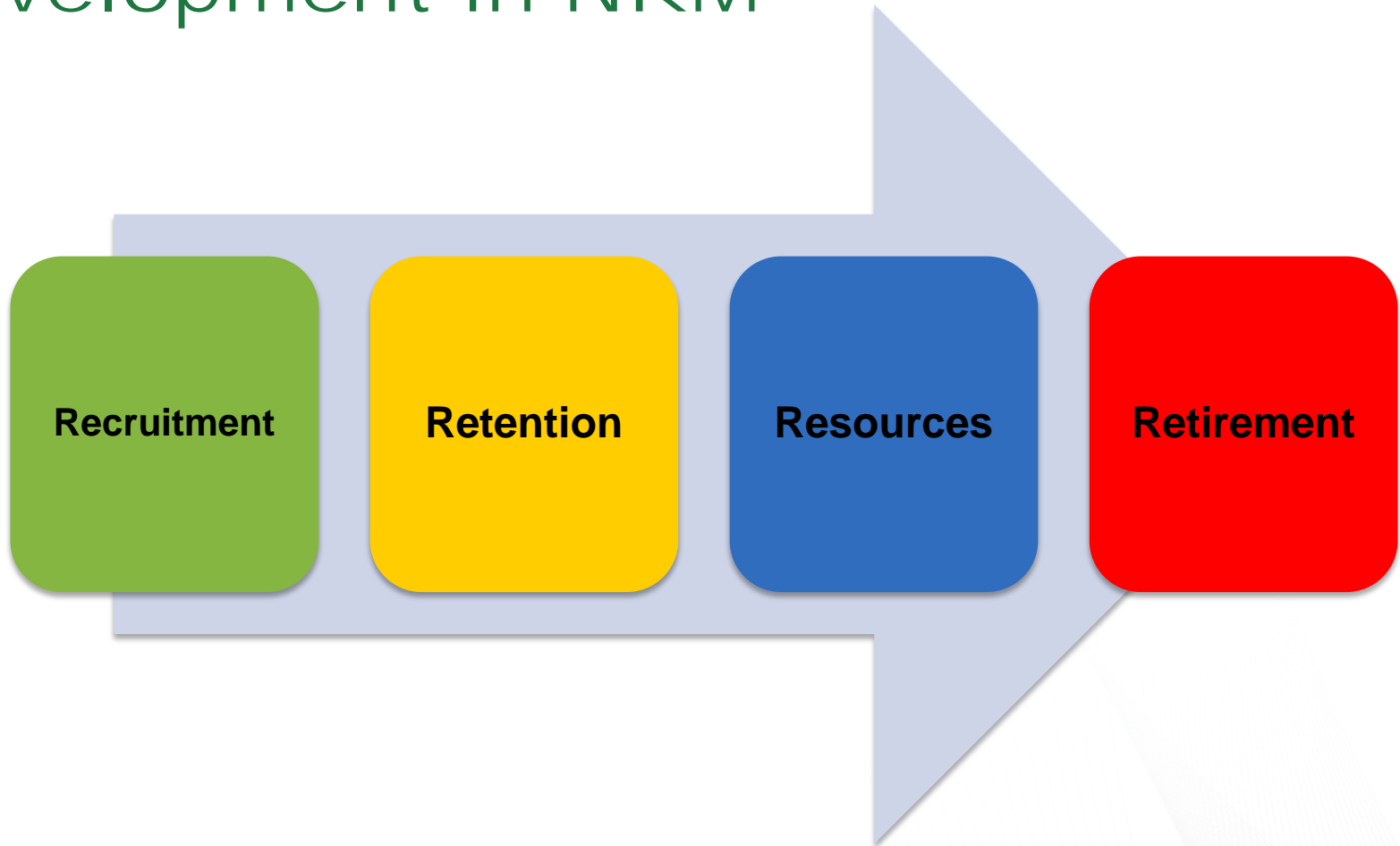
IAEA Report No. NG-T-6.7

NKM Objectives

- **Safety** - *Achieve safe operation and maintenance* of all nuclear facilities by sharing of operational experience
- **Economic** - *Achieve gains in economics and operational performance* through effective management of the resource knowledge
- **Security** - *Achieve responsible use* by properly identifying and protecting nuclear knowledge from improper use
- **Innovation** - *Facilitate innovation* to achieve significant improvements in the safe, economical operation of all new nuclear projects
- **Sustainability** - *Maximize the flow of nuclear knowledge from one generation to the next*

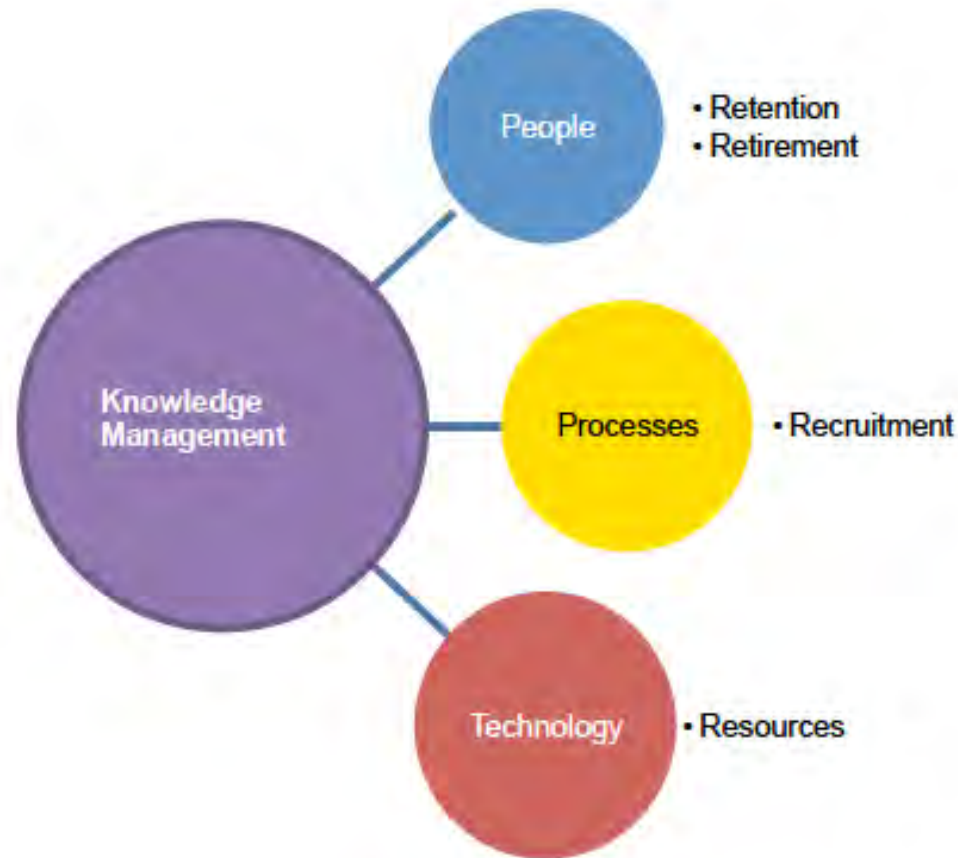
M. Scaffoni, 10th School of Nuclear Knowledge Management: Strategy, Approach and Achievements, Trieste, August 2013

"4R" Paradigm of Human Capital Development in NKM



S. Dewji, S. Poe, B. Kirk, Human Capital Roadmap in Safeguards and Nonproliferation Education, Training, and Knowledge Retention — Knowledge Management Strategic Plan, ORNL/TM-2014/673, January 2015.

Elements of an NKM System



S. Dewji, S. Poe, B. Kirk, Human Capital Roadmap in Safeguards and Nonproliferation Education, Training, and Knowledge Retention — Knowledge Management Strategic Plan, ORNL/TM-2014/673, January 2015.

What is Nuclear Knowledge Management (NKM)?

- NKM in radiation protection and health physics in United States must be the foundation connecting
 - All activities:
 - Occupational
 - Medical
 - Space
 - Security & Emergency Response, etc.
 - All stakeholders
 - Federal government
 - Academia
 - National Laboratories
 - Domestic and international communities
 - NGOs, professional societies, etc.

Radiation Protection Nuclear Knowledge Management Effort

Radiation Protection Technician

- Contamination monitoring
- Systematic surveys



Health Physicist

- Dosimeter processing
- Bioassay
- Dose and shielding calculations



R&D Scientist

- Models, dosimetry, risk coefficients, ICRP recommendations, standards development
- Long history of peer-reviewed publication



NKM Methodology

Task

Strategic Milestone

**Step 1. Conduct a
Knowledge Loss
Risk Assessment**

**Identify the population of
experts who possess at-risk
unique and critical
knowledge**

**Step 2. Determine
approach to capture,
maintain, and share
the unique and
critical knowledge**

**Create a documented
knowledge retention plan**

**Step 3. Monitor and
evaluate knowledge
management effort**

**Monitor implementation of
Knowledge Retention Plan**

Step 1: Knowledge Loss Risk Assessment

Knowledge Prioritization

- **Knowledge prioritization** is based on the premise that there is critical knowledge in an organization that needs to be identified
- **Critical Knowledge**
 - ✓ Established in context of specific position
 - ✓ Important to success of the organization
 - ✓ Imperative to independently perform associated duties
 - **Unique Knowledge:** Although some knowledge may be critical, a subset may be identified as unique
 - Is usually carried out by managers as part of a **knowledge loss risk assessment**
 - Categorized by a **position risk factor**

Step 1: Knowledge Loss Risk Assessment

$$\begin{array}{cccc} \text{Position} & \times & \text{Attrition} & = & \text{Total} \\ \text{Risk Factor} & & \text{Risk Factor} & & \text{Risk Factor} \end{array}$$

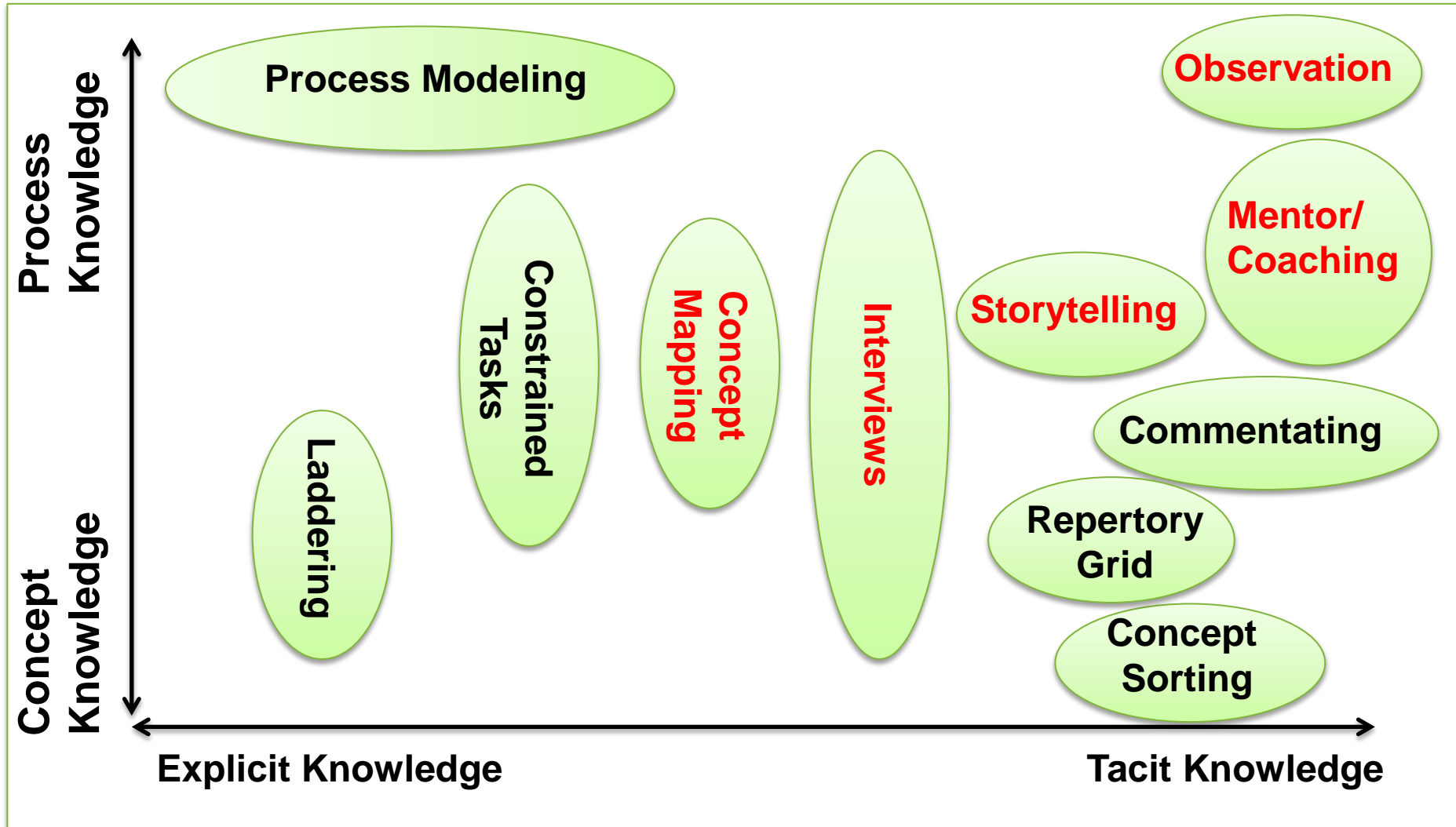
- **Position Risk Factor:** *Position criticality through estimate of difficulty/effort required to replace position* (Scale 1-5)
 - Management/Group Leader
 - Peers/Community of Practice
 - Self-Identification
- **Attrition Risk Factor:** (Scale 1-5)
 - Human Resource model based on benefit/retirement plan
 - Manager/Leader may know from dialogue w/employee
 - Self-Identify
- **Total Risk Factor** (Scale 1-25)

Step 1: Example of Identifying Critical and Unique Knowledge

ROLE	Radiation Protection Technician	Health Physicist	R&D Radiation Protection Scientist
<i>Knowledge Prioritization</i>	<ul style="list-style-type: none"> • Not unique or critical knowledge 	<ul style="list-style-type: none"> • Some critical but not necessarily unique 	<ul style="list-style-type: none"> • Unique and Critical Knowledge
<i>Position Risk Factor</i>	<ul style="list-style-type: none"> • 1-2 	<ul style="list-style-type: none"> • 2-4 	<ul style="list-style-type: none"> • 4-5
<i>Risk to Organization of Loss</i>	<ul style="list-style-type: none"> • Minimal 	<ul style="list-style-type: none"> • Limited Operations Affected 	<ul style="list-style-type: none"> • Innovation • Mission statement in jeopardy
<i>Potential Benefit to Organization</i>	<ul style="list-style-type: none"> • Continuity of operations • Safety 	<ul style="list-style-type: none"> • Continuity of operations, support to R&D, and to meet stakeholder needs • Safety 	<ul style="list-style-type: none"> • Innovation potential/continuity technical leadership • Ability to carry out and grow mission statement

Step 1. Capture of Critical Knowledge

Selection Criteria: Tools and Methods



NKM Methodology

Task

Strategic Milestone

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management effort**

***Monitor implementation of
Knowledge Retention Plan***

Step 2: Create a documented knowledge retention plan

CRPK Knowledge Management Initiative

- CRPK proposes to develop a formal knowledge capture roadmap and implementation strategy
 - Outline how to capture both the explicit (tangible) and tacit (intangible) knowledge from outgoing subject matter experts (SME) in the field of radiation protection and radiation protection research
 - Centralized electronic hub - *Center for Radiation Protection Knowledge Management Portal*
 - *CRPK KM Portal* ensure knowledge management becomes an inherent practice in the radiation protection community
- **KM in radiation protection is integral and critical for stakeholder mission support and domestic R&D innovation and leadership**

CRPK NKM Initiative: Model Efforts



NIS Office of Nuclear Safeguards and Security

NEXT GENERATION SAFEGUARDS INITIATIVE

In 2008, the Department of Energy, National Nuclear Security Administration (DOE/ NNSA) established the Next Generation Safeguards Initiative (NGSI) to develop the policies, concepts, technologies, expertise, and international safeguards infrastructure necessary to strengthen and sustain the international safeguards system as it evolves to meet new challenges.

NGSI consists of five sub-program elements:

1. Policy Development and Outreach
2. Concepts and Approaches
3. International Nuclear Safeguards Engagement
4. Technology Development
5. Human Capital Development

NNSA
Office of Nonproliferation and International Security (NIS)



Managing Nuclear Knowledge

IAEA

IAEA

<http://nnsa.energy.gov/mediaroom/factsheets/nextgenerationsafeguards>

NKM Methodology

Task

Strategic Milestone

**Step 1. Conduct a
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***Identify the population of
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management effort**

***Monitor implementation of
Knowledge Retention Plan***

Step 3: Monitor and Evaluate

Measure of Success of Knowledge Capture Effort

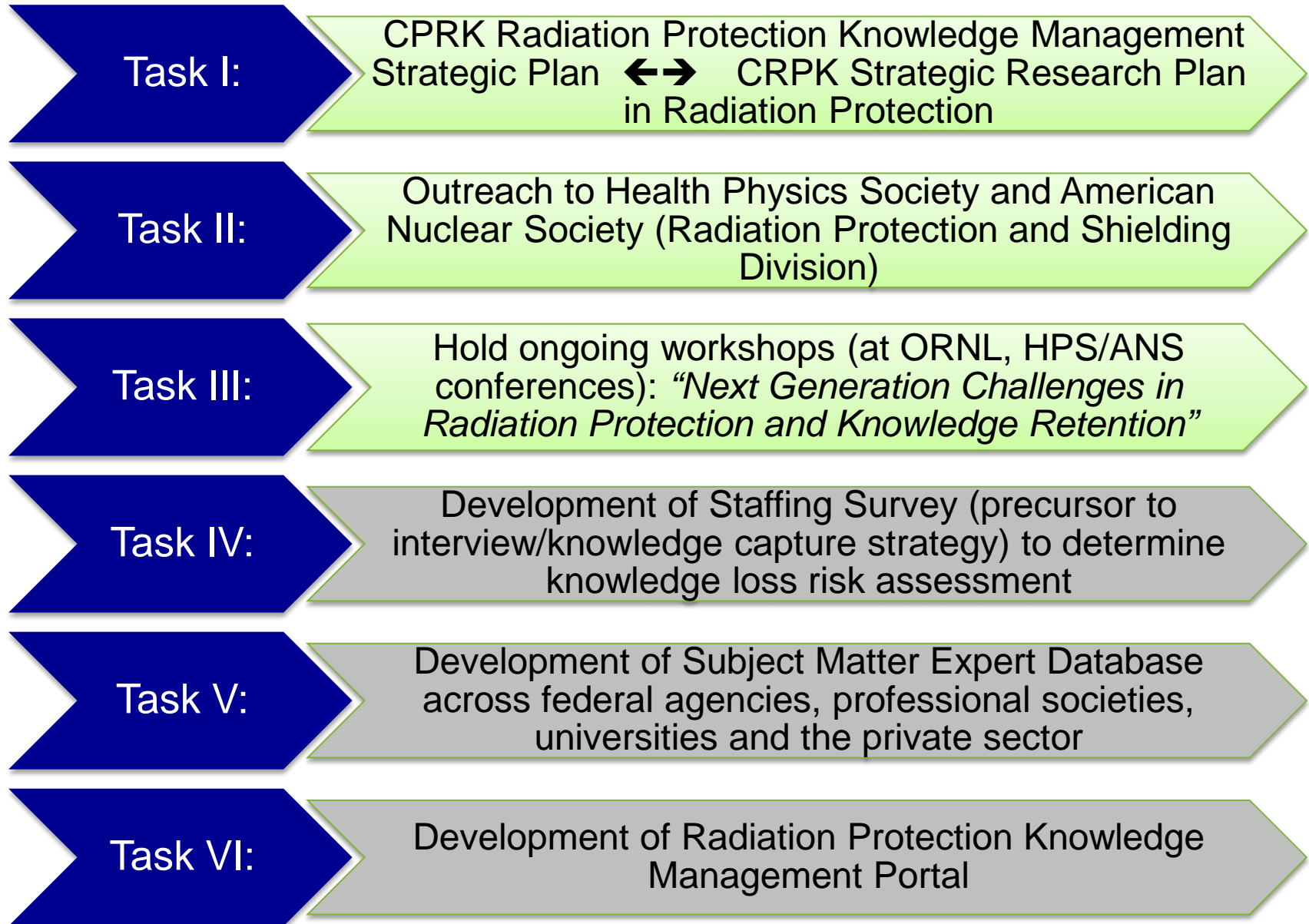
KM Project Effort Milestones

- Knowledge Loss Risk Assessment: Unique and critical knowledge identified and covered
- Percentage of mapped processes
- Track percentage of completion of milestone tasks outlined in Knowledge Retention Plan
- Lessons Learned

Organization Mission Milestones

- Human performance errors.
- Outsourcing to external organizations/rehire retirees as consultants.
- Successfully meeting its mission/business goals?
- Is innovative R&D output produced? (Proposals funded; publications in peer reviewed journals)

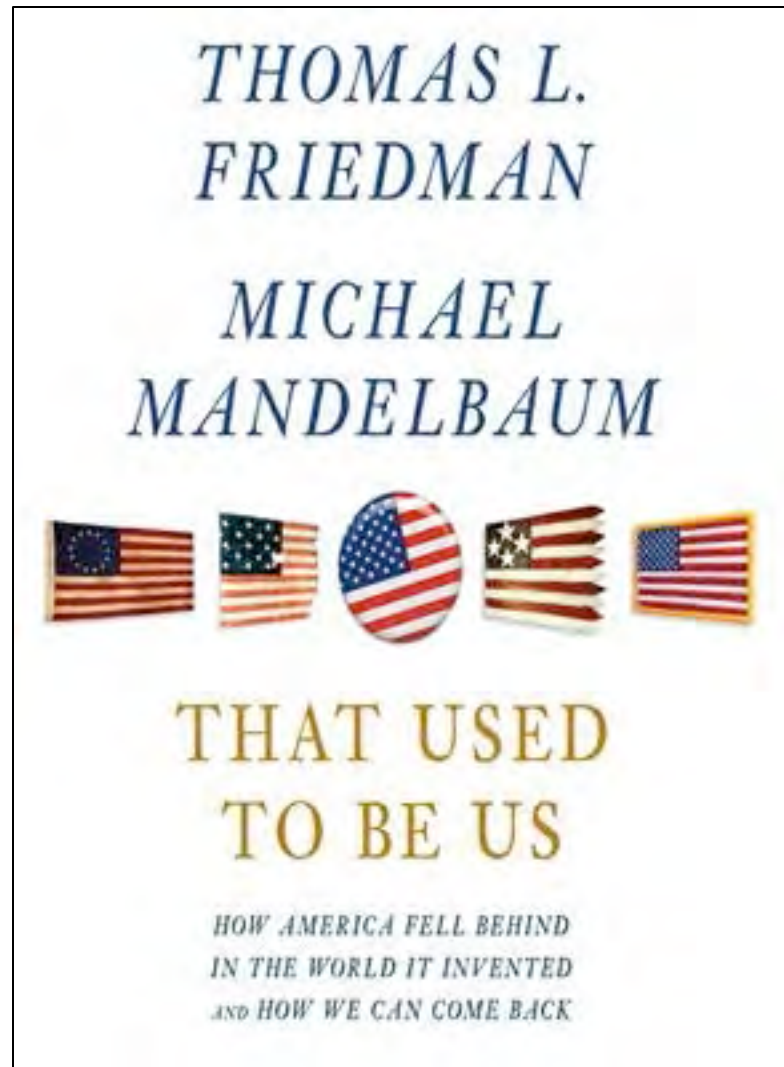
CRPK NKM Initiative: Proposed Strategic Milestones



CRPK NKM Initiative: Proposed Strategic Milestones

- 2016 Annual Meeting of the Health Physics Society (Spokane, WA): Next Generation Challenges
 - HPS 2015 featured presentations from academia, federal government, laboratories, committees, CRPK, NCRP, EURADOS
- 2016 American Nuclear Society Winter Meeting: Software Sustainability in Radiation Protection and Shielding Data and Codes

That used to be us...



References

- IAEA TECDOC 1586 - Planning and Execution of Knowledge Management Assist Missions for Nuclear Organizations (http://www-pub.iaea.org/MTCD/publications/PDF/TE_1586_web.pdf)
- IAEA TECDOC 1248 – Risk Management of Knowledge Loss in Nuclear Industry Organizations (<http://www-pub.iaea.org/books/IAEABooks/7495/Risk-Management-of-Knowledge-Loss-in-Nuclear-Industry-Organizations>)
- S. Dewji, S. Poe, B. Kirk, Human Capital Roadmap in Safeguards and Nonproliferation Education, Training, and Knowledge Retention — Knowledge Management Strategic Plan, ORNL/TM-2014/673, January 2015.
- M. Scaffoni, 10th School of Nuclear Knowledge Management: Strategy, Approach and Achievements, Trieste, August 2013

The Business of Health Physics – Jobs in a Changing Market

Matt Moeller, CHP
Dade Moeller
April 12, 2016

2016 NCRP Annual Meeting –
Meeting the Needs of the Nation for Radiation Protection

Purpose

- Provide perspectives on our profession in terms of the economics of jobs

Why?

It's about changing markets

It's about filling jobs

It's about maintaining specialties

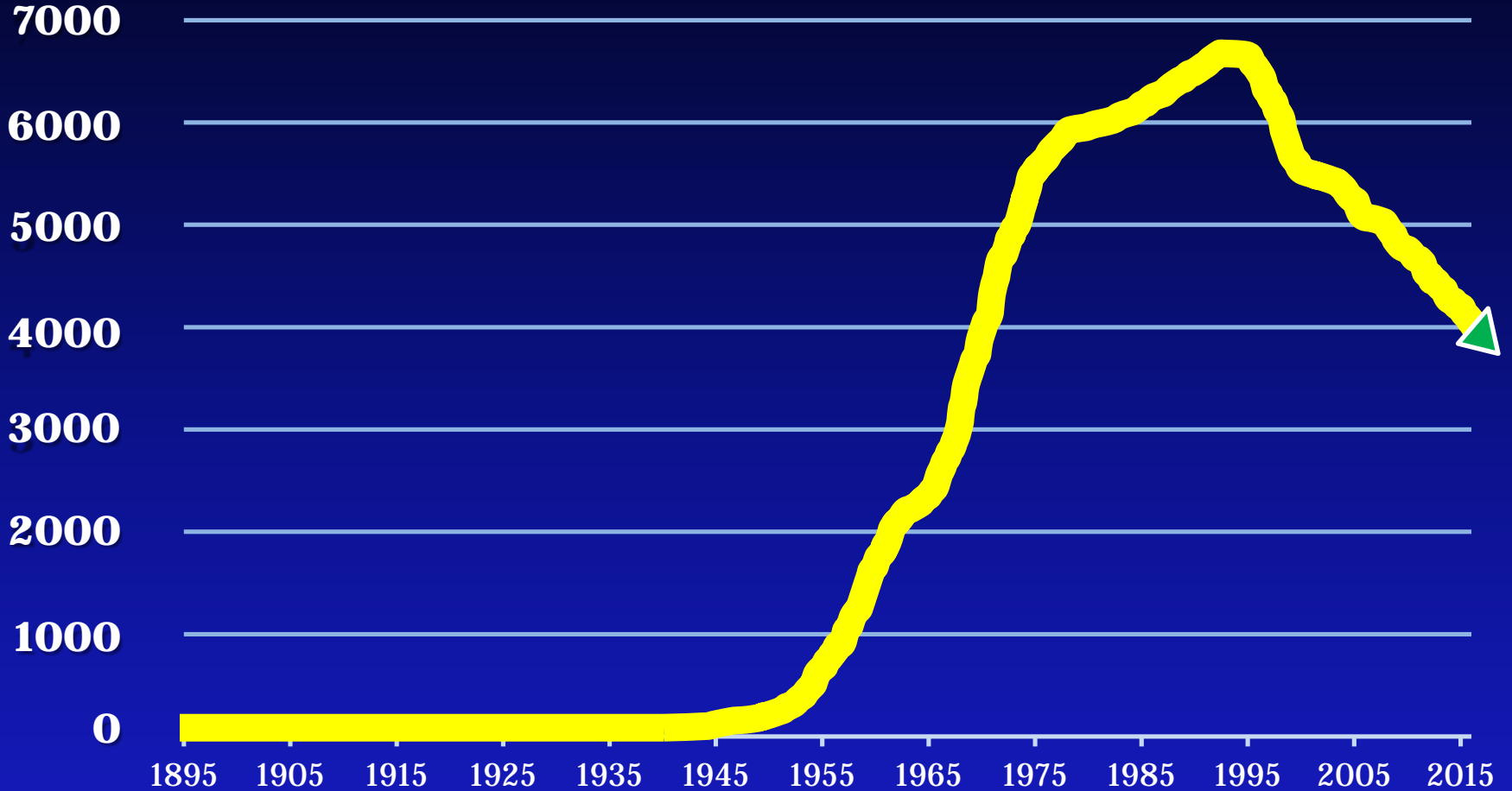
It's about preserving the science

Approach

- **To review the evolution of radiation safety and health physics jobs**
- **To characterize and quantify past and current work involving radioactive materials**
- **To critically assess job opportunities in economic terms**
- **To recommend measures for preserving the science and specialties**

Concern

Chart Title



Annual Estimates of Health Physics Professionals

Filling Needs

- **Rapidly expanding the nuclear weapons complex**
- **Atmospheric testing of nuclear weapons**
- **Building the nuclear navy**
- **Developing medical and industrial devices**
- **Building electric generating nuclear power plants**
- **Collecting and disposing of radioactive waste**
- **Assessing potential harm to people and the environment from past and current activities**

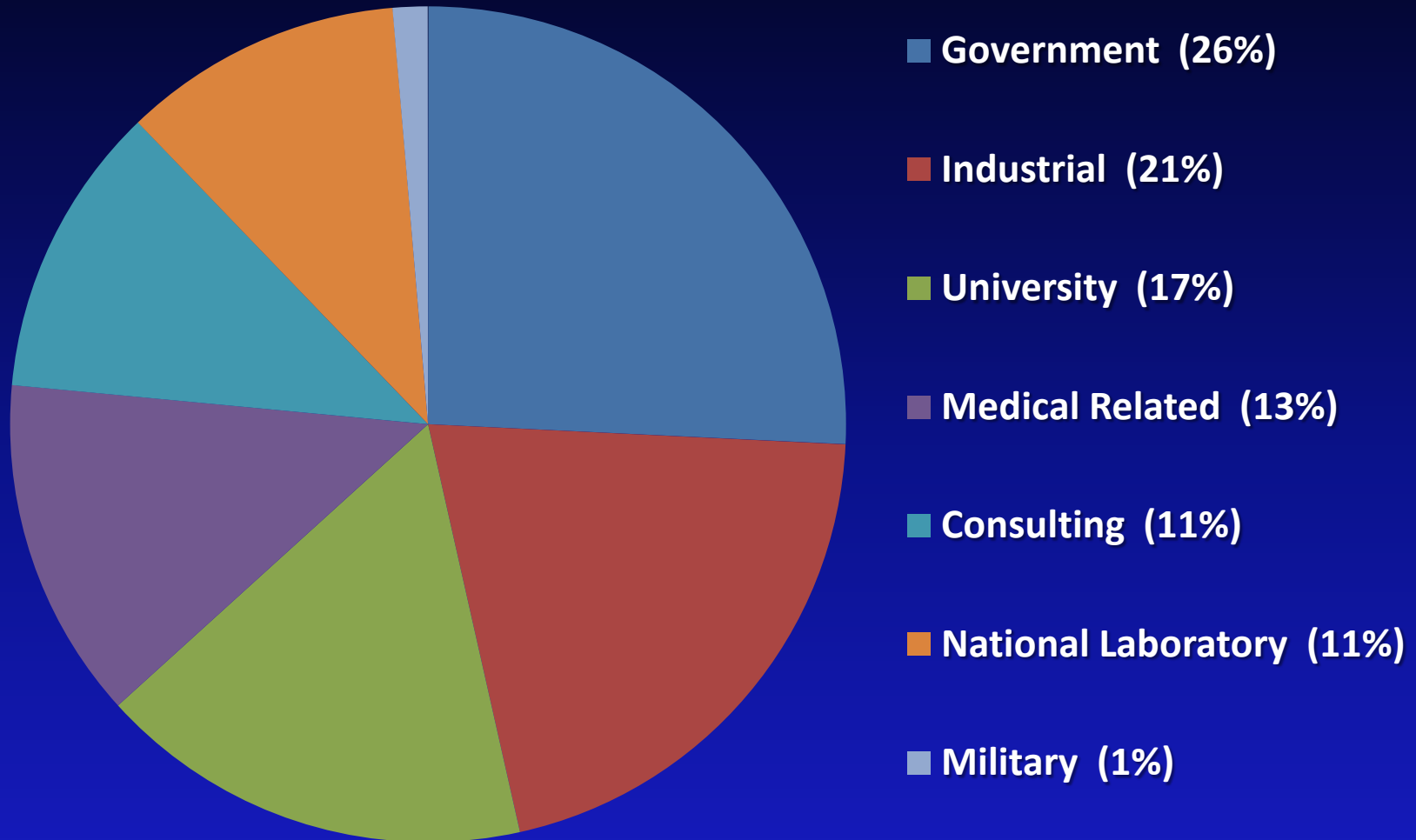
Quantifying Jobs

- **Early discovery and work with radioactive materials**
- **Establishing standards for exposure and use**
- **Determining the impact of radiation on matter, its transport, uptake and health effects**
- **Developing ecological surveillance and environmental monitoring programs**
- **Refining worker, public, environmental standards**
- **Limiting exposures from radiation generating devices**
- **Estimating doses to workers and the public**

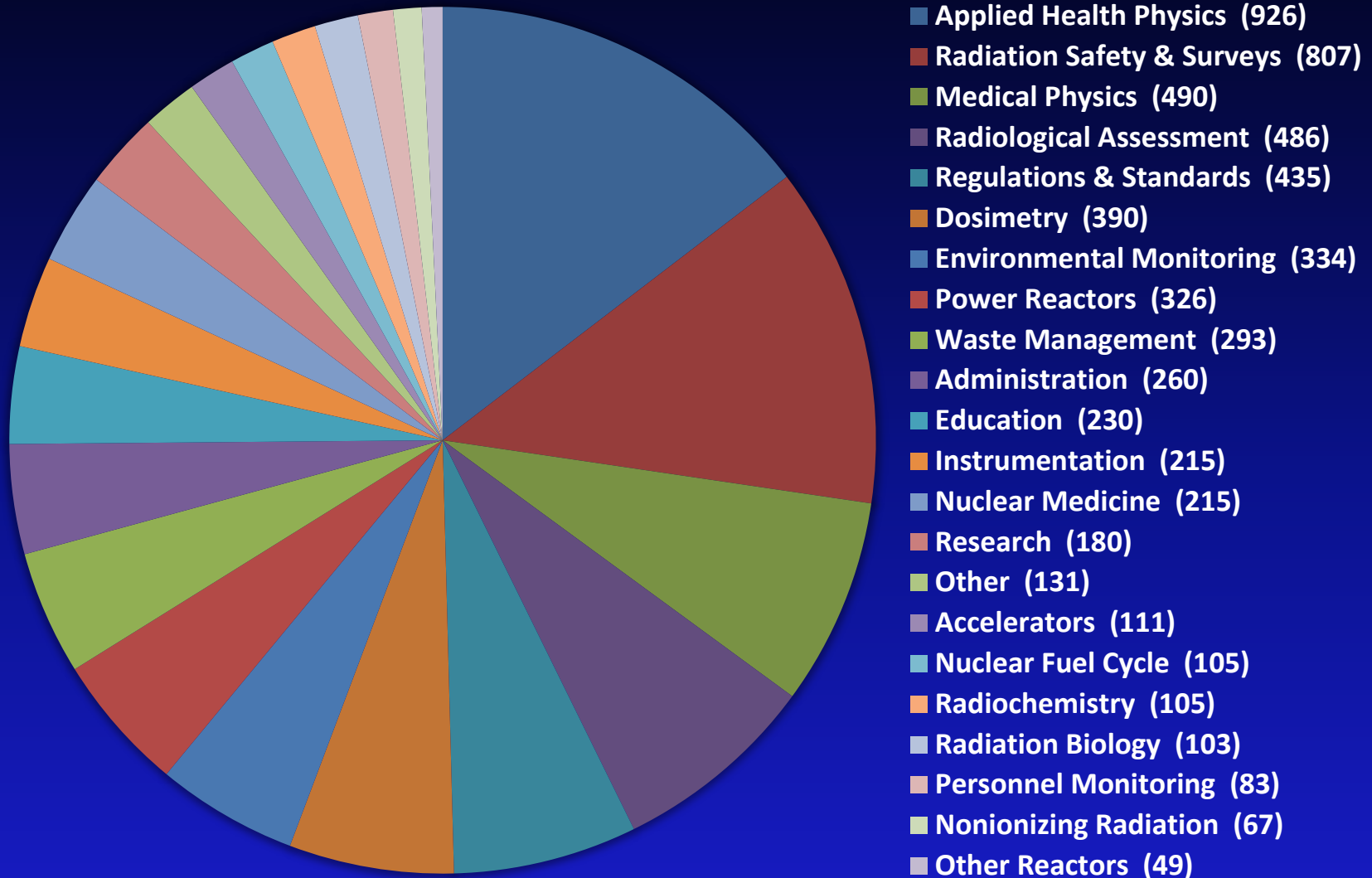
Current Work

- **Conducting research**
- **Reacting to major nuclear accidents**
- **Remediating the nuclear weapons complex**
- **Sustaining aged nuclear power plants**
- **Updating X-ray and medical devices**
- **Securing fugitive radioactive materials**
- **Removing spent radioactive armaments & penetrators**
- **Dealing with the threat of terrorism**
- **Compensating individuals harmed by radiation**

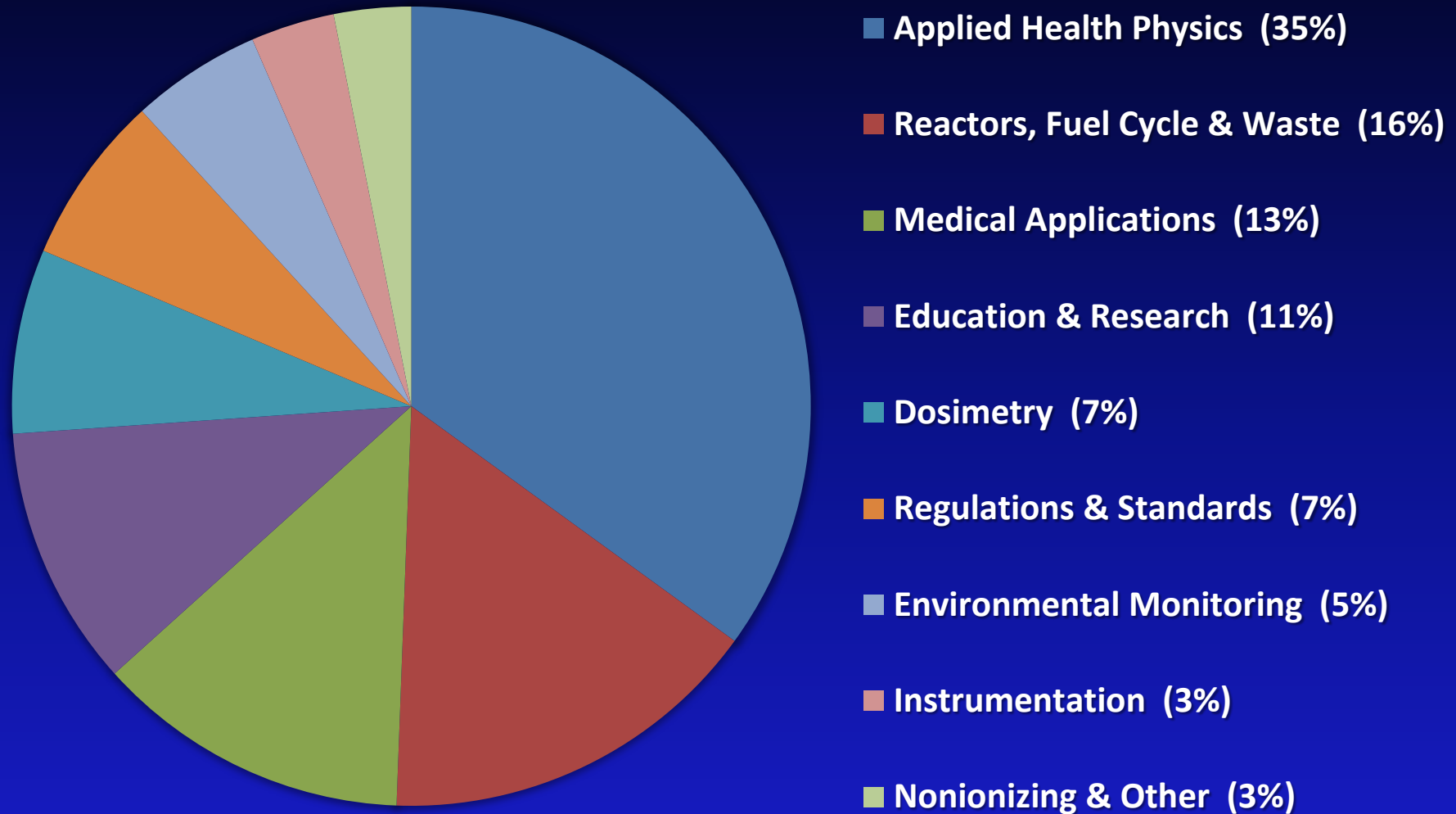
HPS Membership – Employment



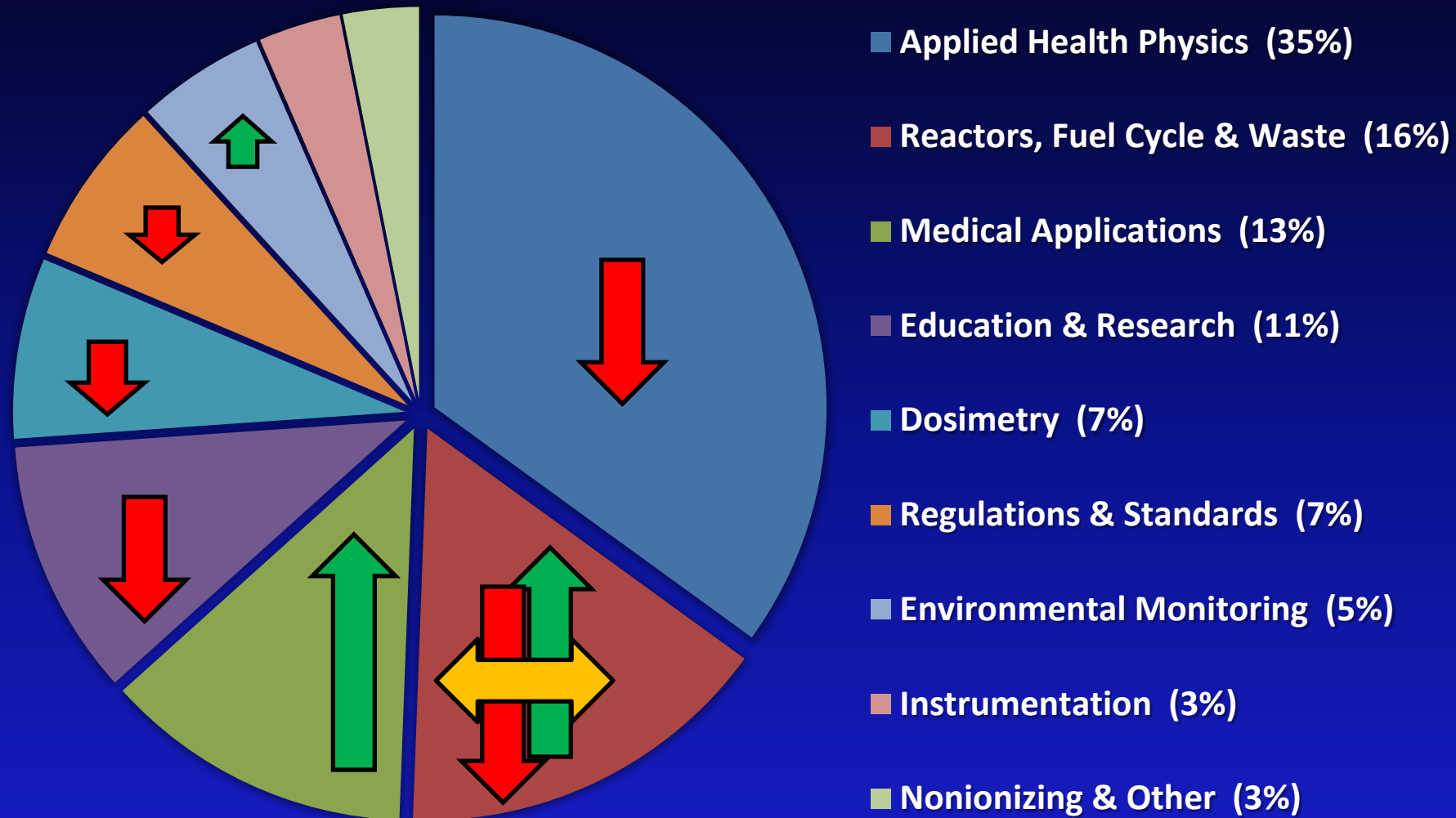
HPS Membership – Specialties



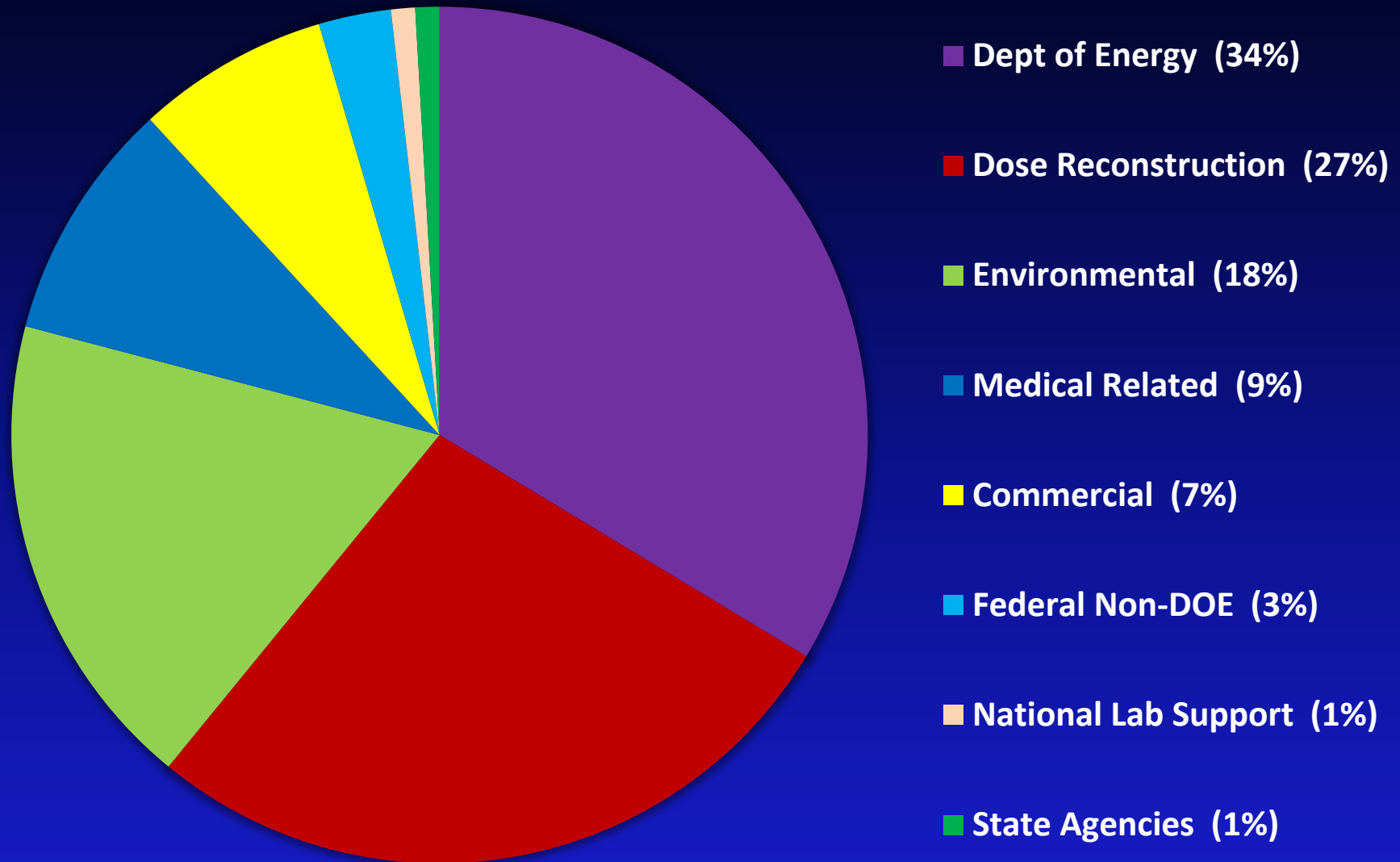
HPS Specialties – Consolidated



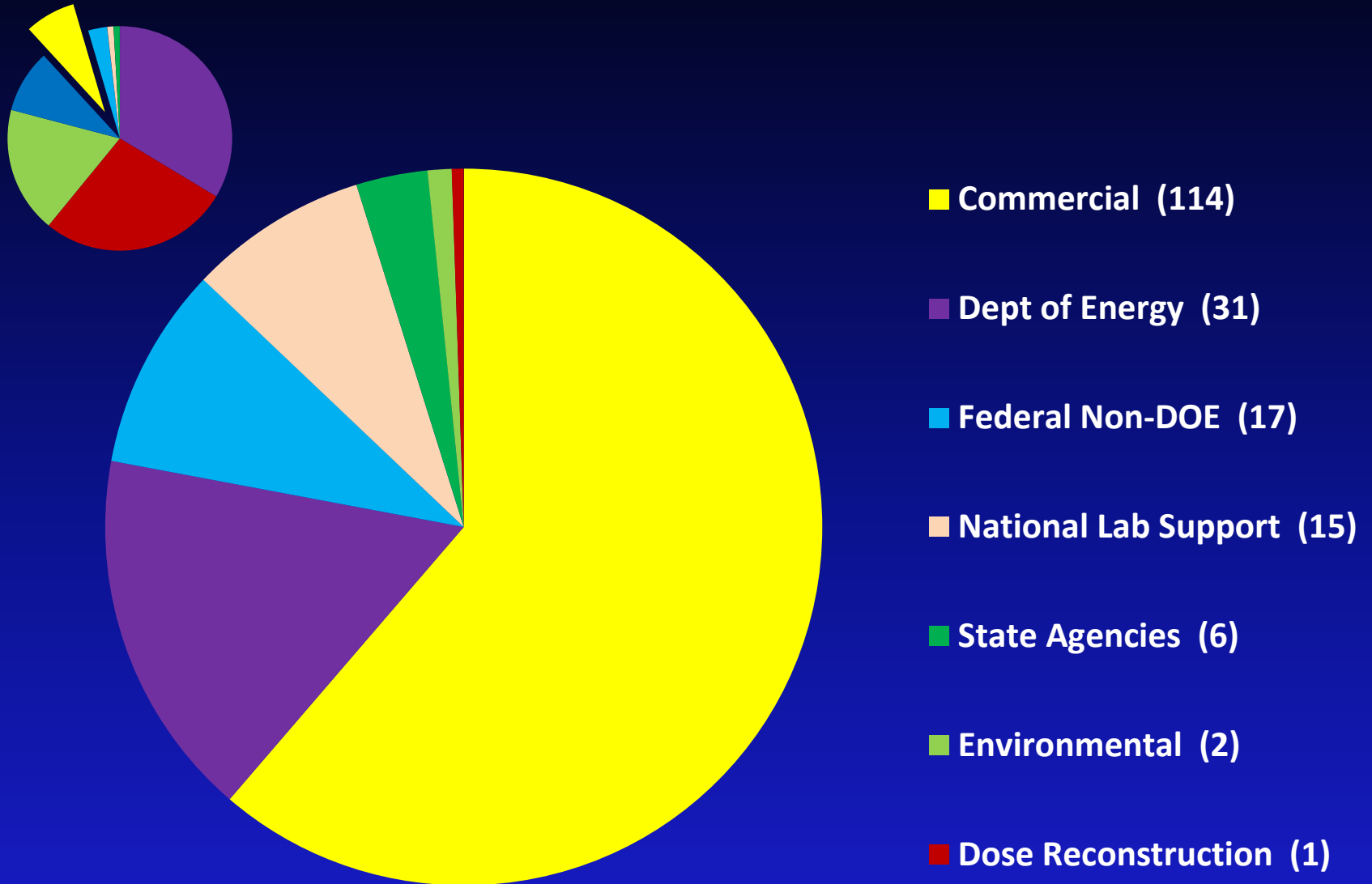
HPS Specialties – Consolidated



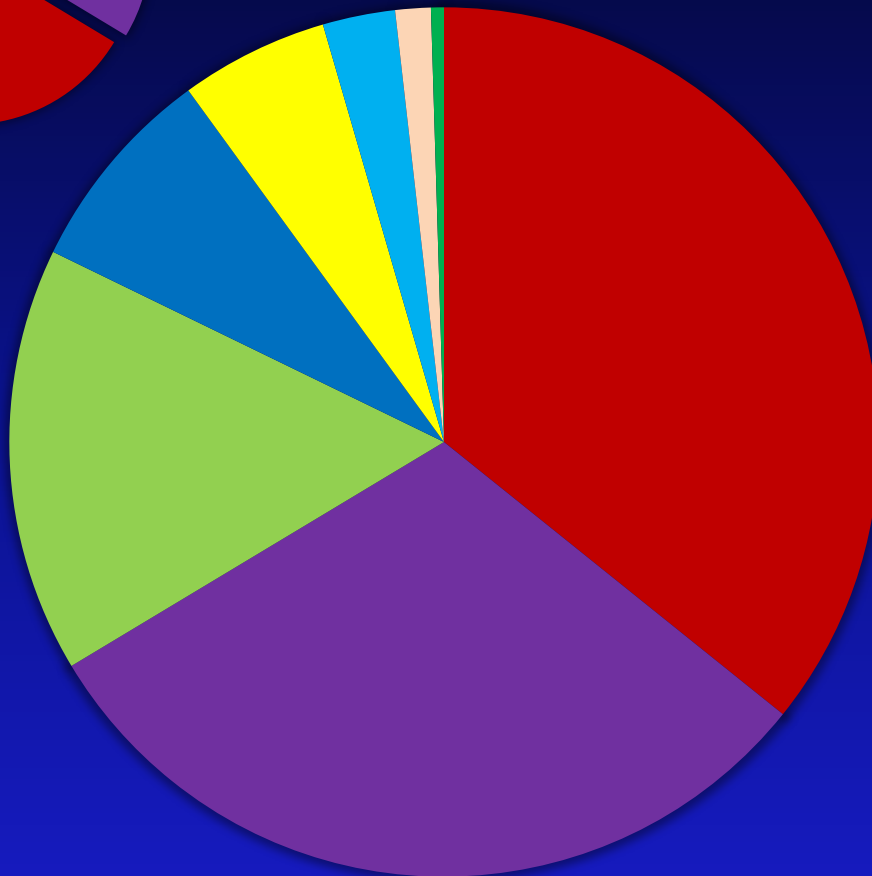
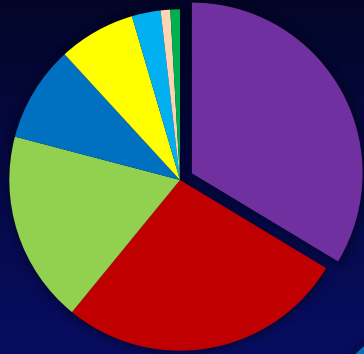
Business Market – Revenues



Business Market – Contracts

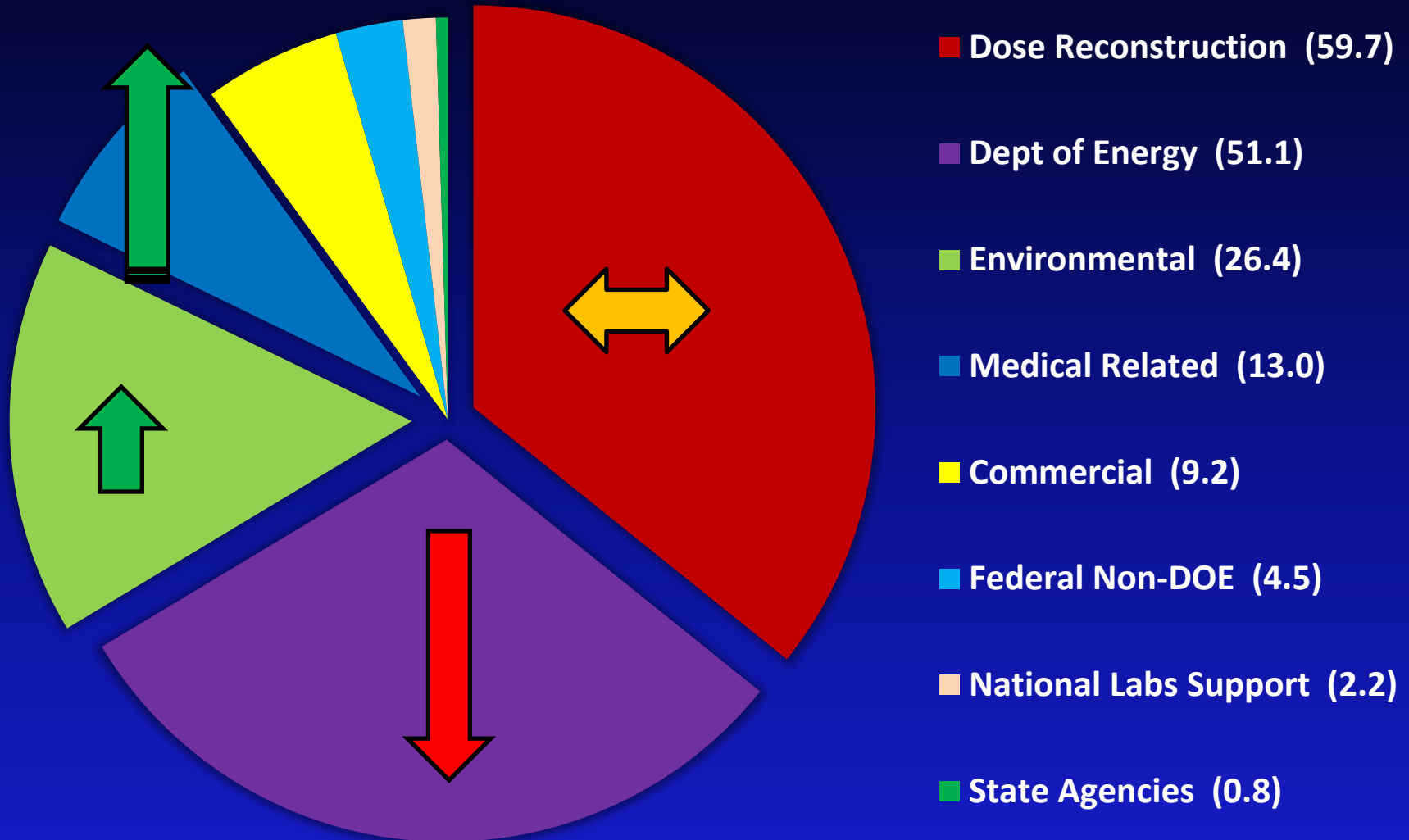


Business Market – Real Jobs



- Dose Reconstruction (59.7)
- Dept of Energy (51.1)
- Environmental (26.4)
- Medical Related (13.0)
- Commercial (9.2)
- Federal Non-DOE (4.5)
- National Labs Support (2.2)
- State Agencies (0.8)

Business Market – Future Jobs



Assessing Jobs

- Health physics has changed and will continue to change
- The focus will likely be responding to significant events, inadvertent exposures and technology development
- Technology will not decrease (total) job demand
- Consumer concerns will result in an industry that screens consumer products
- Waste management needs will not go away
- People will always want to know if they were harmed
- Funding will be affected by the next major event
- Medical, medical, medical

Facing Realities

- Work is no longer groundbreaking
- HPs have controlled and limited radiation doses
- Operations are routine and scripted
- Operations are not “missing” HPs
- HP specialties have become luxuries
- Radiation is not a new science
- Research funding disappearing
- Students going elsewhere

Factors Affecting Supply

- Programs are developed
- Operations are routine
- Work is covered by mature procedures
- Radiation protection is practiced effectively
- Adverse impacts are rare (though significant)
- Generalists are filling positions
- Generalists are benefiting (and happy \$)
- HP professionals are being replaced

Lessons From Other Industries

- Consider the economics governing change
- Dental care – hygienists clean teeth
- Medical care – nurse practitioners see patients
- As a society, we accept some risk to lower costs

Changing markets – Dealing with economics by using individuals with lesser education, qualifications and experience to deliver services

Preserving the Science

(*Lessons From Other Industries*)

- Establish job standards (*Pharmacists*)
- Require calculations to be certified (*Engineers*)
- Improve regulatory drivers (*Transportation*)
- Attract the next generation (*Medicine*)
- Make it “essential to national security” (*TSA*)

Preserving the Science

- **Accept the economics** – *It's dictating personnel*
- **Develop job standards** – *Or lose the science*
- **Use favorable economics** – *Capture data and events where better qualified staff would have prevented significant costs*
- **Make HPs more relevant to broader operations** – *Provide additional safety training with integrated safety management and conduct of ops*
- **Take someone else's job** – *Prepare HPs to capture safety positions with more responsibility*

Questions?

Contact Information

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Meeting the Needs of First Responders:

Scientific Experiments to Operational Tactics
for the First 100 Minutes After an Outdoor
Explosive Radiological Dispersal Device

Stephen V. Musolino
Daniel Blumenthal
Brooke Buddemeier
Fredrick T. Harper

The Problem

Radiation protection experts do not routinely respond to emergencies and may lack skills to support an emergency

Responders need:

Sound scientific advice for planning and,
Radiation protection experts to assist with an actual emergency response.

OR

During a radiological emergency, fear and lack of familiarity about radiation add complexity and uncertainty to decisions and operations

- Responders may not adequately manage their own safety
 - Responders may delay essential lifesaving activities

It is 11:00 and an explosion just occurred in your city



11:02



PD FD
FD PD

More than
1,000 RDD
characterization
tests have been
performed by
Fred Harper at
SNL in the last
25 years

Have semi-empirical
models for metals in
different geometries,
liquids, salts ceramic
powders, and preliminary
models for ceramics.

MATERIAL	PHYSICAL FORM	DEVICE STRATEGIES TESTED
Ag	Metal	17
Al	Metal	5
Bi	Metal	3
Co	Metal	1
Cu	Metal	2
Mo	Metal	1
Pb	Metal	1
Ir	Metal	3
Stainless Steel	Metal	2
Ta	Metal	1
U	Metal	1
CeO ₂	Ceramic (2 densities per device)	7
SrTiO ₃	Ceramic (3 densities per device)	8
Tb/Pd	Cermet	1
Co	Liquid	2
CsCl	Liquid (several different relative humidity and temps)	6
BaSO ₄	Slurry	1
CeO ₂	Ceramic Powder	7
MnO ₂	Ceramic Powder	4
UO ₂	Ceramic Powder	1
CeO ₂	Pressed Powder	3
CsCl	Powdered Salt	7
BaSO ₄	Powdered Salt	2

Our Key Scientific Research

Harper, FT, Musolino, SV, and Wentz, WB. **Realistic radiological dispersal device hazard boundaries and ramifications for early consequence management decisions**, Health Phys. 93:1-16, 2007

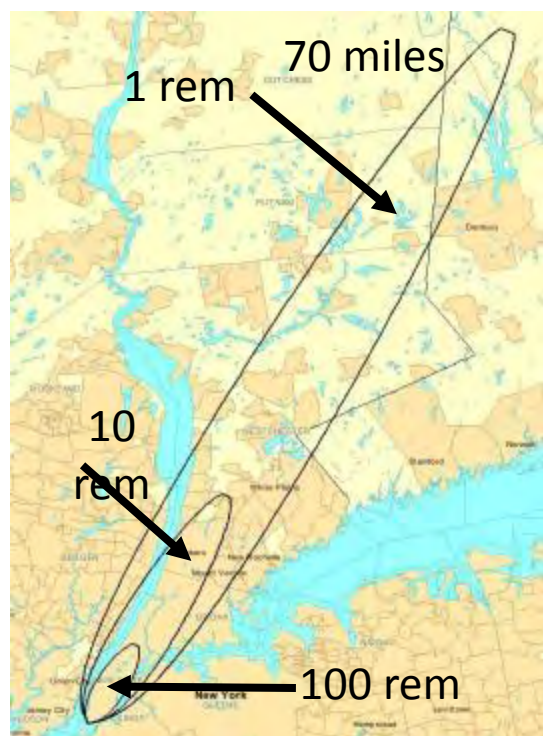
Musolino, SV, Harper, FT. **Emergency response guidance for the first 48 hours after the outdoor detonation of an explosive radiological dispersal device**, Health Phys. 90:377-385, 2006

Musolino, SV, Harper, FT, Buddemeier, B, Brown, M, Schluack, R. **Updated Emergency Response Guidance For The First 48 Hours After The Outdoor Detonation Of An Explosive Radiological Dispersal Device**, Health Physics, 105:65-73, 2013

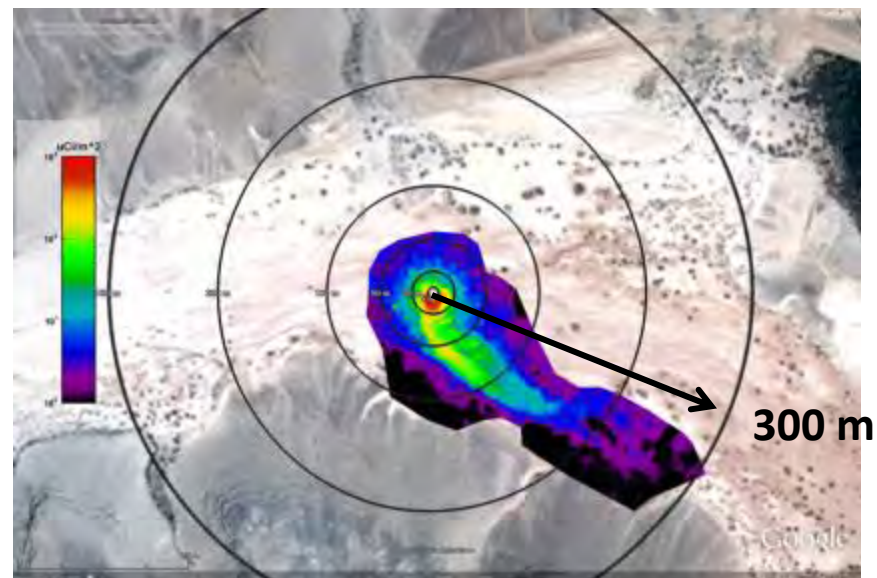


Our Goal is to Dispel Misinformation & Challenge Bad Assumptions

Misinformation



From experiments



Federation of American Scientists. Dirty bomb:
Response to Threat, FAS Public Interest Report, J.
Federal. Am. Scient. 55(2), 1-10

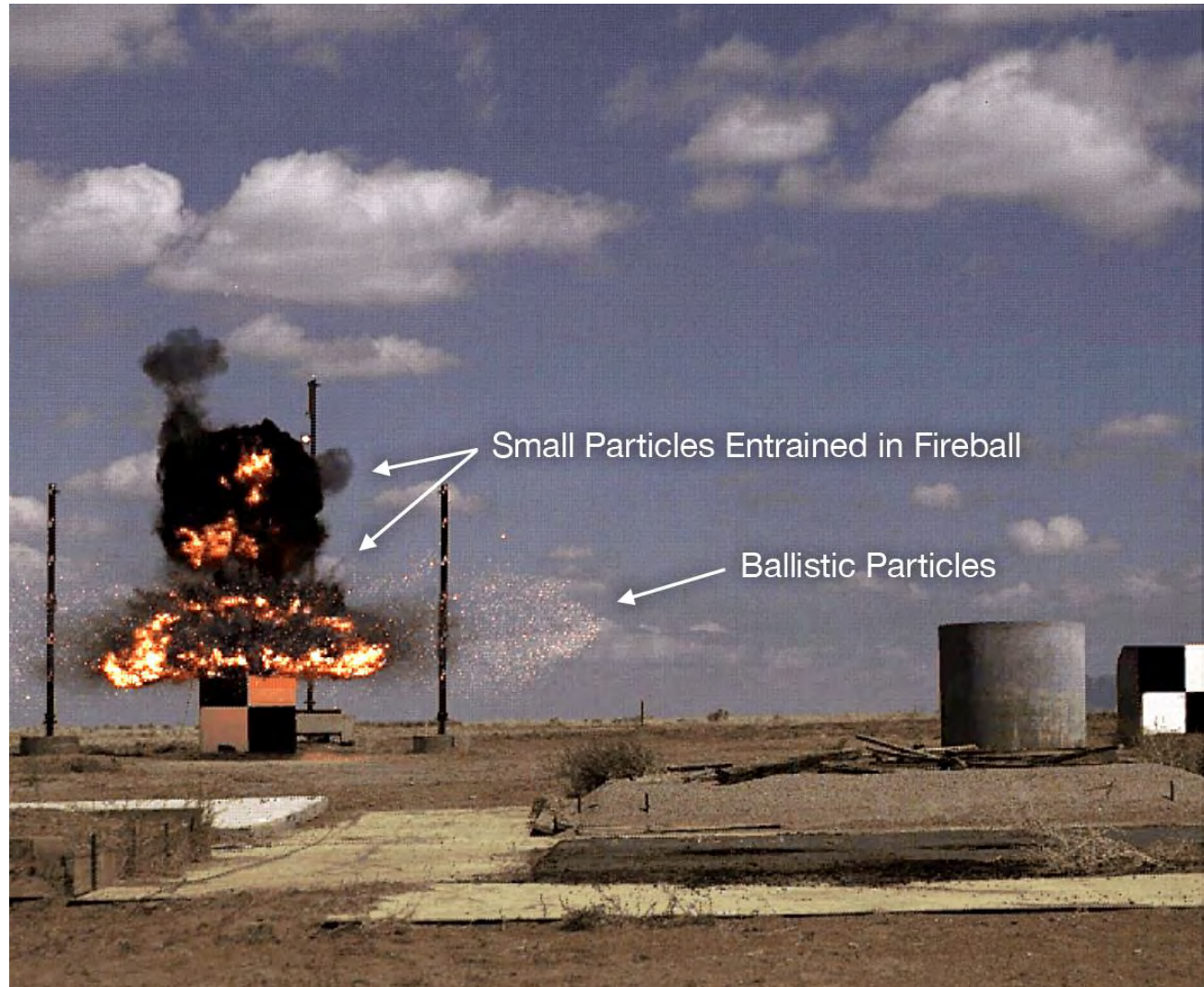
**Large Particle/Frag Velocity at 4 m
at 725 m/s, at 10 m 400 m/s, at 23 m 145**







Large and Small Particle Fates

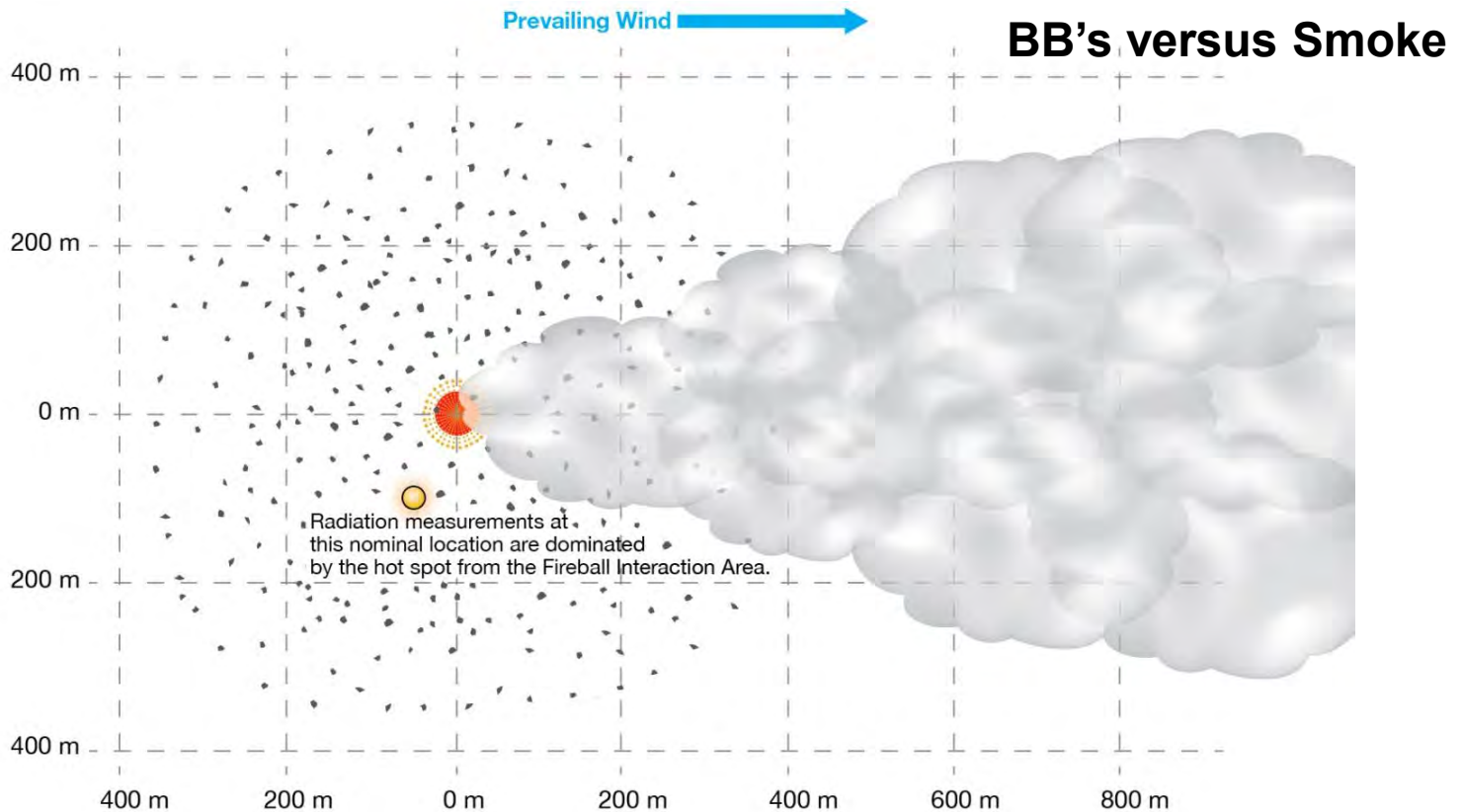
Detonation Near the Ground

5% of small particles (< 100 μm) in the fireball get “painted” on the fireball interaction area



Particle/Frag Size, HE amount/location determine deposition pattern – size matters

-  Fireball Interaction Area
-  Large Particles (~ 100-500 μm)
-  Ballistic Fragments (> 1 cm)
-  Downwind Fallout (small particles)



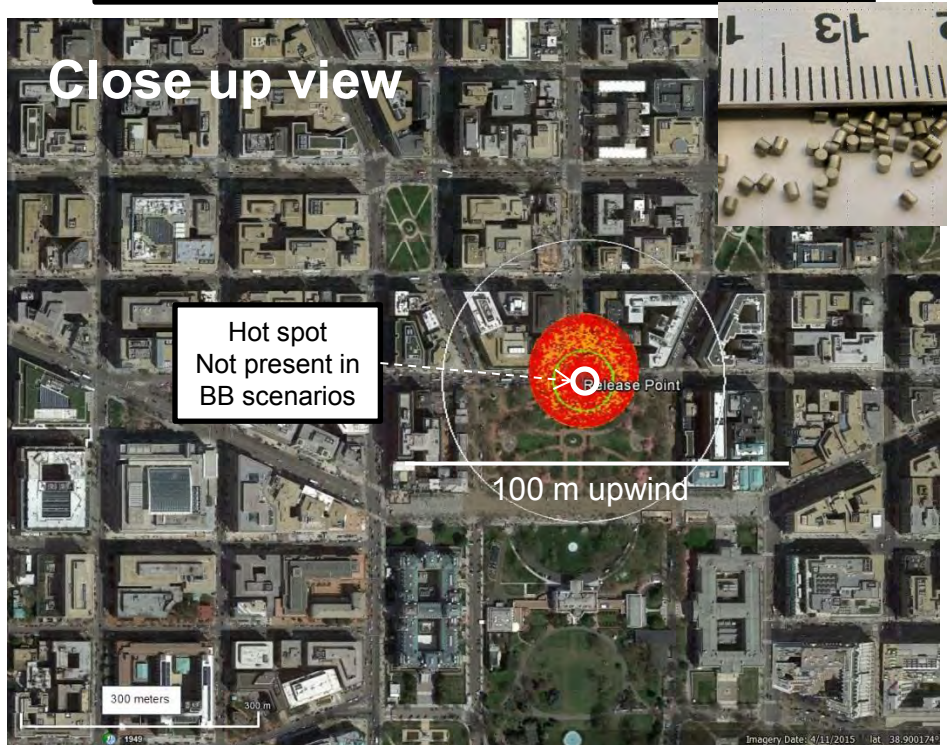
5,000 Ci Rad Material, 55 lbs HE

- 1 mR/hr (Nal detector saturation)
- 10 mR/hr (NCRP hot zone)
- 10 R/hr (NCRP Dangerous rad zone)
- 1.5 psi (Complete glass breakage)
- 0.05 psi (No glass breakage)

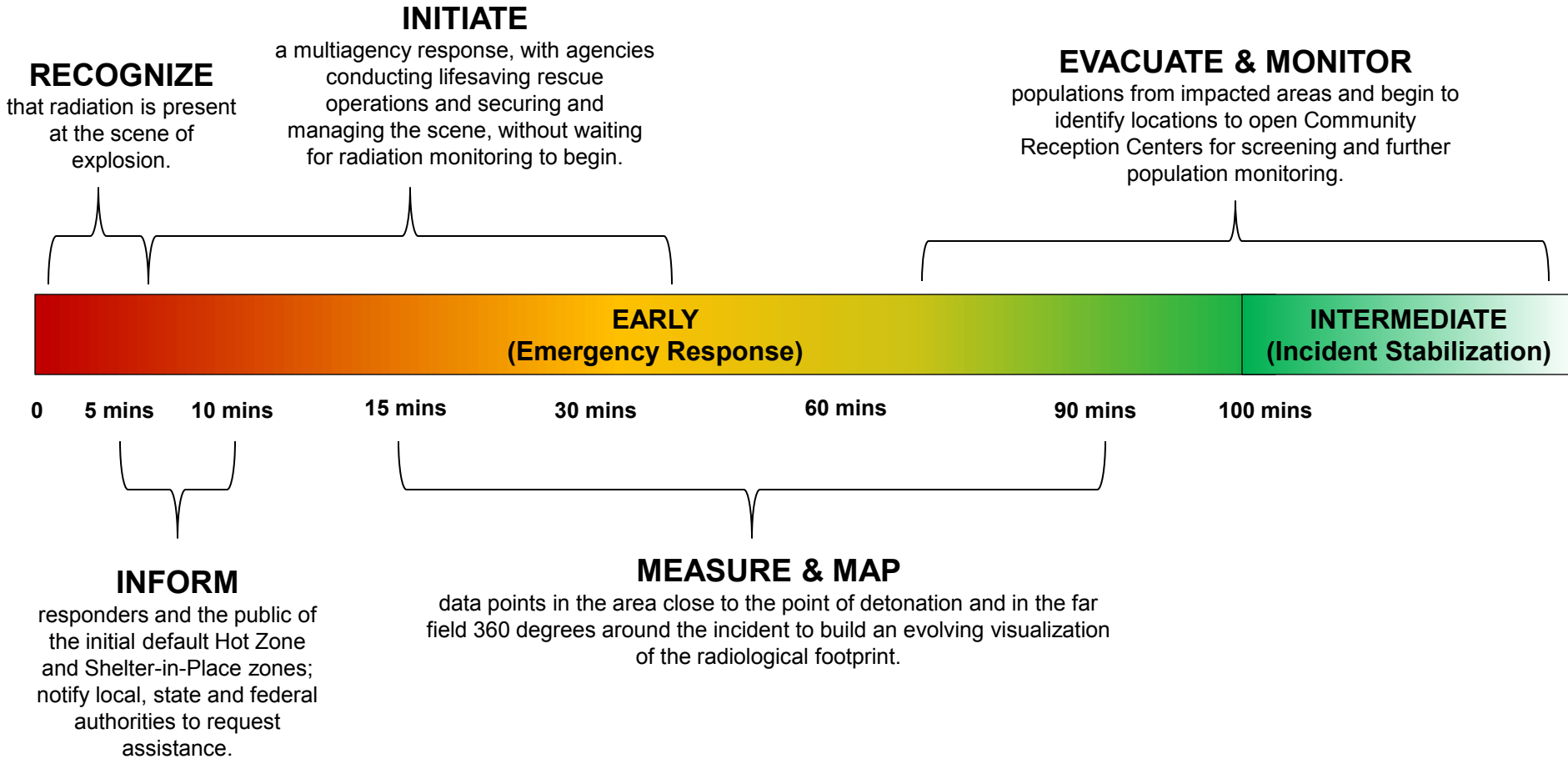
Dispersal: **BBs** (> 90% of material)

Dispersal: **Smoke** (< 2% of material)

Close up view



A Concept for a Successful Response



A Concept for a Successful Response

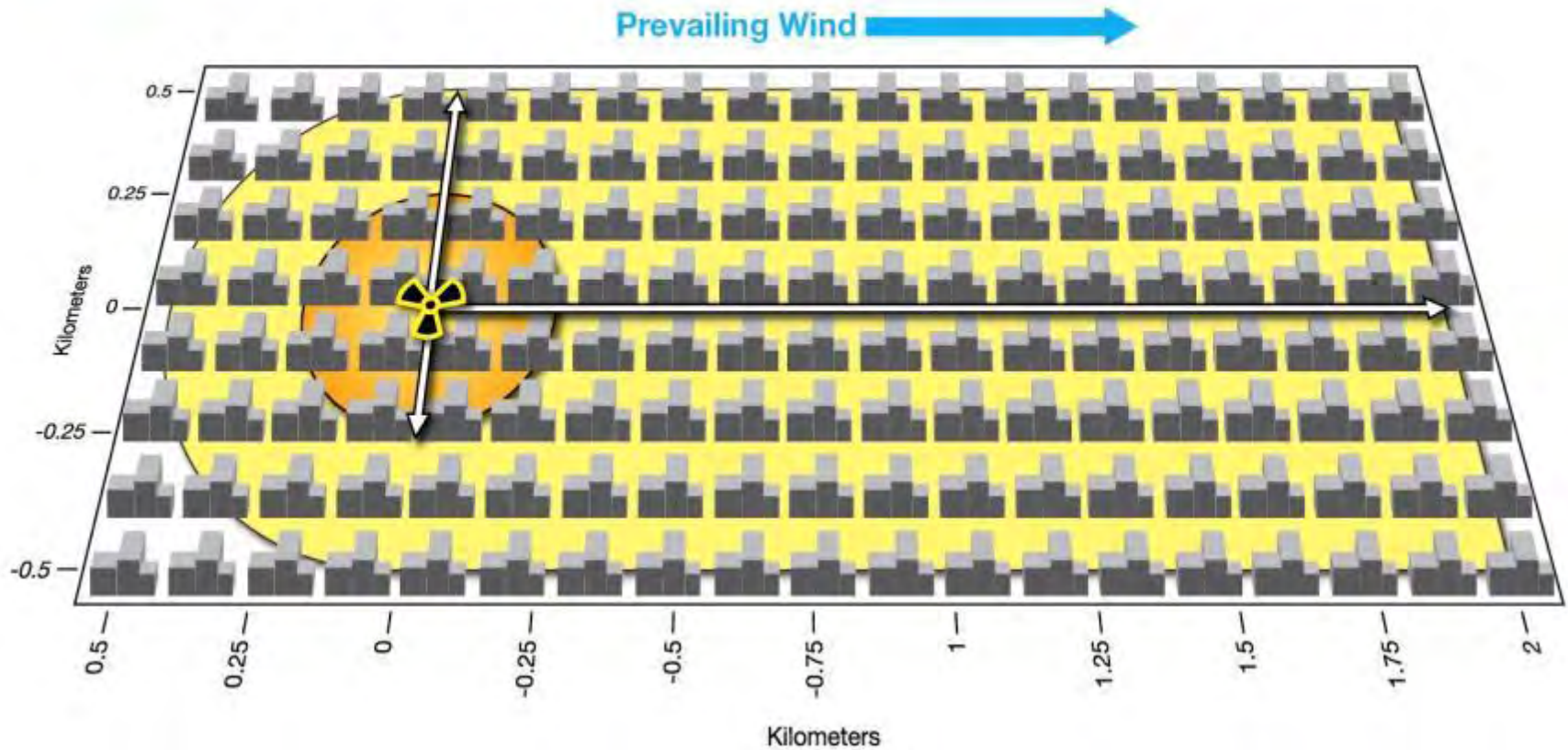


RECOGNIZE 0 – 5 minutes	<ol style="list-style-type: none"> 1. Initial Response and On Scene Recognition 2. Confirm the Presence of Radiation
INFORM 5 – 10 minutes	<ol style="list-style-type: none"> 3. Give Report from the Scene 4. Issue Protective Actions to the Public 5. Notify Partners and Request Assistance
INITIATE 5 – 40 minutes	<ol style="list-style-type: none"> 6. Initiate Lifesaving Rescue Operations 7. Secure and Manage the Scene
MEASURE & MAP 15 – 90 minutes	<ol style="list-style-type: none"> 8. Measure and Map Radiation Levels
EVACUATE & MONITOR >70 minutes	<ol style="list-style-type: none"> 9. Commence Phase Evacuations 10. Monitor and Decontaminate

Issue Protective Actions to the Public

- Initial Shelter in Place (500 m in all directions and 2,000 m downwind)
- Initial Hot Zone (250 m from release)

Looks simple but 25 years of Fred's work justifies this recommendation and assures it keeps people safe



Initiate Lifesaving Rescue Operations

Do Not Delay Any Lifesaving Rescue Efforts

- Begin immediately:
 - Search and rescue
 - Fire suppression
 - Medical triage and treatment
- Just because radiation is detected does not indicate a high hazard condition.
- Radiation monitoring equipment, although desirable, ***is not required*** to begin lifesaving operations.

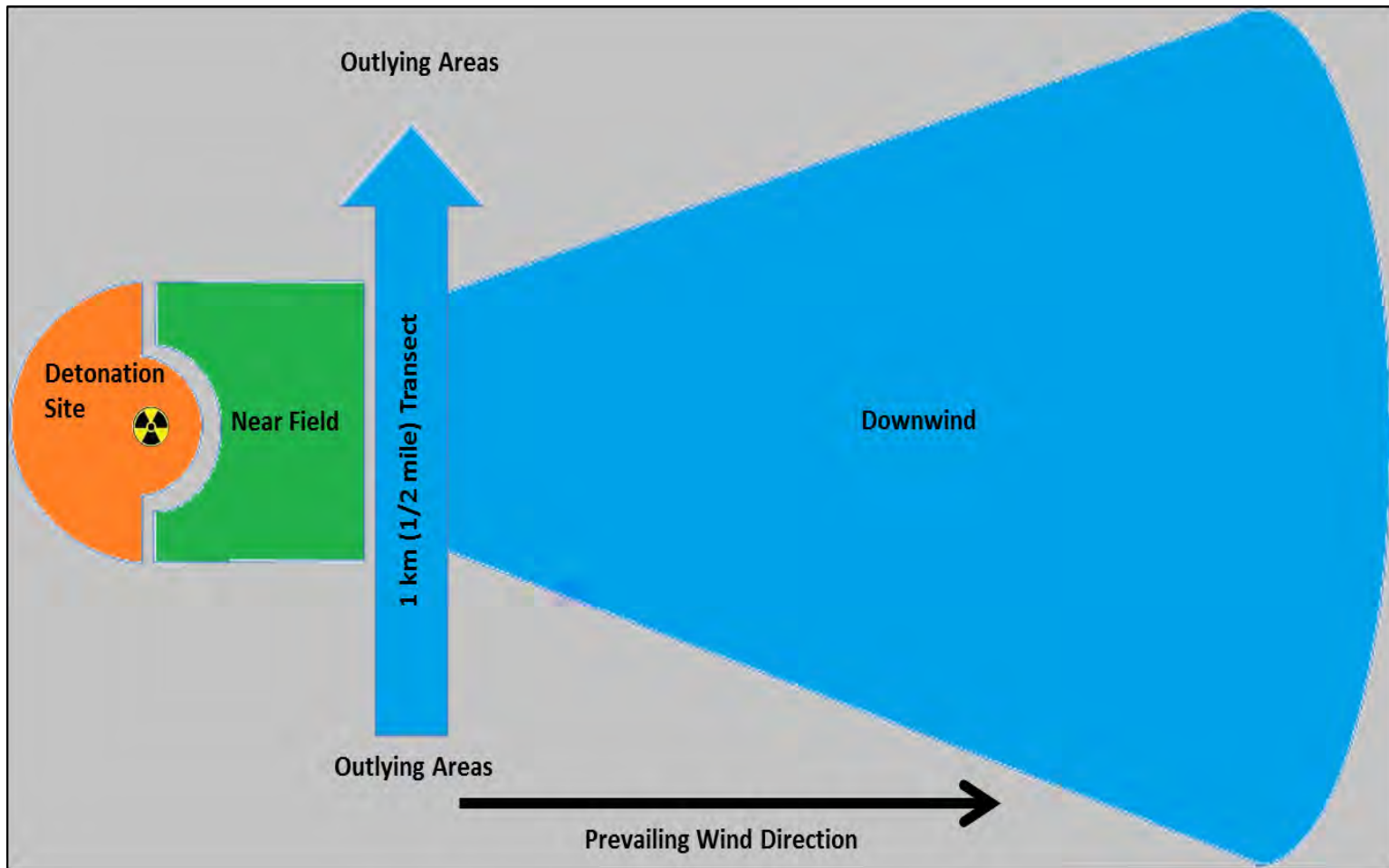
Fred's work enables this recommendation

Measure and Map Radiation Levels

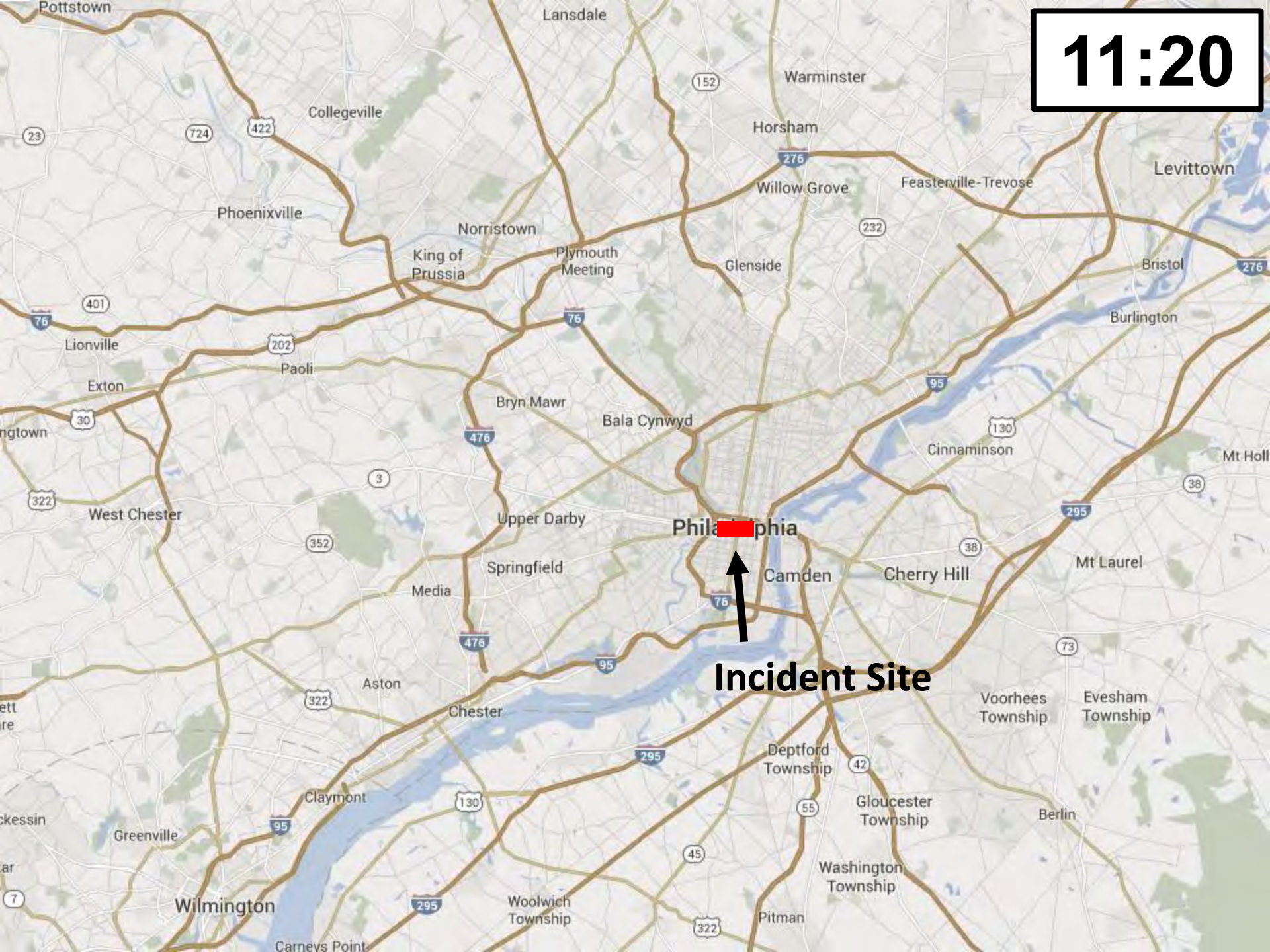
“You can’t model your way out of this problem, you can only measure your way out.”

- Initial data points collected will provide early diagnostic data
 - Aerosol vs. fragmentation (“Smoke” vs. “BBs”)
 - Locations of contamination, or lack there of
 - Promptly rule in or out alpha emitting isotope
- Tactical approach need to get the data for an **analyst** to make informed decisions

Measure and Map Radiation Levels



11:20

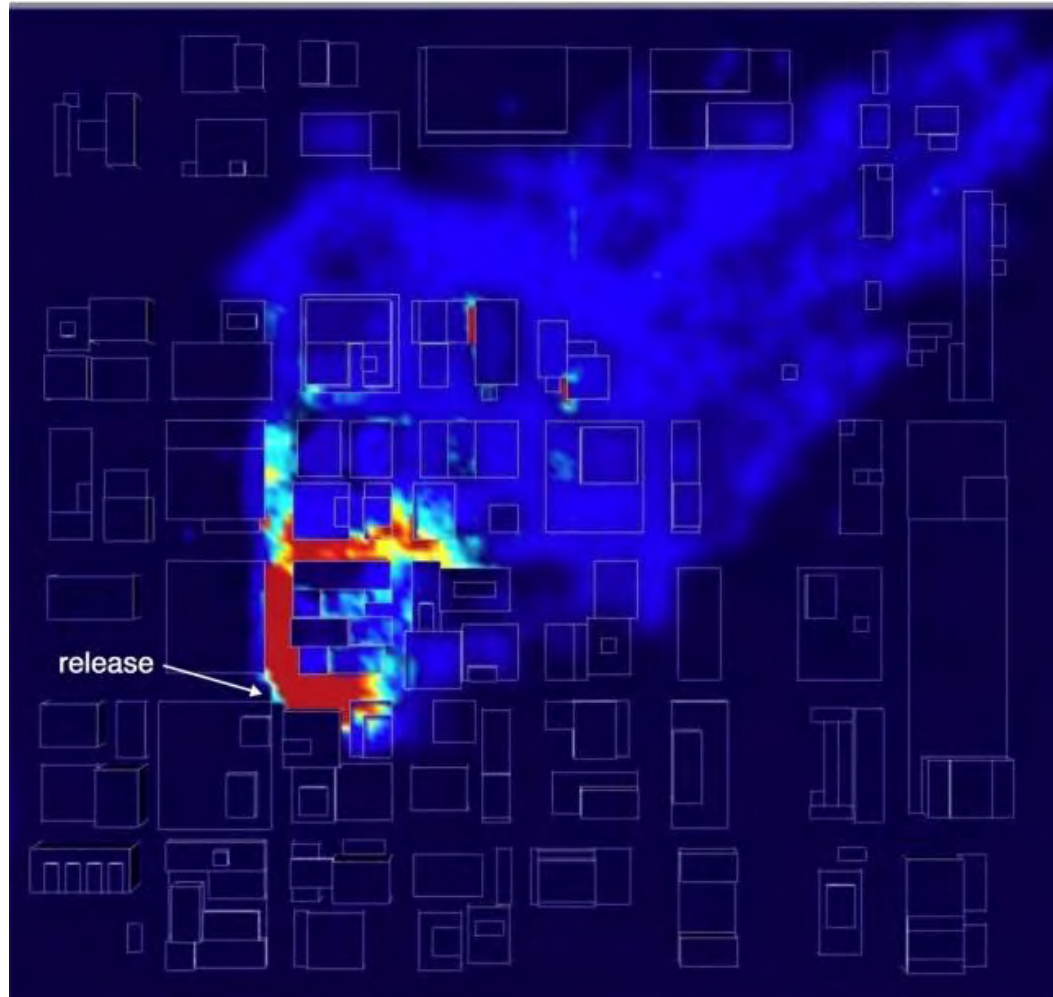


Philadelphia

Incident Site

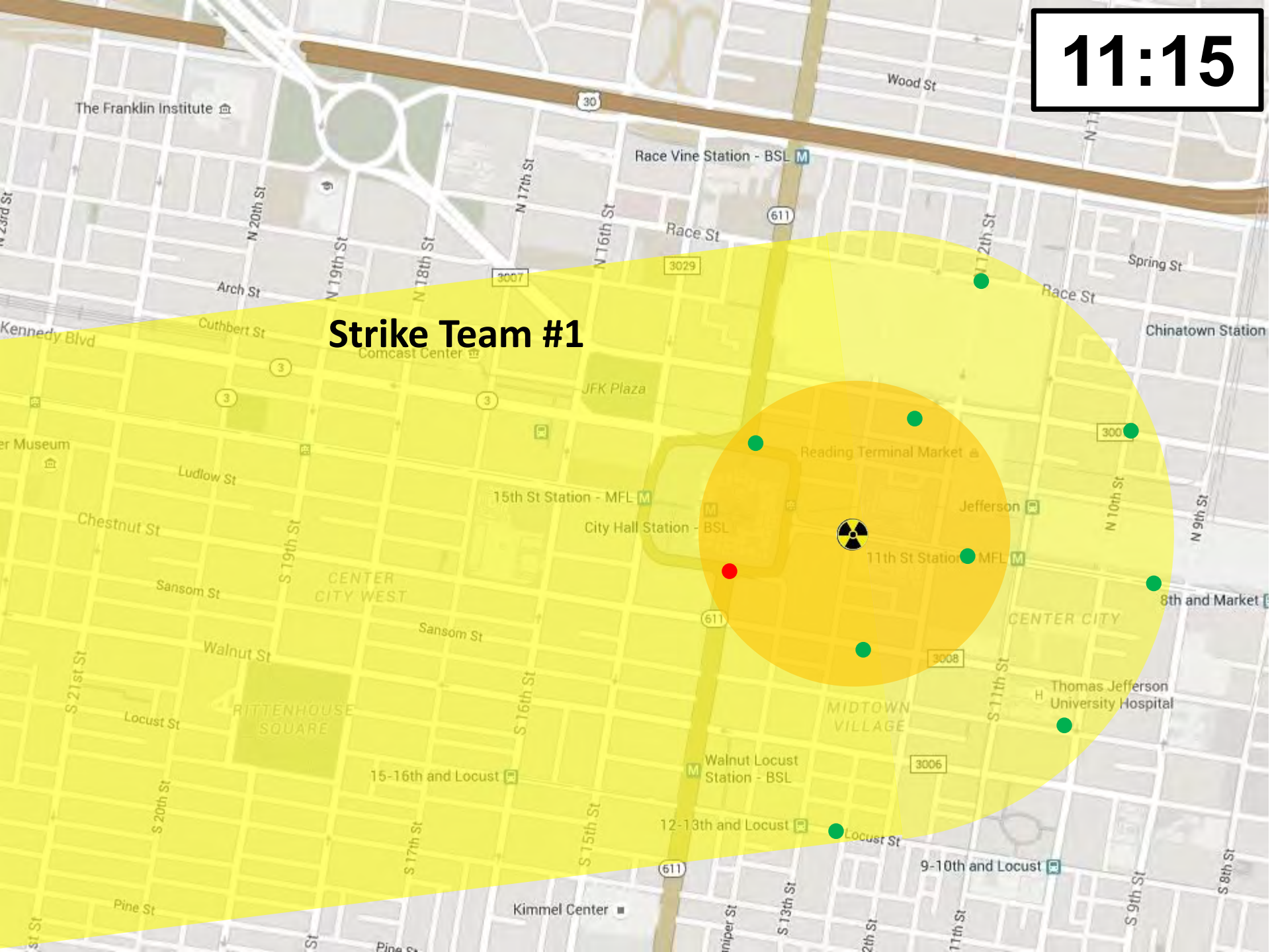
Measure and Map Radiation Levels

Measurements For Actual Boundaries



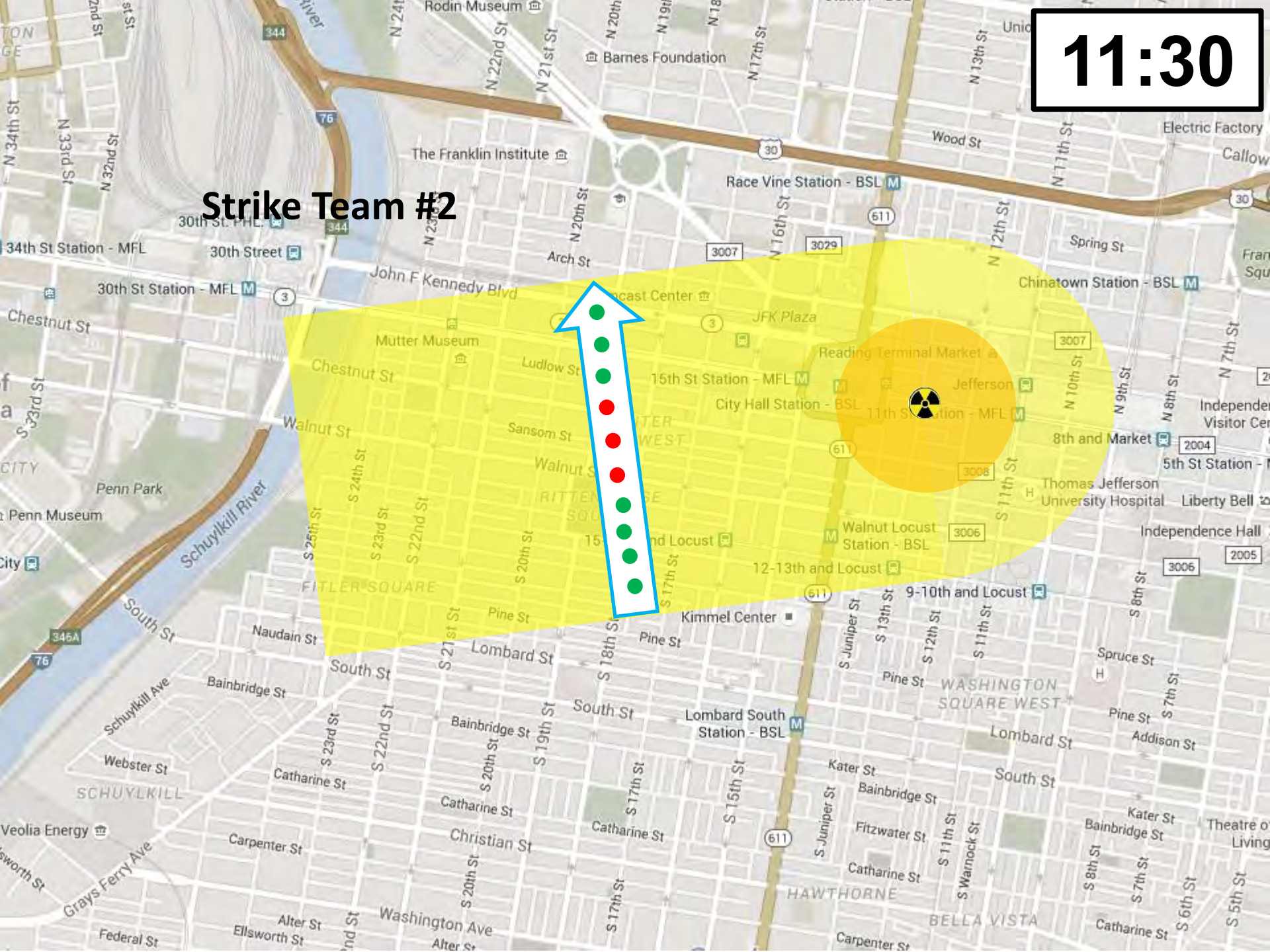
11:15

Strike Team #1

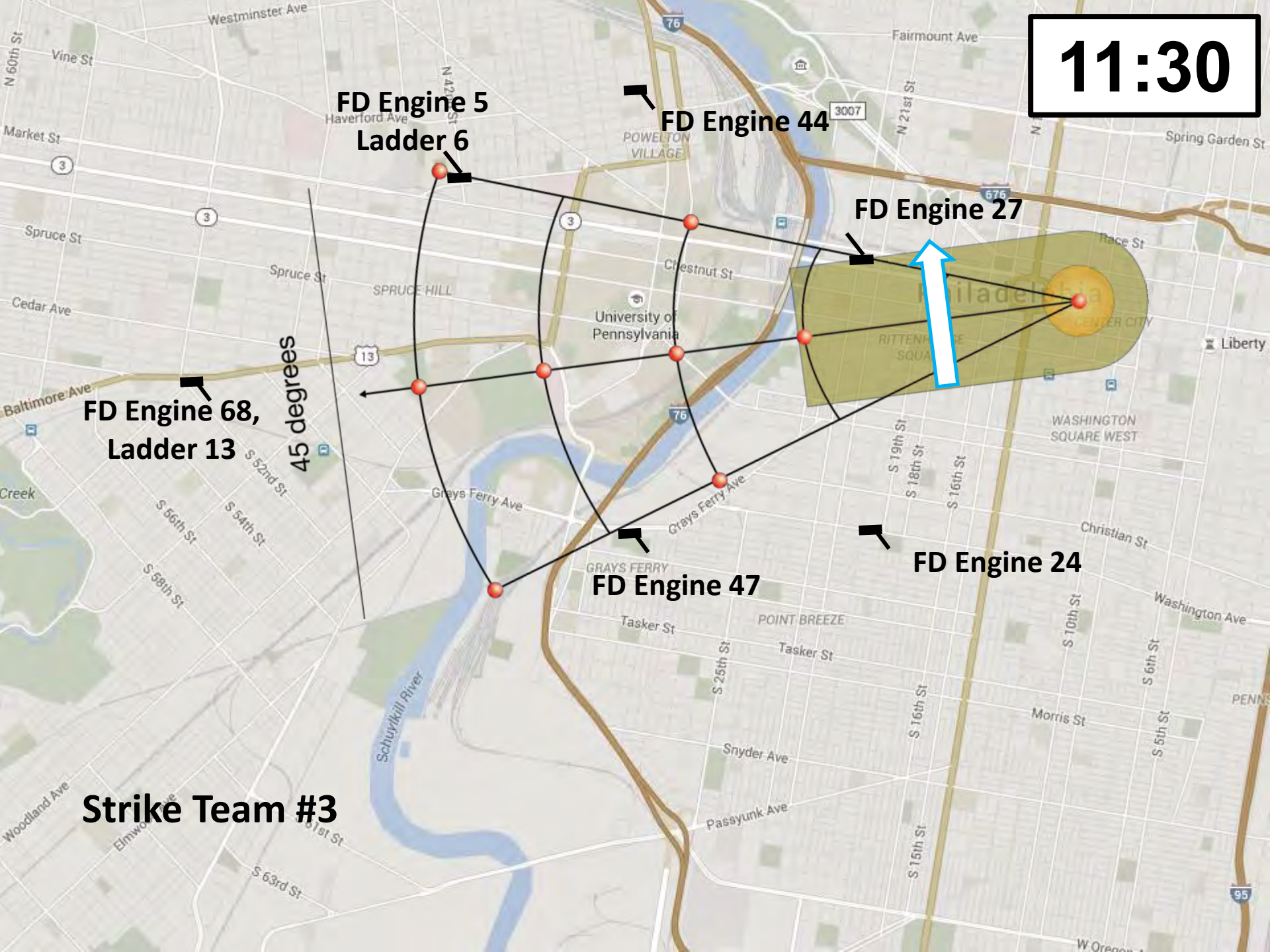


11:30

Strike Team #2



11:30



**FD Engine 5
Ladder 6**

FD Engine 44

FD Engine 27

**FD Engine 68,
Ladder 13**

45 degrees

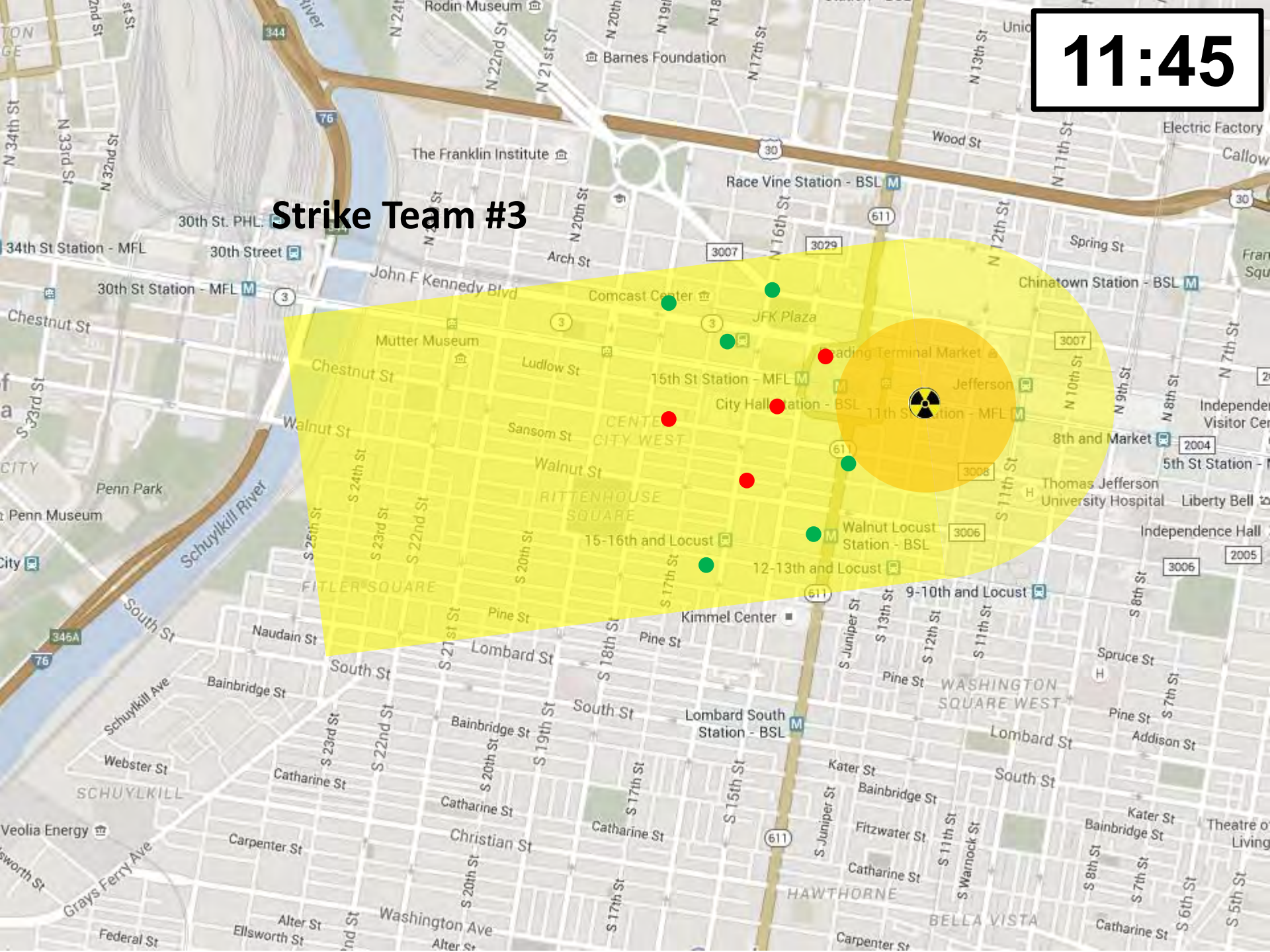
FD Engine 47

FD Engine 24

Strike Team #3

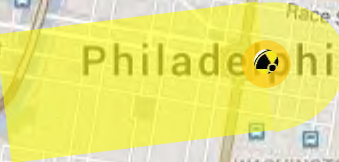
11:45

Strike Team #3



11:45

Strike Team #4



Who is the radiation expert to advise decision-makers?

- How will the incident get support from radiation professionals?
 - Within 100 minutes a qualified analyst is needed to interpret the field data and assist decision-makers protect people and bound the incident.
 - Beyond 100 minutes, the transition to recovery needs support before and after outside resources arrive



Radiological Operations Support Specialist (ROSS)

A Call to Arms for Health Physicists

ROSS as a Solution

Radiological Operations Support Specialist program is a means for ***local health physicists and other personnel with radiological knowledge*** to support radiological response operations in an emergency.

ROSS volunteers will support emergency operations by:

- Supporting the incident command system structure,
- Helping access specialized federal resources and tools,
- Interpreting and explaining data and predictive modeling,
- Providing guidance to responders, incident commanders, elected officials, and decision-makers on appropriate protection actions for responders and the public, and
- Aiding public and responder communication efforts.

ROSS Integration

The ROSS is a State and Local asset, not a representative of federal agencies.

They report to *and work in the best interests of* state and local agencies.

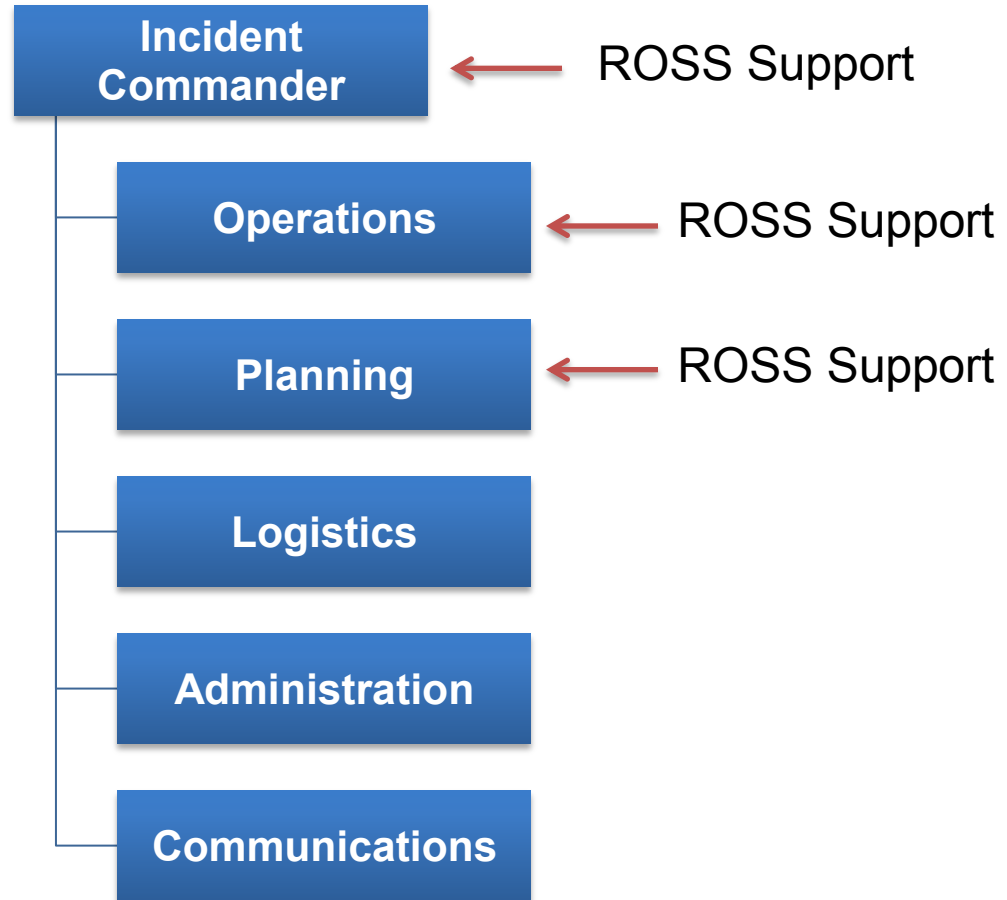
The ROSS can be used throughout the response structure, but will be most effective as a ***Technical Specialist to Command Staff***

ROSS Within ICS

ROSS at Incident Command Post

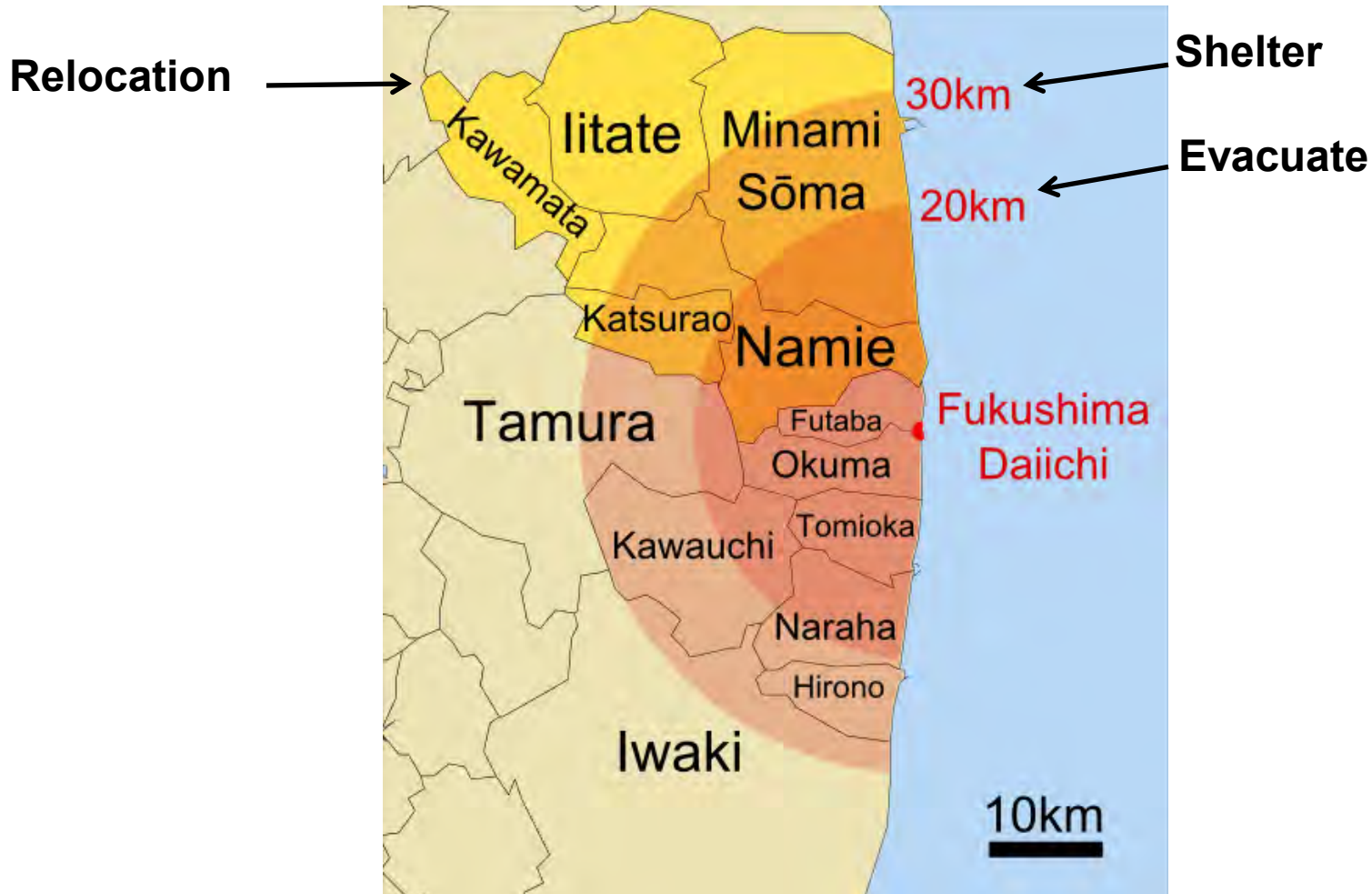


ROSS at Branch



What if the incident was a nuclear detonation?

But first, Fukushima has some lessons



Human Toll

Evacuation from the Radiation Hazard

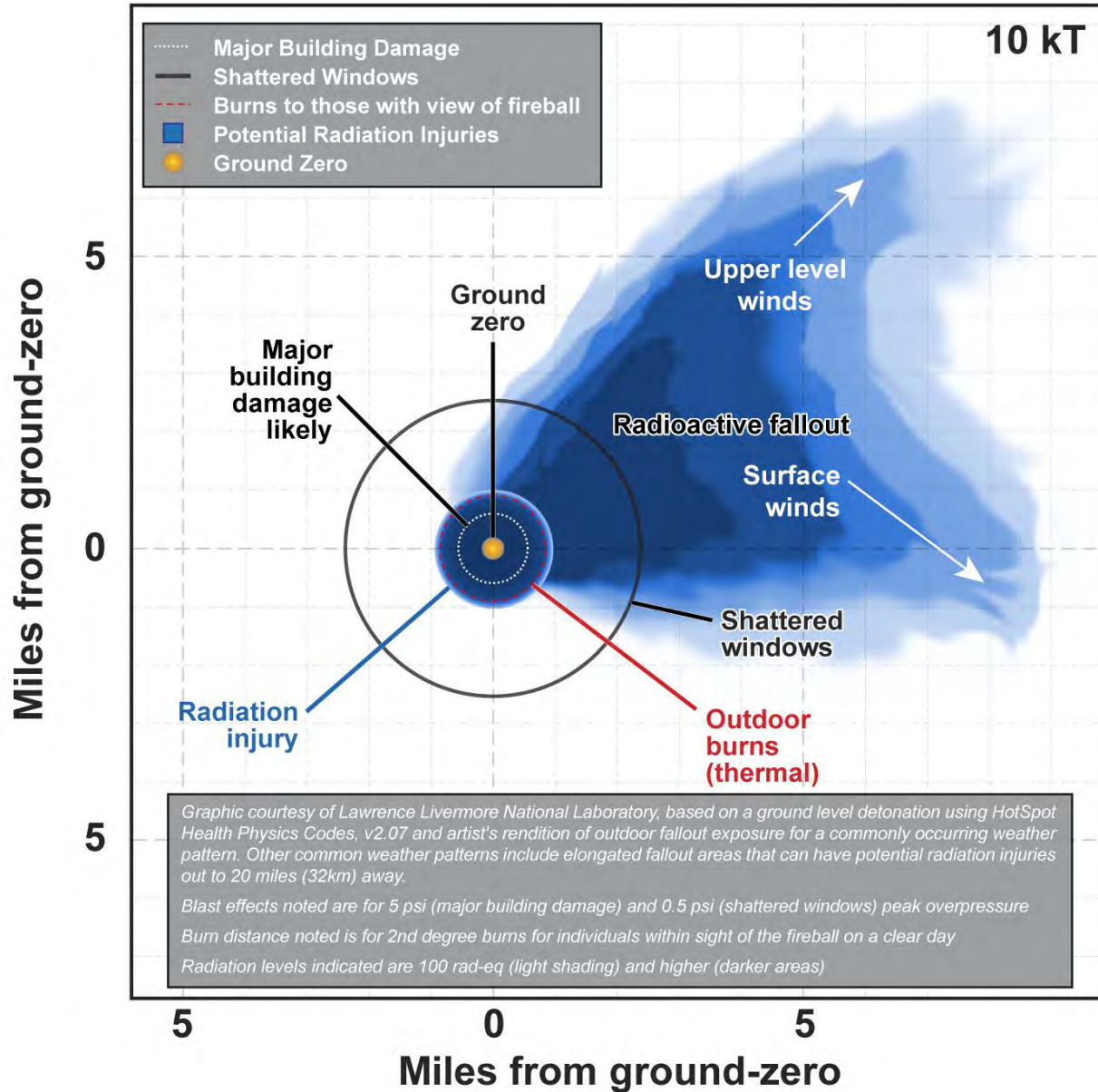
Prefecture	Direct Fatalities from the Earthquake and Tsunami	Indirect Fatalities from Displacement	Total	% Indirect
Iwate	4,669	446	5,115	8.7 %
Miyagi	9,596	900	10,496	8.6 %
Fukushima	1,559	1,793	3,352	53.5 %



Example: Futaba Hospital – 3 miles from the reactors

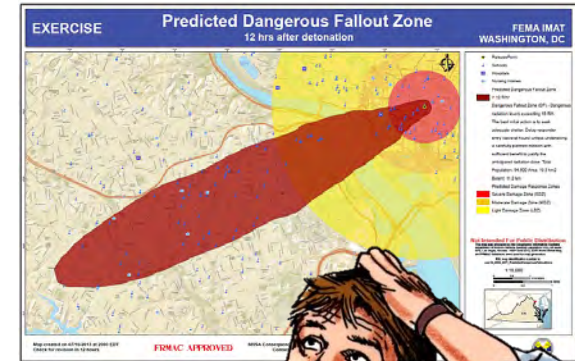
- 130 patients not ambulatory, 98 were in the sister nursing home
- 19 patients died in the five days to complete the evacuation
- Some could not survive the journey to the evacuation center

Effects of a Nuclear Detonation



Response Community Frustration

- Exercises and Real world radiological events have demonstrated the difficulty in ***obtaining*** and ***interpreting*** “plume maps” by incident commanders and emergency managers.
- Incident Commanders get conflicting advice and inconsistent guidelines for basic issues:
 - Shelter / Evacuation recommendations
 - Population monitoring and decontamination
 - Definition of the Hot Zone
 - Responder protection (PPE, dose limits, etc..)

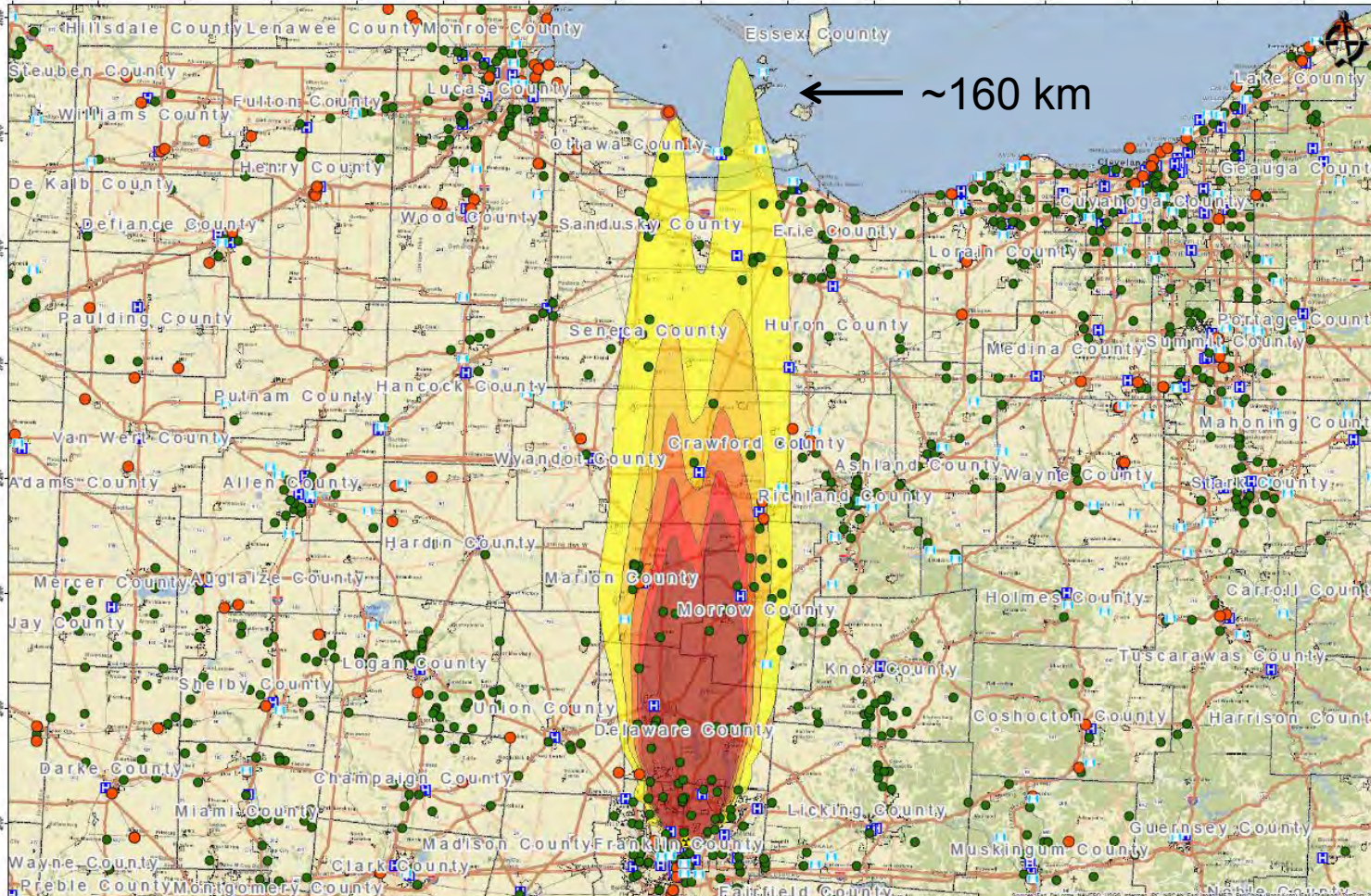


EXERCISE

Predicted Evacuation and Sheltering Areas

Total Effective Dose Equivalent From Aug 14th - Aug 18th

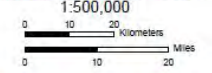
SET 01
VIBRANT RESPONSE
COLUMBUS, OH



- Release Point
 - Wastewater Treatment Plants
 - Electric Power Generation Plants
 - Substations
 - Hospitals
 - Major Highways
 - Counties
 - City Limits
- TEDE From Aug 14th - Aug 18th**
- 5 rem
Early Phase DRL 0.008 cGy/yr
Population : 455,000
 - 4 rem
Early Phase DRL 0.007 cGy/yr
Population : 482,000
 - 3 rem
Early Phase DRL 0.005 cGy/yr
Population : 540,000
 - 2 rem
Early Phase DRL 0.003 cGy/yr
Population : 600,000
 - 1 rem
Early Phase DRL 0.002 cGy/yr
Population : 767,000

This map was produced by the Geographic Information Systems department of NNSA's Remote Sensing Laboratory (RSL) at Nellis AFB, Las Vegas, Nevada. HSP Gold 2012, ESRI World Street Map, and FRMAC databases were used for map generation.

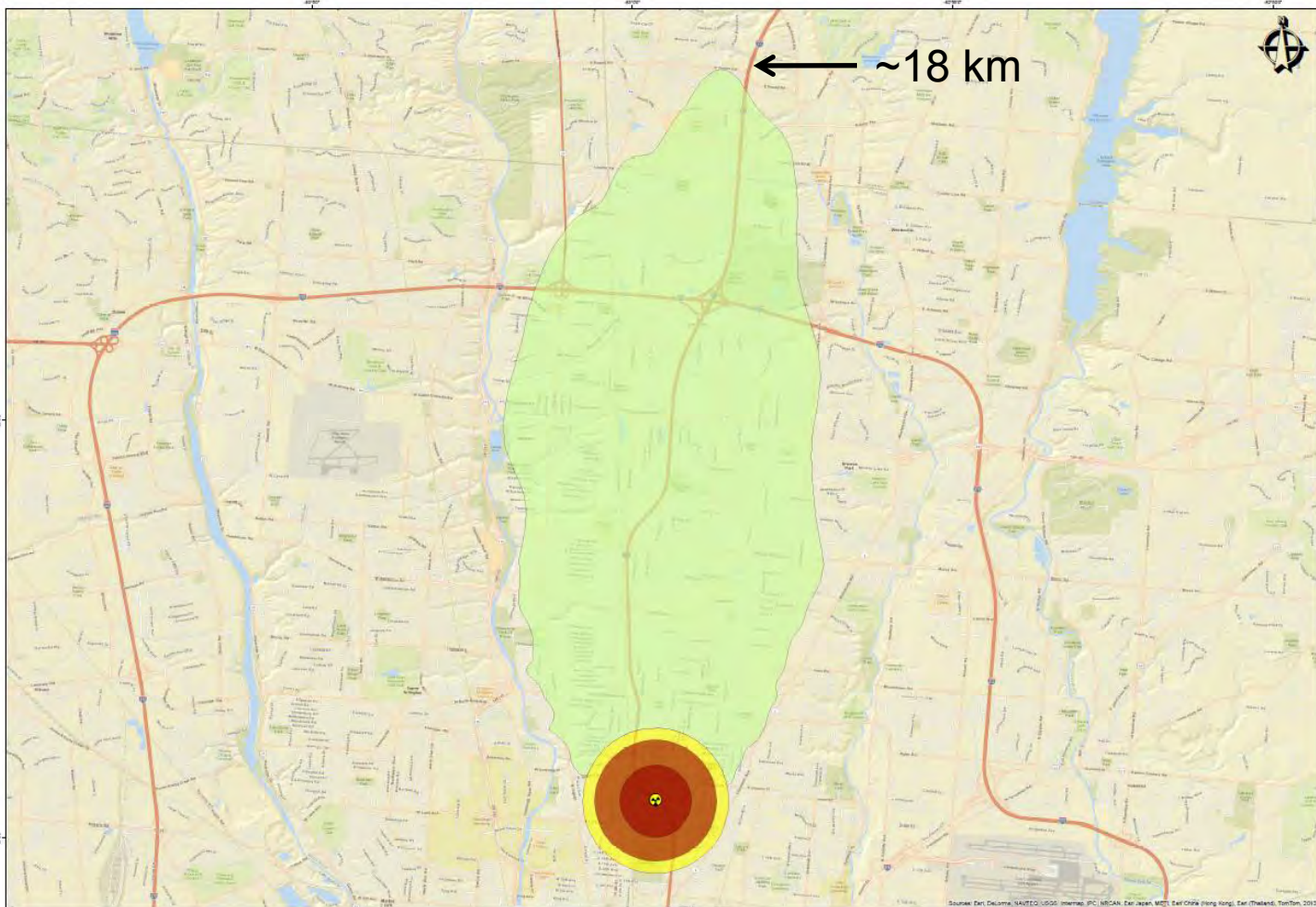
RSL map identification number is:
08122013VibrantResponse_EvacuationShelteringSet1



FRMAC APPROVED

FRMAC APPROVED





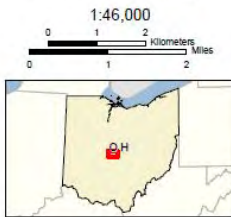
- Release Point
- Prompt Radiation Fatalities No Recovery**
 Population : 18,962
 Fatalities: 18,962
- Prompt Radiation Fatalities With Recovery**
 Population : 16,565
 Fatalities: 16,565
- Prompt Radiation Expectant Within Days**
 Population : 13,852
 Fatalities: 6,926
- Ground Deposition Expectant Within 30 Days**
 Population: 161,179
 Fatalities: 80,589

Populations are not cumulative.
 Area with no recovery includes 5,000 at stadium and 10,000 at fairground.
 Assumed 50% fatality for expectant populations.
 Contaminated fatalities with recovery: 16,565

Fatalities due to ground deposition can be reduced if the population were immediately sheltered.
 If sheltered in basements: 10,400
 If sheltered in houses: 34,600

Population counts based on nighttime Landsat HSIP 2012 dataset.

department of NNSA's Remote Sensing Laboratory (RSL) at Nellis AFB, Las Vegas, Nevada. HSIP Gold 2012, ESRI World Street Map, and FRMAC databases were used for map generation.
 RSL map identification number is: 08152015VibrantResponse_Casualty



Map Created on: 8/15/2013 10:27:31 AM EDT
 Check for revision in 12 hours

FRMAC APPROVED

FRMAC APPROVED



**Where Are the Radiation Professionals?
(for emergency response)**

Meeting the Needs of the Nation for Radiation Protection: Meeting Medical Needs



2016 NCRP Annual Meeting

Donald P. Frush, MD, FACR FAAP
Duke University Medical Center



No Disclosures

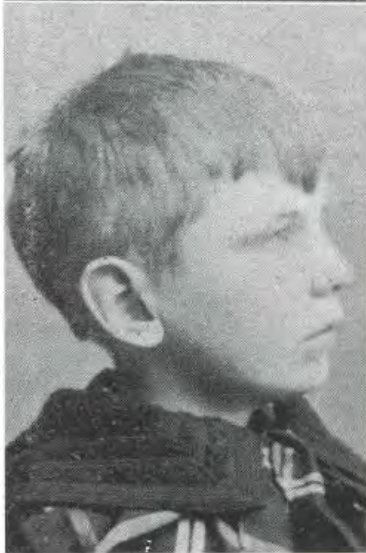
Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- Dose monitoring
- Emergency response
- Risk determination

Patient Radiation Safety

- MDs have not been successful stewards





Effect of x-rays on the hair (Kolle, 1897).
Top, Large area of hair missing from the side of a boy's head 3 weeks after an x-ray exposure of 40 minutes with the tube about 18 inches from the skull. The boy gave no history of pain, itching, or other signs of inflammation; all he knew was that on the previous night the hair had suddenly fallen out. *Bottom*, Appearance of the boy 4 months later. The new hair grew well and had been cut three times.⁶



Gary Tramontina for The New York Times, bottom



Monica Almeida The New York Times, bottom

http://www.nytimes.com/2010/08/01/health/01radiation.html?_r=4&ref=health&pagewanted=all

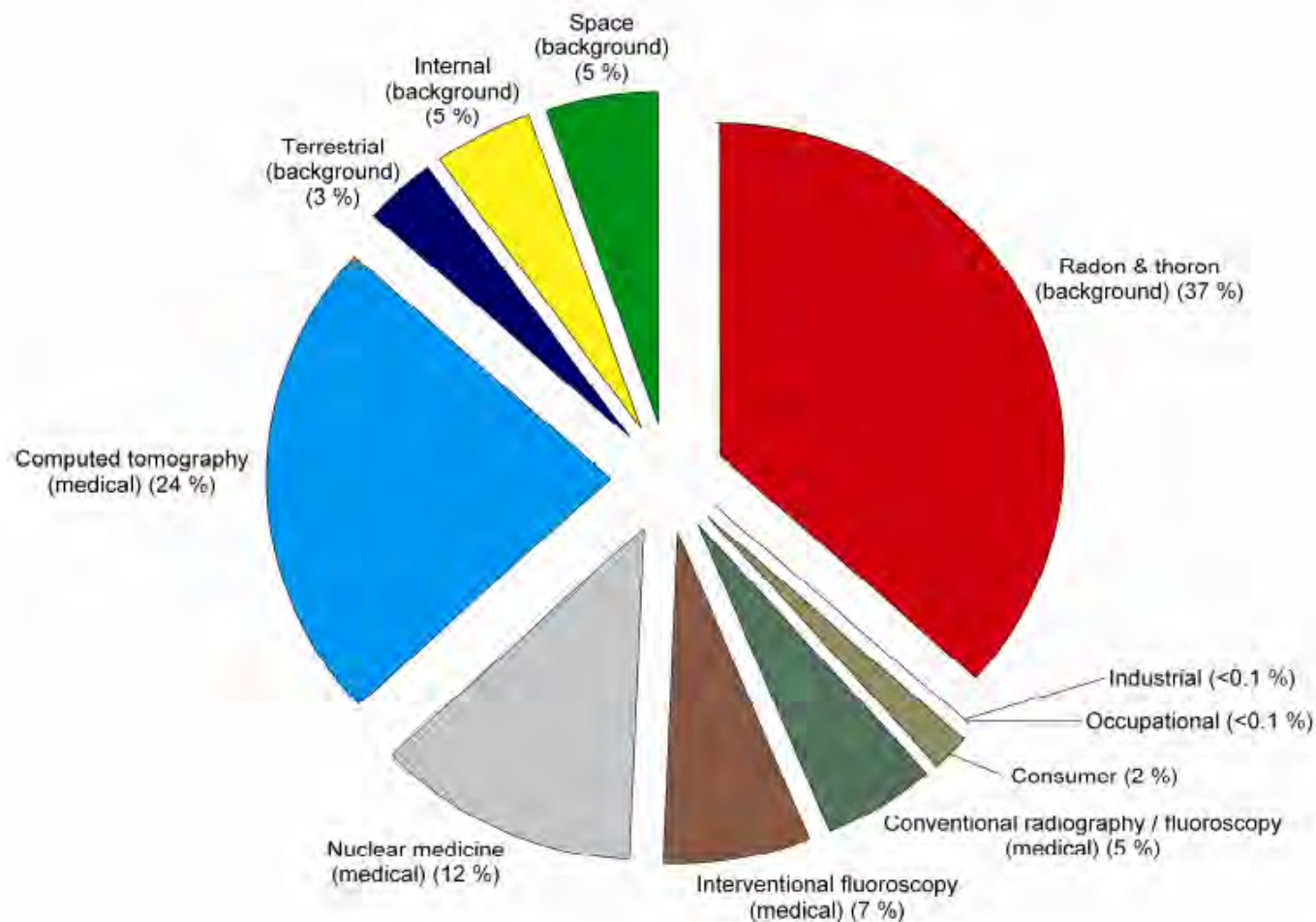
Patient Radiation Safety

- MDs have not been successful stewards
- Multiple stake holders: e.g.,
 - Physicians
 - Scientific community
 - Technologists
 - Administrators
 - Professional Organizations/Societies
 - Reg/Guidance/Accred/Gov't
 - Industry

Medical Status Quo

- **Increased use**
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- Dose monitoring
- Emergency response
- Risk determination

All Exposure Categories
Collective Effective Dose (percent), 2006



NCRP; March 3rd, 2009

We Do A Lot

ARTICLE

ONLINE FIRST

The Use of Computed Tomography in Pediatrics and the Associated Radiation Exposure and Estimated Cancer Risk

Diana L. Miglioretti, PhD; Eric Johnson, MS; Andrew Williams, PhD; Robert T. Greenlee, PhD, MPH; Sheila Weinmann, PhD, MPH; Leif I. Solberg, MD; Heather Spencer Feigelson, PhD, MPH; Douglas Roblin, PhD; Michael J. Flynn, PhD; Nicholas Vanneman, MA; Rebecca Smith-Bindman, MD

Importance: Increased use of computed tomography (CT) in pediatrics raises concerns about cancer risk from exposure to ionizing radiation.

Objectives: To quantify trends in the use of CT in pediatrics and the associated radiation exposure and cancer risk.

Design: Retrospective observational study.

Setting: Seven US health care systems.

Participants: The use of CT was evaluated for children younger than 15 years of age from 1996 to 2010, including 4 857 736 child-years of observation. Radiation doses were calculated for 744 CT scans performed between 2001 and 2011.

Main Outcomes and Measures: Rates of CT use, organ and effective doses, and projected lifetime attributable risks of cancer.

Results: The use of CT doubled for children younger than 5 years of age and tripled for children 5 to 14 years of age between 1996 and 2005, remained stable between 2006 and 2007, and then began to decline. Effective doses varied from 0.03 to 69.2 mSv per scan. An effective dose of 20 mSv or higher was delivered by 14%

to 25% of abdomen/pelvis scans, 6% to 14% of chest scans, and 3% to 8% of head scans. Projected lifetime attributable risks of solid cancer were higher for younger patients and girls than for older patients and boys. Risks were also higher for patients who underwent CT scans of the abdomen/pelvis or spine than for patients who underwent other types of CT scans. For girls, radiation-induced solid cancer is projected to result from 390 abdomen/pelvis scans, 330 to 480 chest scans, and 270 to 800 spine scans, depending on age. For boys, leukemia was highest from head scans for younger than 5 years of age at a rate of 1.9 cases per 100 000 children. Nationally, 4 million pediatric CT scans are projected to cause 4870 future cancers. The highest 25% of doses to the median might prevent 25% of these cancers.

Conclusions and Relevance: The increase in pediatric CT use, combined with the wide variation in radiation doses, has resulted in many children receiving high-dose examination. Dose-reduction strategies targeted to the highest quartile of doses could reduce the number of radiation-induced cancers.

JAMA Pediatr.
Published online June 10, 2013.
doi:10.1001/jamapediatrics.2013.311

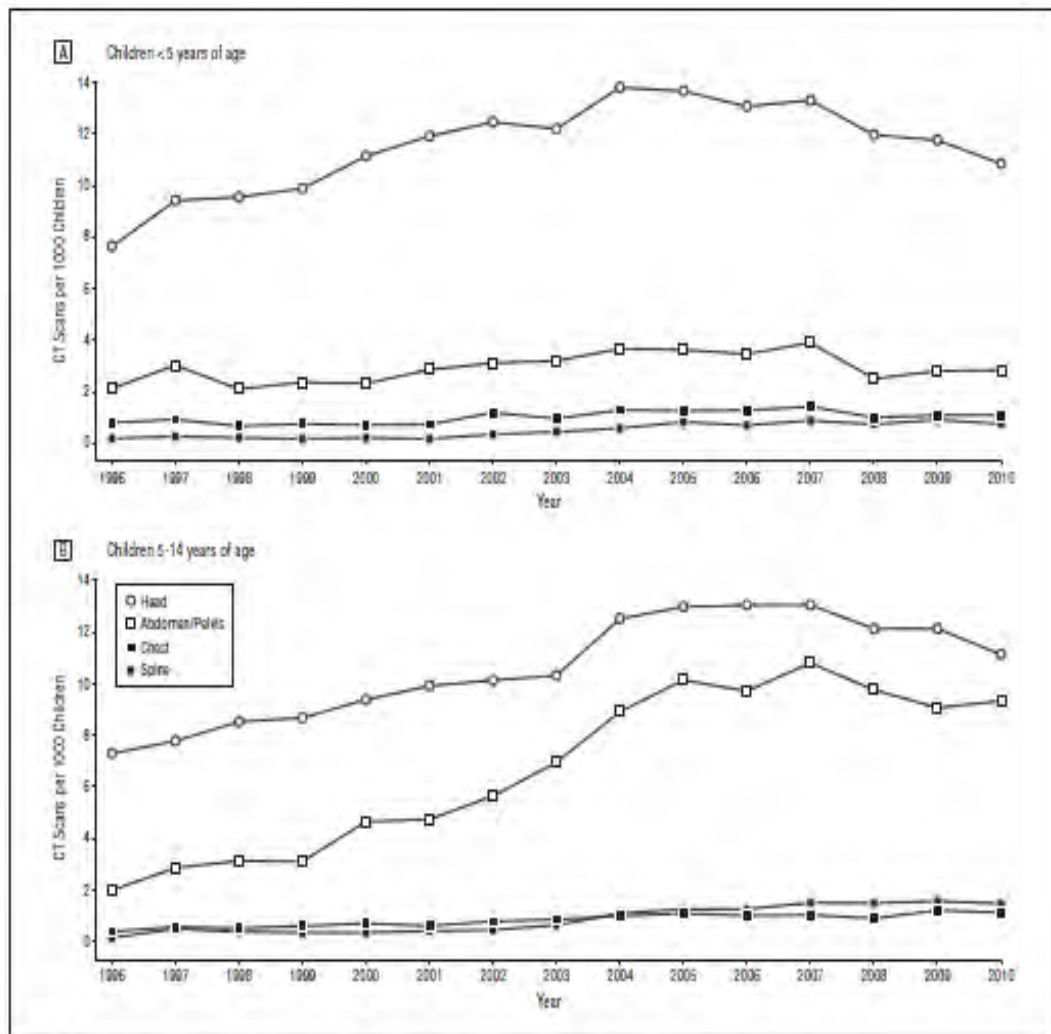


Figure 2. Trends in the use of computed tomography (CT) over time, by age group and anatomic area imaged.

ONLINE FIRST

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to 25% of abdomen/pelvis scans, 6% to 14% of spine scans, and 3% to 8% of chest scans. Projected lifetime attributable risks of solid cancer were higher for younger patients and girls than for older patients and boys, and they were also higher for patients who underwent CT scans of the abdomen/pelvis or spine than for patients who underwent other types of CT scans. For girls, a radiation-induced solid cancer is projected to result from every 300 to 390 abdomen/pelvis scans, 330 to 480 chest scans, and 270 to 800 spine scans, depending on age. The risk of leukemia was highest from head scans for children younger than 5 years of age at a rate of 1.9 cases per 10 000 CT scans. Nationally, 4 million pediatric CT scans of the head, abdomen/pelvis, chest, or spine performed each year are projected to cause 4870 future cancers. Reducing the highest 25% of doses to the median might prevent 43% of these cancers.

Conclusions and Relevance: The increased use of CT in pediatrics, combined with the wide variability in radiation doses, has resulted in many children receiving a high-dose examination. Dose-reduction strategies targeted to the highest quartile of doses could dramatically reduce the number of radiation-induced cancers.

JAMA Pediatr.

Published online June 10, 2013.

doi:10.1001/jamapediatrics.2013.311

Table 1. Distribution of Effective Doses and Mean Organ Doses from Computed Tomography by Anatomic Region and Patient Age^a

	Head			Abdomen/Pelvis			Chest			Spine		
	<5 y	5-9 y	10-14 y	<5 y	5-9 y	10-14 y	<5 y	5-9 y	10-14 y	<5 y	5-9 y	10-14 y
Patients, No.	98	79	102	72	89	115	52	37	58	10	14	18
Effective dose, percentile												
Mean	3.5	1.5	1.1	10.6	11.1	14.8	5.3	7.5	6.4	5.8	7.7	8.8
25th	1.4	0.5	0.6	3.2	3.5	6.4	2.5	2.6	3.1	0.6	1.5	2.5
50th	2.6	1.2	1.0	4.7	8.0	11.1	3.1	3.9	5.3	2.9	4.1	5.3
75th	4.8	2.0	1.6	14.4	14.8	20.0	4.8	10.5	8.6	6.3	10.5	10.3
95th	11.2	3.2	2.6	30.2	32.9	35.0	20.5	26.1	18.4	26.6	26.7	42.0
Dose ≥20 mSv, % of patients	0.0	0.0	0.0	13.9	15.7	25.2	5.8	8.1	3.4	10.0	14.3	5.6
Mean organ dose, mGy												
Brain	28.8	25.3	29.8	0.1	0.1	0.1	0.3	0.4	0.3	0.8	1.1	0.7
Thyroid	11.8	1.2	1.0	1.0	0.6	0.6	11.4	17.5	13.6	10.8	11.4	6.4
Esophagus	3.7	0.6	0.4	5.1	5.2	6.9	8.4	12.4	10.3	8.4	7.6	8.5
Lungs	1.9	0.4	0.3	7.6	6.2	8.1	10.2	15.0	13.2	7.7	7.1	9.7
Breast	0.9	0.1	0.1	14.8	13.0	14.0	7.8	10.6	9.9	8.3	13.0	9.7
Stomach wall	0.7	0.1	0.0	15.9	18.1	25.3	6.1	8.7	8.0	7.5	14.5	17.9
Liver	0.8	0.1	0.0	16.3	18.0	25.3	6.9	9.9	8.9	8.6	14.9	20.3
Colon wall	0.3	0.0	0.0	16.0	18.8	26.2	2.3	2.7	2.9	2.6	5.0	1.7
Rectosigmoid wall	0.1	0.0	0.0	12.1	13.8	16.7	0.7	0.6	0.8	0.6	1.1	0.7
Bladder wall	0.1	0.0	0.0	13.0	14.6	16.6	0.7	0.4	0.7	0.6	0.7	0.6
Prostate	0.1	0.0	0.0	9.0	10.1	11.0	0.7	0.1	0.7	0.6	0.7	0.6
Uterus	0.1	0.0	0.0	12.6	13.5	16.9	0.4	0.6	0.7	0.6	0.7	0.6
Ovaries	0.1	0.0	0.0	14.6	15.4	19.6	0.5	0.7	0.7	0.6	0.7	0.6
Red bone marrow	10.6	6.5	4.2	5.1	5.6	9.2	3.3	3.9	3.9	3.3	3.9	3.9

AP CT in 10-14 yo varied from 6.4-35.0 mSv

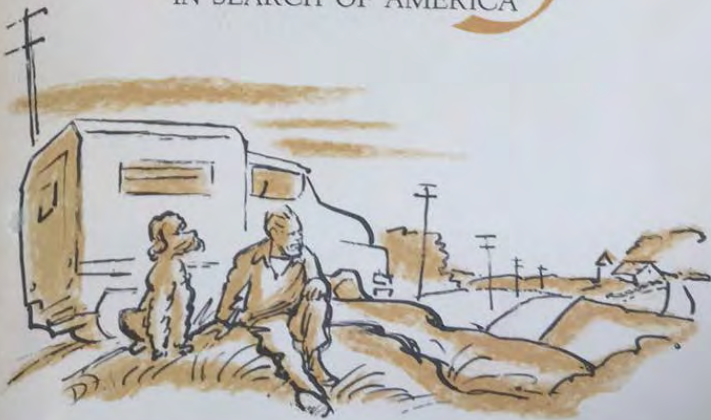
**Miglioretti et al
JAMA Pediatrics 2013; 167(8): 700-7**

Medical Status Quo

- Increased use
- **Radiation exposure scrutiny**
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- Dose monitoring
- Emergency response
- Communication gaps

STEINBECK

*Travels
with
Charley*
IN SEARCH OF AMERICA



“We value virtue but do not discuss it. The honest bookkeeper, the faithful wife [or husband], the earnest scholar get little of our attention compared to the embezzler, the tramp, the cheat.”

***Page 164
John Steinbeck 1961***

Consumer Reports: Surprising Dangers of CT Scans and X- rays ...

RADIATION RISKS

The surprising dangers of CT scans and X-rays
Patients are often exposed to cancer-causing radiation for little medical reason, a Consumer Reports investigation finds

Published: January 27, 2015 06:00 AM



When James Duncan, M.D., a radiologist at Washington University in St. Louis, experienced intense pain in his abdomen in 2010, he rushed to a local emergency room. His doctors suspected kidney stones, but they wanted to be sure, so they ordered a CT scan. Duncan remained motionless as the machine captured a detailed, 3D image of his abdomen. He knew that the test was done when the machine stopped whirring. So he was surprised when the scanner kicked back on after a few seconds.

"I later learned that the technician running the CT mistakenly believed that the first scan didn't include the top of my kidneys, and decided to acquire more images 'just to be sure,'" Duncan says. "The irony: I was getting ready to give a lecture on reducing radiation exposure from medical imaging. And there I was, reluctantly agreeing to a CT scan and then getting overexposed."

Duncan will never know whether that specific scan caused any long-term harm, because it's almost impossible to link radiation exposure from any one medical test to a future illness. But like other researchers, he knows that doctors today order millions of radiation-based imaging tests each year, that many of them are unnecessary, and that the more radiation people are exposed to, the greater their lifetime risk of cancer.

"that about one-third of those scans serve little if any medical purpose"

Recently...

-----Original Message-----

From:

To: imagegently

Sent: Tue, Jan 26, 2016 10:25 am

Subject: 6 Month Old Skull X-rays

Dear Dr. Frush,

Yesterday our 6-month-old son pulled a cord by a coffee table, and a lamp fell onto him, hitting his head. Although bruised, he seemed all right. Nevertheless, we had him checked at the ER, where he was given 5 skull x-rays.

This radiation dose for such a young age had me concerned. Not knowing where to go with my questions, I found your website and would greatly appreciate any insight on how this may affect him. Some sources indicate that infant skull x-rays can damage IQ. Should we be worried?

Thank you kindly for any feedback you may provide.

Sincerely,

Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- **Misinformation/misunderstanding**
- Increasing regulation, accreditation, “guidance”
- Dose monitoring
- Emergency response
- Risk determination

2001

“...about 1500 of those [children] will die later in life from radiation induced cancer...”

www.usatoday.com THE PATRIOT'S NEWSPAPER 50 CENTS

FINAL SPORTS

Super Bowl

Let the hype begin

Clock is ticking toward Sunday
Full report, 1-4c
► 10 years ago, war raged on our minds. IC
► 4 exciting history boxes

USA TODAY

NO. 1 IN THE USA

3rd Children's Classics
'Gladiator' wins best drama film

Rita Roberts, Tom Hanks honored for 25th anniversary
Alamo famous named best comedy film
► The Red Carpet 3D

Submitter: Contact Us Anytime



Monday, January 22, 2001

Newsline

usatoday.com's new look

Get the news, sports, entertainment and more on our new look. It's a total change for the better.

► **1000** Get the news, sports, entertainment and more on our new look. It's a total change for the better.

Asia stocks raised overnight

Stocks in Asia were up 17 points, 1.8% in U.S. trading time. The Nikkei rose 136.25 to 10,180. The Hang Seng rose 1,100 to 10,180.

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States reviewing, relaxing drug laws

New York is the first state to consider it as a national trend. Other states are reviewing drug laws. Texas has said that harsh measures have done little to reduce crime rates.

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New Philippine president vows unity

President Arroyo promised to bring the Philippines back to a state of national unity. She is the first woman president in the country's history.

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Female freshmen lack tech confidence

Study of new college freshmen shows that a majority of female freshmen lack confidence in their ability to use computers and other technology.

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Jackpot returning public life

Michigan's lottery is back in business. The state is expected to see a significant increase in revenue from the lottery.

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Today's debut: Bill Clinton's exit

Bill Clinton's memoirs are set to be published. The book is expected to provide a candid look at his presidency.

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Sports: Irvan breaks 50 again

Phil Irvan has broken the 50-minute barrier in the Indy 500 race. He is the first driver to do so since 1997.

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Like kids rock rickles, ballistics

Scientists are studying the effects of radiation on children. The study is expected to provide valuable information on the risks of radiation exposure.

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USA TODAY Staphylococcus

Staphylococcus aureus is a common bacterium. It is often found on the skin and in the nose. It can cause a variety of infections.

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Election still splits court

By Tom Ichniowski

WASHINGTON — The weeks after an historic U.S. Supreme Court decision may be the most contentious in the history of the nation. The court's ruling on whether states can ban gay marriage has set off a firestorm of controversy.

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Bush debuts with education push

By Michael Hall and Judy Lewis

WASHINGTON — President George W. Bush's first major policy initiative was a push to improve education. He announced a series of measures to help schools and teachers.

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Washington President Bush and Vice President Cheney with other officials at a press conference on education policy.

CT scans in children linked to cancer later

By Tom Ichniowski

WASHINGTON — A new study has found that children who have had CT scans are at a higher risk of developing cancer later in life. The study is the first to show a clear link between CT scans and cancer.

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Pope names cardinals, sets stage for successor

By Cathy N. Davidson

VATICAN CITY — Pope John Paul II has named 12 new cardinals, setting the stage for his successor. The appointments are expected to be announced in the coming weeks.

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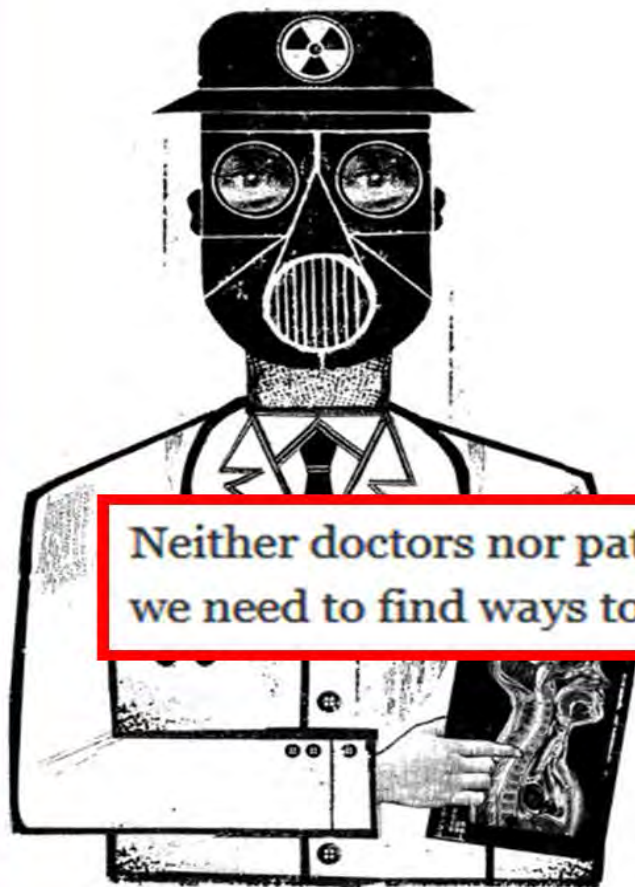
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We Are Giving Ourselves Cancer

By RITA F. REDBERG and REBECCA SMITH-BINDMAN JAN. 30, 2014



Ben Jones

DESPITE great strides in prevention and treatment, [cancer](#) rates remain stubbornly high and may soon surpass heart disease as the leading cause of death in the United States. Increasingly, we and many other experts believe that an important culprit may be our own medical practices: We are silently irradiating ourselves to death.

The use of medical imaging with high-dose radiation — CT scans in particular — has soared in the last 20 years. Our resulting exposure to medical radiation

Neither doctors nor patients want to return to the days before CT scans. But we need to find ways to use them without killing people in the process.

radiation doses of CT scans (a series of [X-ray](#) images from multiple angles) are 100 to 1,000 times higher than conventional X-rays.

Of course, early diagnosis thanks to medical imaging can be lifesaving. But there is distressingly little evidence of

Children's Hospitals Cut Down On CT Scans To Prevent Cancer

A new study shows a major drop in uses of the risky procedure.



Joe Satran
Staff Writer, The Huffington Post



Posted: 05/31/2015 07:31 PM EDT



CREDIT: ADELE STARR/ASSOCIATED PRESS

Children's hospitals have cut down on the number of CT scans performed in recent years.

When your children are sick, it's hard not to want doctors to do everything in their power to cure them. But when it comes to CT scans, less is often more.

That's because CT scanners -- which use X-rays to produce richly detailed images of almost any part of the body -- deliver far higher doses of dangerous ionizing radiation than any other

http://www.huffingtonpost.com/entry/childrens-hospitals-ct-scans-study_55df8791e4b0c818f6175b69

Radiology MD:
“As many as 1 in 300 children who get a CT scan of the abdomen, chest or spine **will eventually develop** a tumor as a result of the radiation...”

And, from accreditation leader in 2016

“...consensus opinion that ... there is harm at low doses”

ALARA, Image Gently and CT-induced cancer

Mervyn D. Cohen

Received: 9 August 2014 / Accepted: 28 September 2014 / Published online: 14 February 2015
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Introduction

The term As Low As Reasonably Achievable (ALARA) goes back to articles in 1980, 1986 and 1999 [1–3]. In 2001, a group of inspired pediatric radiologists introduced the ALARA concept into routine clinical radiology practice [4–7]. The ALARA and the Image Gently campaigns have been very successful in achieving their goals of reducing unnecessary imaging and radiation exposure, inspiring the development of new technology, and expanding our understanding of measuring radiation dose in humans [6–15].

ALARA and Image Gently evolved from a belief that even

incidence from the survivors of the atom bomb can be extrapolated back in a linear fashion to cancer risk from tiny radiation doses. This linear threshold exists for cancer risk from radiation. The linear no threshold theory. With new data from survivors, this linear no threshold theory is being challenged [16–20]. Finally, I will discuss recent epidemiological studies that have linked CT to cancer. These studies must be interpreted with great caution. I will discuss as a pediatric radiologist with information regarding the limitations of these studies that they can share with parents and referring physicians.

Table 1 Media comments on the 2012 Pearce Lancet article, “Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study” [32]

“CT scans in kids linked to leukemia, brain cancer risk”
ABC World News, June 6, 2012

“CT scans increase children’s cancer risk, study finds”
New York Times, June 6, 2012

“CT scans boost cancer risks for kids”
National Public Radio (NPR), June 7, 2012

“CT scans warning after study claims too many could lead to brain cancer”
Guardian newspaper (UK), June 6, 2012

“CT scans can triple the risk of children getting leukemia”
The Times Newspaper (London), June 7, 2012

“CT scans could triple risk of a brain tumour in children”
The Telegraph Newspaper (London), June 7, 2012

“Multiple CT scans on children can increase risk of developing cancer”
BBC News, 7 June 7, 2012

“CT scans on children could triple brain cancer risk”
BBC News, June 6, 2012

“CT scans in children raise risk of cancer”
American Cancer Society, June 7, 2012

“Multiple CT scans in kids triples cancer risk, but researchers caution overall risk low”
CBS News, June 7, 2012

“Child CT scans could raise cancer risk slightly”
USA Today, June 6, 2012

“Childhood CT scans may raise brain cancer, leukemia risks slightly”
Huffington Post, June 6, 2012

“NIH study finds childhood CT scans linked to leukemia and brain cancer later in life”
National Institute of Health NIH News, June 7, 2012

“Child CT scans may up risk of brain cancer, leukemia”
U.S. News and World Report, June 7, 2012

“Children’s CT scans pose cancer risk”
Wall Street Journal, June 7, 2012

Risk Literacy

Communicating Potential Radiation-Induced Cancer Risks From Medical Imaging Directly to Patients

Diana L. Lam¹
David B. Larson²
Jonathan D. Eisenberg³
Howard P. Forman⁴
Christoph I. Lee^{1,5}

OBJECTIVE. Over the past decade, efforts have increasingly been made to decrease radiation dose from medical imaging. However, there remain varied opinions about whether, for whom, by whom, and how these potential risks should be discussed with patients. We aimed to provide a review of the literature regarding awareness and communication of potential radiation-induced cancer risks from medical imaging procedures in hopes of providing guidance for communicating these potential risks with patients.

MATERIALS AND METHODS. We performed a systematic literature review on the topics of radiation dose and radiation-induced cancer risk awareness, informed consent regarding radiation dose, and communication of radiation-induced cancer risks with patients undergoing medical imaging. We included original research articles from North America and Europe published between 1995 and 2014.

RESULTS. From more than 1200 identified references, a total of 22 original research articles met our inclusion criteria. Overall, we found that there is insufficient knowledge regarding radiation-induced cancer risks and the magnitude of radiation dose associated with CT examinations among patients and physicians. Moreover, there is minimal sharing of information before nonacute imaging studies between patients and physicians about potential long-term radiation risks.

CONCLUSION. Despite growing concerns regarding medical radiation exposure, there is still limited awareness of radiation-induced cancer risks among patients and physicians. There is also no consensus regarding who should provide patients with relevant information, as well as in what specific situations and exactly what information should be communicated. Radiologists should prioritize development of consensus statements and novel educational initiatives with regard to radiation-induced cancer risk awareness and communication.

Clinical Vignette

A common scenario in the outpatient clinic or emergency department is the young adult who is referred for CT of the abdomen and pelvis to evaluate for subacute or chronic abdominal pain. Physical examination and laboratory results do not reveal the cause. If this patient would like to know about the radiation risks of CT, then who should talk with the patient, and what information should be provided? This article provides a review of the literature regarding awareness of radiation dose from medical imaging among patients, referring clinicians, and radiologists; communication practices related to potential radiation-induced cancer risk; and resources for discussing these potential risks with patients.

The Imaging Question

How should radiologists communicate potential radiation-induced cancer risks from medical imaging with patients and referring clinicians?

Background and Importance

Between the 1980s and 2000s, CT utilization in the United States doubled almost every 2 years [1–3]. Moreover, between 1980 and 2006, CT use contributed to almost half of the approximately 600% increase in ionizing radiation exposure per capita [4]. However, the magnitude of increased cancer incidence attributable to rising utilization of medical imaging remains unclear. Data linking radiation dose and carcinogenesis are based on projections, mostly from atomic bomb survivors, occupational exposures, and

CONCLUSION. Despite growing concerns regarding medical radiation exposure, there is *still limited awareness* of radiation-induced cancer risks among patients and physicians. There is also *no consensus regarding who should provide patients with relevant information*, as well as in what specific situations and exactly what information should be communicated.

Radiologists [the imaging team] should prioritize development of consensus statements and novel educational initiatives with regard to radiation-induced cancer risk awareness and communication.

Keywords: informed consent, patient-physician communication, radiation dose, radiation-induced cancer

DOI:10.2214/AJR.15.15087

Received May 31, 2015; accepted without revision June 1, 2015.

C. I. Lee is supported in part by a grant from the American Cancer Society (MRSO-14-180-01-CPHPS).

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³Institute for Technology Assessment, Department of Radiology, Massachusetts General Hospital, Boston, MA.

⁴Department of Diagnostic Radiology, Yale University School of Medicine, New Haven, CT.

⁵Department of Health Services, University of Washington School of Public Health, Hutchinson Institute for Cancer Outcomes Research, Fred Hutchinson Cancer Research Center, Seattle, WA.

This is an ahead-of-print version of the article; the final version will appear in the November 2015 issue of the *AJR*.

AJR 2015; 205:1–9

0361-803X/15/2055-1

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Risk Literacy

TABLE 3: Physician Understanding of the Ionizing Radiation Risk of Ultrasound and MRI^a

Reference	Year	Location	Method	Population	Ultrasound	MRI
Shiralkar et al. [27]	2003	England	Written survey	130 physicians (120 nonradiologists, 10 radiologists)	6/130 (5)	11/130 (8)
Jacob et. al. [12]	2004	England	Written survey	240 physicians (218 nonradiologists, 22 radiologists)	23/240 (10) ^b	68/240 (28) ^b
Thomas et al. [14]	2006	Canada	Written survey	220 pediatricians	8/220 (4) ^b	—
Soye and Paterson [17]	2008	England	Written survey	153 physicians (140 nonradiologist, 13 radiologists)	15/153 (10)	34/153 (22)
McCusker et al. [18]	2009	Ireland	Written survey	269 medical students and junior physicians	—	73/269 (27) ^b
Heyer et al. [24]	2010	Germany	Written survey	134 pediatricians	—	19/134 (14)
Bosanquet et al. [28]	2011	England	Written survey	112 physicians	16/112 (14) ^c	
Uri [21]	2012	UK	Online survey	100 physicians	15/100 (15) ^c	15/100 (15) ^c

Note—UK = United Kingdom. Numeric data are given as no. (%), where numbers represent participants who believed ultrasound or MRI emitted ionizing radiation.

Dash indicates not reported. Numbers may not add up owing to rounding.

^aPopulation noted was the total number included in the data analysis of the study, and the denominators for the reported results are based on the number of respondents per survey question.

^bExtrapolated from reported percentages.

^cThis study did not separate ultrasound and MRI results and thus was not included in our weighted averages.

Recommendations

- **NCRP PAC 7**
- **Formal communication networks**
 - **Shared resources: ID gaps, avoid redundancies**
 - **e.g., current Imaging Communication Network (ICN)**



Global Validation

Consumer Reports: Surprising Dangers of CT Scans and X- rays ...

- Meeting at CR
- NCRP, ACR, IG and IW
- May 2015
- Add'l press "quieter"

RADIATION RISKS

The surprising dangers of CT scans and X-rays
Patients are often exposed to cancer-causing radiation for little medical reason, a Consumer Reports investigation finds

Published: January 27, 2015 06:00 AM



When James Duncan, M.D., a radiologist at Washington University in St. Louis, experienced intense pain in his abdomen in 2010, he rushed to a local emergency room. His doctors suspected kidney stones, but they wanted to be sure, so they ordered a CT scan. Duncan remained motionless as the machine captured a detailed, 3D image of his abdomen. He knew that the test was done when the machine stopped whirring. So he was surprised when the scanner kicked back on after a few seconds.

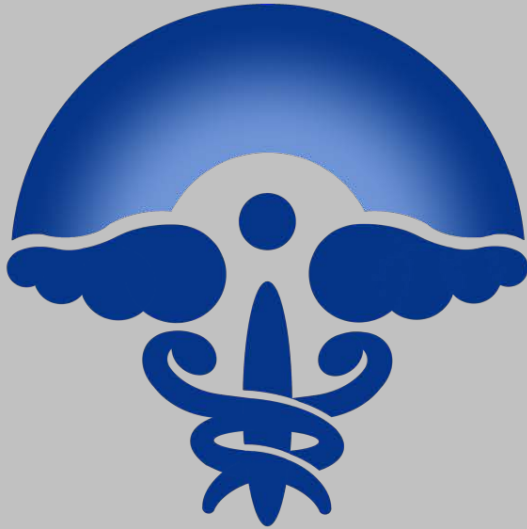
"I later learned that the technician running the CT mistakenly believed that the first scan didn't include the top of my kidneys, and decided to acquire more images 'just to be sure,'" Duncan says. "The irony: I was getting ready to give a lecture on reducing radiation exposure from medical imaging. And there I was, reluctantly agreeing to a CT scan and then getting overexposed."

Duncan will never know whether that specific scan caused any long-term harm, because it's almost impossible to link radiation exposure from any one medical test to a future illness. But like other researchers, he knows that doctors today order millions of radiation-based imaging tests each year, that many of them are unnecessary, and that the more radiation people are exposed to, the greater their lifetime risk of cancer.

"that about one-third of those scans serve little if any medical purpose"

Recommendations

- **NCRP PAC 7**
- **Communication networks**
 - **Shared resources: ID gaps, avoid redundancies**
 - **e.g., current Imaging Communication Network**
- **Patient advocacy groups**
- **Align with communication experts**
- **Develop social media strategies**
- **Institutional medical radiation programs**



Duke Medical Radiation Center

- Radiologists
- Technologist
- Medical physicists
- Health physicists
- Engineering
- RSO
- Administrators
 - e.g. compliance officials
- Cardiologists
- Radiation oncologists
- Gastroenterologists
- Emergency physicians
- IT experts
- Urologists
- Orthopedists
- Vascular surgeons

Recommendations

- **NCRP PAC 7**
- **Communication networks**
 - **Shared resources: ID gaps, avoid redundancies**
 - **e.g., current Imaging Communication Network**
- **Patient advocacy groups**
- **Develop social media strategies**
- **Align with communication experts**
- **Institutional medical radiation programs**
- **Content**



World Health
Organization

Radiation Risk Communication

Improving Risk/Benefit Dialogue in Paediatric Imaging

COMMUNICATING RADIATION RISK IN PAEDIATRIC IMAGING

What health care providers need to know
to support risk-benefit dialogue



COMMUNICATING RADIATION RISK IN PAEDIATRIC IMAGING



IMAGE WISELY[®]

Radiation Safety in Adult Medical Imaging

image
gently[®]



Tenets: Should Remember

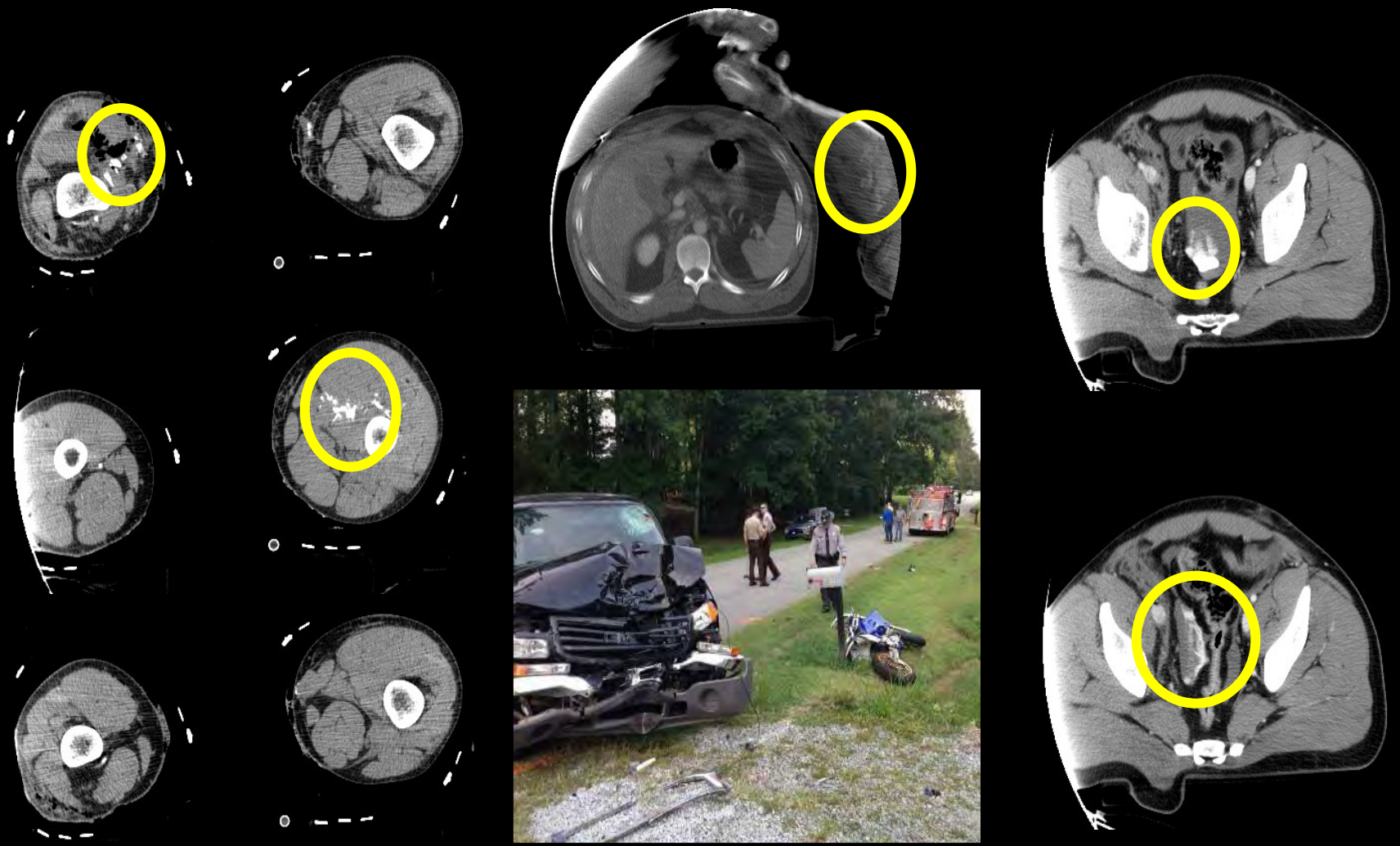


- **Content is important**
- **Delivery is equally important**
 - when, who, how

Recommendations

- NCRP PAC
- Communication networks
 - Shared resources: ID gaps, avoid redundancies
 - e.g., Imaging Communication network
- Patient advocacy groups
- Align with communication experts
- Develop social media strategies
- Institutional medical radiation programs
- Content
- Emphasize *VALUE!!!*

Really? Benefit Risk *Balance*?



Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- **Increasing regulation, accreditation, “guidance”**
- Dose monitoring
- Emergency response
- Risk determination



The Joint Commission

July 2015, TJC mandates that:

- 1. “The [hospital/practice] documents the radiation dose ($CTDI_{vol}$ or DLP) on every study produced during a computed tomography (CT) examination. The radiation dose must be exam specific, summarized by series or anatomic area, and documented in a retrievable format.”, and*
- 2. “The [hospital/practice] reviews and analyzes incidents where the radiation dose ($CTDI_{vol}$ or DLP) emitted by the computed tomography (CT) imaging system during diagnostic CT exams exceeded expected dose ranges identified in imaging protocols.”*

Recently out for field review

The Joint Commission

Proposed National Patient Safety Goal on Pediatric Computed Tomography (CT) Imaging

Ambulatory Health Care (AHC), Critical Access Hospital (CAH), and Hospital (HAP) Accreditation Programs

NPSG.17.01.01

1 AHC Improve the appropriate use of computed tomography (CT) imaging of the head and chest for pediatric
2 patients.

NPSG.17.01.01

1 AHC Improve the appropriate use of computed tomography (CT) imaging of the head and chest for pediatric
2 patients.

Rationale for NPSG.17.01.01

3 CT imaging is often used for pediatric patients with head trauma. When used properly, CT imaging
4 saves lives. However, children are more susceptible than adults to the effects of ionizing radiation, so it
5 is important to eliminate unnecessary radiation exposure. This can be achieved by the use of guidelines
6 to determine when CT examinations are necessary for minor pediatric head trauma and when dual
7 phase CT exams of the head and chest are needed for pediatric patients.

21 phase CT exams of the head and chest are needed for pediatric patients.

Elements of Performance for NPSG.17.01.01

EP Text for NPSG.17.01.01, EP 1

22 AHC 1. Implement evidence-based practices for CT imaging of pediatric patients with minor head trauma.
23 Note: Organizations are expected to adopt evidence-based practices such as the Pediatric
24 Emergency Care Applied Research Network's (PECARN) Childhood Head Trauma: A Neuroimaging
25 Decision Rule, which predicts the need for brain imaging after pediatric head injury.

26 CAH 1. Implement evidence-based practices for CT imaging of pediatric patients with minor head trauma.
27 Note: Critical access hospitals are expected to adopt evidence-based practices such as the Pediatric
28 Emergency Care Applied Research Network's (PECARN) Childhood Head Trauma: A Neuroimaging
29 Decision Rule, which predicts the need for brain imaging after pediatric head injury.

NEMA Standard Attributes on CT Equipment Related to Dose Optimization and Management (XR-29)

- ***DICOM structured dose reporting,***
- ***A CT Dose Check feature for dose alerts and notifications,***
- ***Automatic Exposure Control (AEC) to help manage radiation dose and image quality, and***
- ***Reference Adult and Pediatric Protocols “pre-loaded”***

Not Meeting Guidelines:

January 2016: 5% reimbursement reduction

January 2017: 15% reimbursement reduction



Radiation Protection Guidance for Diagnostic and Interventional X-Ray Procedures

Federal Guidance Report No. 14

CT: pages 58-64



DEPARTMENT OF HEALTH & HUMAN SERVICES
Centers for Medicare & Medicaid Services
7500 Security Boulevard, Mail Stop C2-21-16
Baltimore, Maryland 21244-1850



Center for Clinical Standards and Quality / Survey & Certification Group

Ref: S&C-15-38-Hospitals

DATE: May 15, 2015

TO: State Survey Agency Directors

FROM: Director
Survey and Certification Group

SUBJECT: Revised Hospital Radiologic and Nuclear Medicine Services Interpretive
Guidelines—State Operations Manual (SOM) Appendix A

Memorandum Summary

Updated Guidance for Hospital Services: The Centers for Medicare & Medicaid Services (CMS) has updated the interpretive guidelines for the hospital Conditions of Participation (CoPs) for the below to reflect current accepted standards of practice:

- o Radiologic Services at 42 CFR 482.26, and
- o Nuclear Medicine Services at 42 CFR 482.53

Background

Radiologic and nuclear medicine services have improved the ability to detect and treat a wide

**... “updated the interpretive
guidelines for the hospital
Conditions of Participation
(CoPs) for the below to reflect
current accepted standards of
practice”**

... prompting additional investigations of the risks associated with scans.

Recommendations

- **Consensus review of proposals**
- **Communication networks**
- **Support for medical physicists**
- **Support for technologists**
- **Support for IT**

Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- **Dose monitoring**
- Emergency response
- Risk determination



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Division of Medical Assistance

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Beverly Eaves Perdue, Governor
Lanier M. Cansler, Secretary

Craig L. Gray, MD, MBA, JD, Director

June 30, 2011

To: Jane Doe
555 Main Street
Anywhere, NC 12345

Dear Ms. Doe,

This letter is to inform you that you had 10 or more CT scans in 2010. This is more than most people get in a year. Medicaid records show that you went through a CT scanner ## times in 2010.

CT scans, sometimes called CAT scans, expose you to radiation while taking a picture of what is inside your body. Too much radiation can be bad for your health. It can increase your chances of getting some kinds of cancer.

Sometimes CT scans are important for doctors to see what is going on when you are sick or hurt. But sometimes there may be other ways to figure out what is wrong.

If a doctor treating you does not know you well or have your medical records, that doctor will not know how many CT scans you have had. It is important for you to remind them of this information. Showing your doctors this letter will help them treat you as safely as possible. **Please take this letter with you when you go to the emergency department or doctor's office.**

Call 1-800-662-7030 if you have any questions.

Please call [enrollment office number] for help finding a primary care doctor in your town.

Wishing you the best of health,



The Joint Commission

July 2015, TJC mandates that:

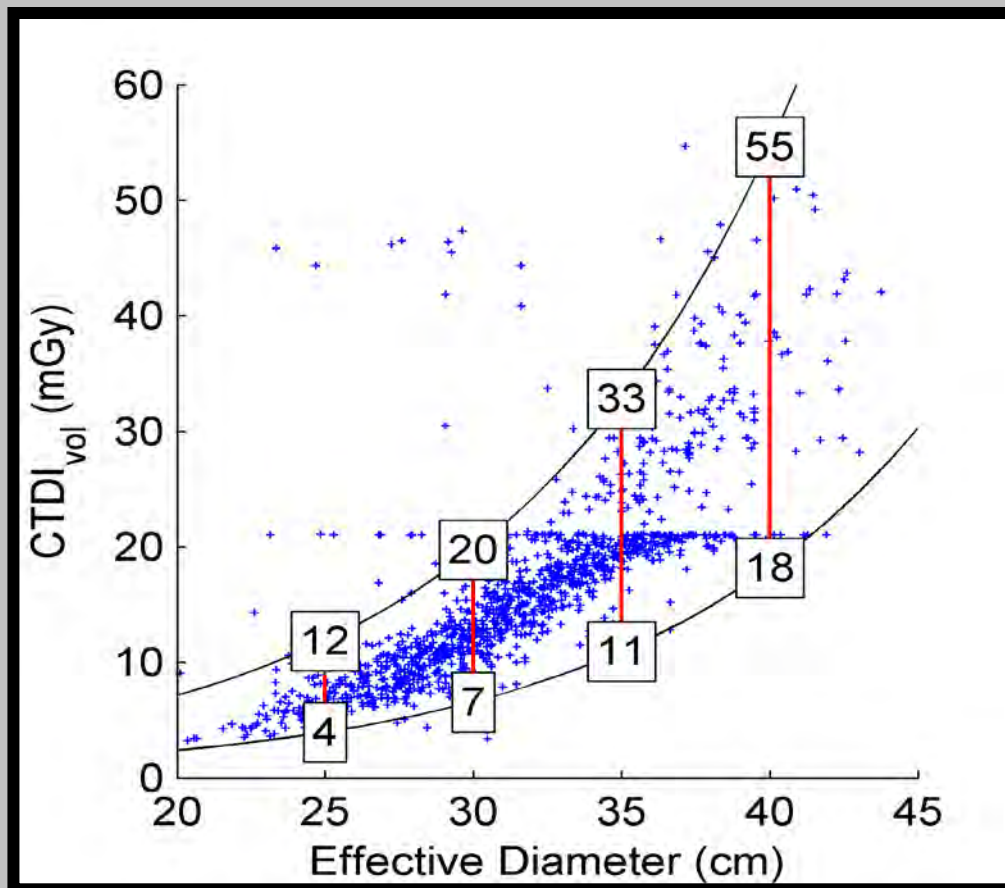
- 1. “The [hospital/practice] documents the radiation dose ($CTDI_{vol}$ or DLP) on every study produced during a computed tomography (CT) examination. The radiation dose must be exam specific, summarized by series or anatomic area, and documented in a retrievable format.”, and*
- 2. “The [hospital/practice] reviews and analyzes incidents **where the radiation dose ($CTDI_{vol}$ or DLP) emitted by the computed tomography (CT) imaging system during diagnostic CT exams exceeded expected dose ranges** identified in imaging protocols.”*

Program Considerations

- **Dose monitoring preferred over “tracking”**
- **Dose estimations**
- **Program elements:**
 - *recording*
 - *monitoring/auditing*
 - *reporting*
- **All imaging experts are accountable**
- **Need to begin to monitor both dose & quality**
- **Parents/patients should not be responsible**

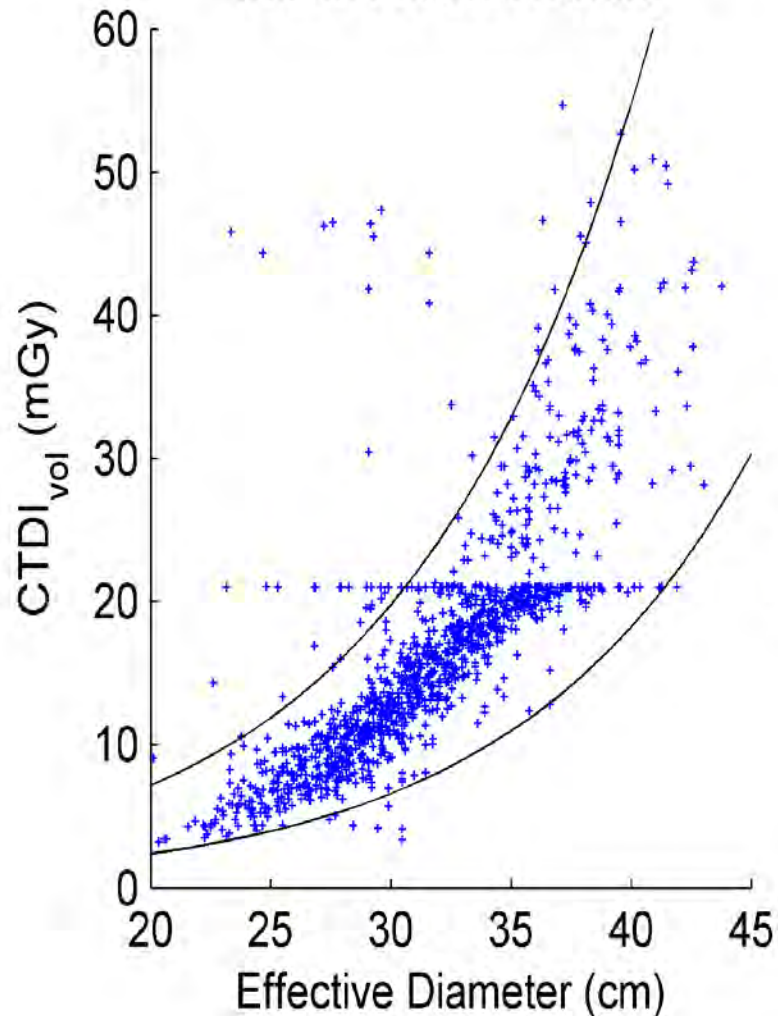
Cumulative Dose Program: Fundamental Elements

- Defined dose metrology
- Individual patient and institutional dose
- Recording process
- Monitoring process
- Defined reports/triggers
- Measures taken (including reporting)

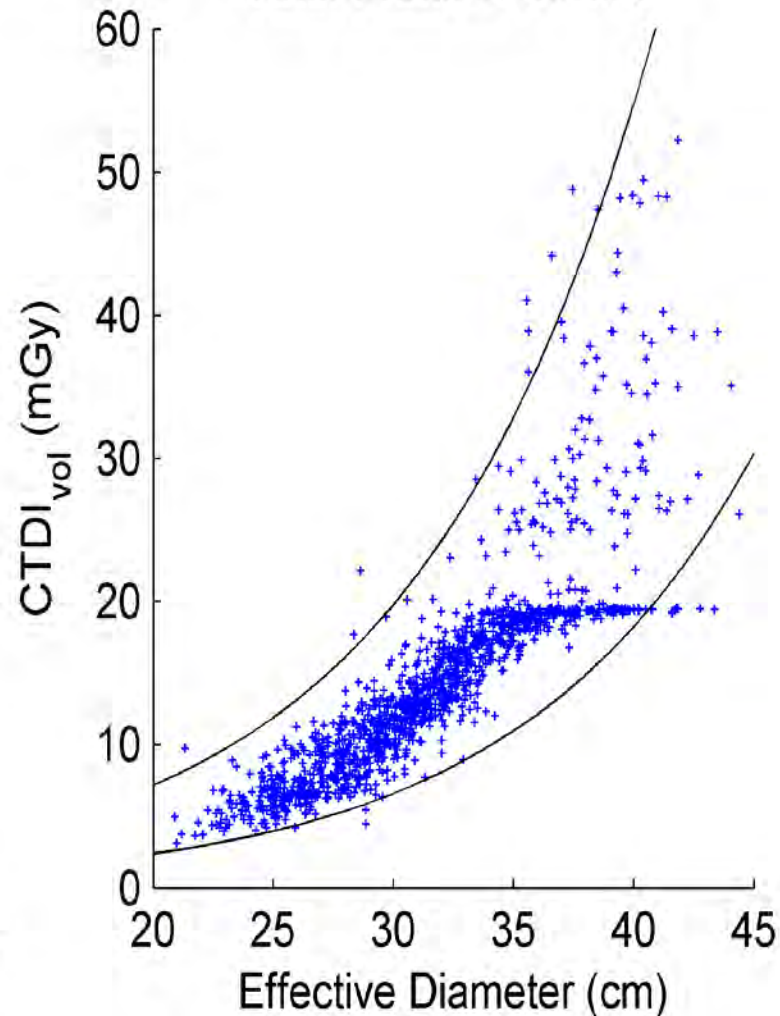


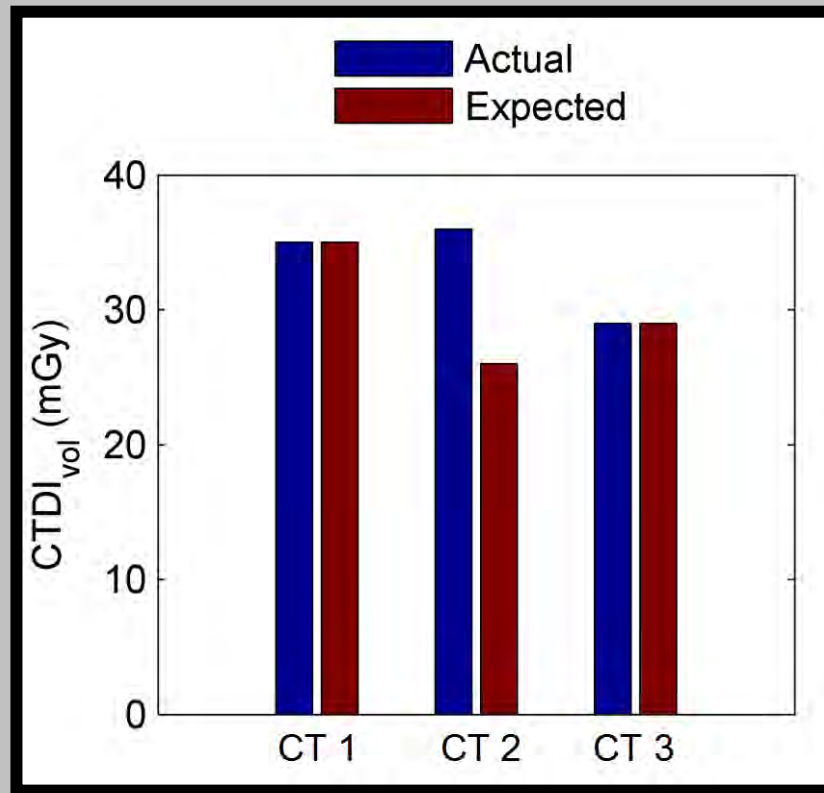
CTDI_{vol} as the metric of dose. The dashed lines represent the 95th percentiles. Dividing the patients into four size groups, the minimum and maximum target levels can be established based on the state of practice. Note that in this example, the dose is defined based not on targeted image quality rather based on existing dose ranges in the facility.

Before Protocol Review



After Protocol Review





A comparison of actual versus expected dose across scanners for the orbits protocol. A recent protocol review of the orbits CT protocol for CT system 2 revealed that the median CTDI was 36 mGy, whereas the expected CTDI based on the documented protocol definition was 26 mGy.

CT Dose Monitoring Program

“Best Practices”

- **Access: Connection and collection of dose-relevant data**
- **Integrity: Data quality and accuracy**
- **Metrology: Meaningful quantities to monitor**
- **Analytics: From data to knowledge**
- **Informatics: Dose monitoring as a secure, integrated solution**

CT Dose Monitoring Program: The Horizon

- **Standardized analytics**
- **Improved dose metrology**
- **Enhanced data management**
- **All modalities**
- **All providers**
- **Beyond radiation dose**
 - **Include quality metrics**



Meeting Medical Needs

- Accurate risk assessment
- Accurate dose metrics
- Dose monitoring
- **Benchmarks (eg DRLs)**
- Disaster response/mass casualty
- Integrated programs
- Emphasis on imaging quality and value

American College of Radiology (ACR) CT Dose Index Registry:

A Resource for Pediatric CT
Diagnostic Reference Levels



Donald Frush¹
Mythreyi Chatfield²
Benjamin Wildman-Tobriner¹

¹*Department of Radiology, Duke University Medical Center*

²*American College of Radiology*

No Disclosures

Introduction

- **Limited information on CT dose estimations**
 - Community and academic practices
 - Contemporary dose-estimations: size-specific dose estimates (SSDE)
 - Body region (type of scan)
 - Gender and age distribution
- **The ACR Dose Index Registry is a resource for pediatric CT practice**
 - To date, no information on value of resource for children

		Patients Age 18 and Younger
Year	Quarter	
2011	3	1742
	4	4364
2012	1	8027
	2	11341
	3	16544
	4	18890
2013	1	22245
	2	27247
	3	31983
	4	30647
2014	1	31339
	2	31366
	3	37098
	4	36974
All		309807
Census Division		
	Outside US states	1323
	New England Division	15092
	Middle Atlantic Division	71754
	East North Central Division	61537
	West North Central Division	8696
	South Atlantic Division	79827
	East South Central Division	18179
	West South Central Division	21885
	Mountain Division	10351
	Pacific Division	21163
Facility Type		
	Academic	52639
	Community hospital	157223
	Multi-specialty clinic	4188
	Freestanding center	8041
	Childrens hospital	85803
	Other	1913

- **45% from centers with pediatric expertise (children's hospitals, university-based academic programs)**
- **51% of scans were from community**
- **5,387,120 total head, chest, and AP examinations:**
 - **5.8% (309,807) were pediatric**

	Pediatric patients as % of all	Pediatric patients by age					
		0-2	3-6	7-10	11-14	15-18	All
CT ABDOMEN PELVIS W IVCON	5%	2%	11%	15%	24%	48%	100%
CT CHEST W IVCON	2%	6%	19%	14%	19%	42%	100%
CT HEAD BRAIN WO IVCON	7%	7%	21%	16%	21%	35%	100%
		% patients female by age group					
CT ABDOMEN PELVIS W IVCON		42%	40%	45%	52%	61%	
CT CHEST W IVCON		46%	43%	42%	44%	42%	
CT HEAD BRAIN WO IVCON		42%	38%	39%	42%	47%	

- **5,387,120 all ages:**
 - Pediatric: 7% head, 5% AP, and 2% chest
 - 69% of all 309,807 pediatric scans were head
- **Majority (53-62%) performed in males**
 - exceptions were the 11-<15, and 15-18 yr group for AP CT: 52% and 61% were performed in females.
- **11-18 yr group accounted for:**
 - 72% AP
 - 61% chest
 - 56% brain

Exam name	AgeGroup	CTDI _{vol} per exam			DLP per exam			SSDE per exam		
		N	Mean	Median	N	Mean	Median	N	Mean	Median
CT ABDOMEN PELVIS W IVCON										
	0-2	1254	4.9	2.6	1254	122.0	76.7	772	8.8	4.7
	3-6	7691	4.6	3.3	7676	140.5	109.4	4710	8.2	5.9
	7-10	12572	6.2	4.8	12551	217.7	177.6	7577	9.9	7.8
	11-14	19701	10.1	6.9	19665	391.2	297.7	11897	14.1	10.3
	15-18	40323	13.5	9.2	40231	563.9	427.9	24529	17.7	13.0
CT CHEST W IVCON										
	0-2	816	3.4	1.8	815	72.1	35.8	540	6.3	3.5
	3-6	2358	3.3	2.1	2353	75.2	48.0	1571	6.2	3.8
	7-10	2013	4.5	2.8	2009	125.6	76.1	1395	7.1	4.6
	11-14	2756	8.2	4.7	2753	260.8	153.3	1894	10.7	6.5
	15-18	5901	15.5	8.8	5897	564.2	302.5	3823	18.1	10.7
CT HEAD BRAIN WO IVCON										
	0-2	15132	32.9	25.3	15118	447.4	373.7	0	.	.
	3-6	38713	33.2	26.3	38683	458.0	398.9	0	.	.
	7-10	35197	38.6	32.3	35161	546.7	495.0	0	.	.
	11-14	47292	48.1	42.1	47228	696.5	644.3	0	.	.
	15-18	77840	60.0	51.1	77716	877.7	805.1	0	.	.

- **Mean dose estimates:**
 - head CTDI_{vol} 32.9 - 60
 - AP CTDI_{vol} 4.9 - 13.5 SSDE 8.8 - 17.7
 - chest CTDI_{vol} 3.4 - 15.5 SSDE 6.3 - 18.1
- Mean AP CT SSDE and CTDI_{vol} higher than the chest dose estimates for every age group, except for the 15-18 group
- Higher dose estimates with increasing age
- SSDE values always greater than CTDI_{vol} for each age category

Table 2 *Smith Bindman et al Radiology Oct 2015 277; 134-141*

Radiation Dose Metrics in Children

Area and Examination Type	No. of Examinations	CTDI _w (mGy)			DLP (mGy · cm)			Effective Dose (mSv)		
		25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile	25th Percentile	50th Percentile	75th Percentile
Head										
Single phase	1116				290	420	570	1	2	3
Multiphase	166				540	870	1310	3	4	6
All	1282	22	30	38	310	450	650	1	2	4
Chest										
Single phase	292				50	90	130	2	3	4
Multiphase	63				70	150	210	2	6	7
All*	355	2 (3)	3 (4)	5 (6)	60	90	150	2	3	5
Abdomen										
Single phase	625				80	140	230	3	4	6
Multiphase	83				120	210	330	4	6	10
All*	708	2 (4)	4 (5)	5 (9)	90	140	230	3	4	7
Chest and abdomen										
Single phase	49				110	240	380	3	6	12
Multiphase	35				210	300	840	7	9	20
All*	84	3 (4)	4 (6)	8 (12)	130	270	510	5	9	15
Sinus										
Single phase	153				110	270	460	<0.5	1	2
Multiphase	32				270	570	850	1	2	4
All	185	9	18	28	150	310	500	1	1	2
Neck										
Single phase	103				90	140	340	2	3	6
Multiphase	16				170	270	590	4	6	9
All	119	5	6	13	100	160	340	2	4	6
All other areas	1138									

Note.—Examinations were performed in children younger than 1 year (*n* = 483 [12.5%]), 1–4 years (*n* = 949 [24.5%]), 5–9 years (*n* = 991 [25.6%]), and 10–14 years (*n* = 1448 [37.4%]).

* Numbers in parentheses are SSDEs, which reflect an adjusted CTDI_w measurement.

3871 consecutive CT examinations in 2609 children at the five University of California medical centers during 2013

Smith Bindman CTDI (SSDE)

Head: 30 mGy
Abdomen: 4 mGy (5)
Chest: 3 mGy (4)

Goske: 50th percentile CTDI (SSDE)

Abdomen: 3.4 -10.8 mGy (8.6-16.5)

Frush [mean] CTDI (SSDE)

Head: 32.9-60 mGy [47.1]
Abdomen: 4.9-13.5 (8.8 -17.7)
Chest: 3.4-15.5 mGy [10.6]



Computed tomography

Exam	Weight group, kg	Age group, y	EDRL	
			CTDI _{vol} , mGy	DLP, mGy cm
Head	<10	0	25	300
	10-<15	1	25	370
	15-<30	5	38	505
	30-<60	10	53	700
	>60	15	60	900
Thorax	<10	0	2,7	45
	10-<15	1	3,3	80
	15-<30	5	5,6	115
	30-<60	10	5,7	180
	>60	15	6,9	200
Abdomen	<10	0		90
	10-<15	1	5,7	160
	15-<30	5	5,7	170
	30-<60	10	7,0	290
	>60	15	14	580

Smith Bindman CTDI (SSDE)

Head: 30 mGy
Abdomen: 4 mGy (5)
Chest: 3 mGy (4)

Goske: 50th percentile CTDI (SSDE)

Abdomen: 3.4 -10.8 mGy (8.6-16.5)

Frush [mean] CTDI (SSDE)

Head: 32.9-60 mGy [47.1]
Abdomen: 4.9-13.5 (8.8 -17.7)
Chest: 3.4-15.5 mGy [10.6]

Recommendations

- **Medical physicist guidance**
 - includes training opportunities
- **IT expertise**
- **Administration: will cost \$**
- **Industry partnership**
- **Facilitate comprehensive, automated, and integrated programs**

A Solution?



Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- Dose monitoring challenges
- **Emergency response**
- Risk determination

Radiologic Event

- Do all medical providers understand triage?
- What are different types of contamination?
- What are resources?
- Are drills performed?
- What about pts with high dose administered activity?

Recommendations

- **NCRP Annual Meeting 2017**
- **Integration of medical experts and emergency preparedness teams**
- **Response templates**

Medical Status Quo

- Increased use
- Radiation exposure scrutiny
- Misinformation/misunderstanding
- Increasing regulation, accreditation, “guidance”
- Dose monitoring challenges
- Emergency response
- **Risk determination**

CT Scans May Reduce Rather than Increase the Risk of Cancer

Bobby R. Scott, Ph.D.
Charles L. Sanders, Ph.D.
Ron E. J. Mitchel, Ph.D.
Douglas R. Borcham, Ph.D.

ABSTRACT

Extrapolating from data on atomic bomb survivors on the basis of the linear no-threshold (LNT) model as applied to radiation exposure, a recent paper concludes that within a few decades 1.5–2 percent of all cancers in the U.S. population could be caused by current rates of use of computed tomography (CT). This paper ignores the other war-related exposures of the Japanese population, which would be expected to shift the dose-response relationship for cancer induction to the left. Moreover, the LNT model is shown to fail in four tests involving low-dose radiation exposures. Considering the available information, we conclude that CT scans may reduce rather than increase lifetime cancer risk.

Introduction

In a Nov 29, 2007, article in the *New England Journal of Medicine*¹ Brenner and Hall argue that the potential carcinogenic effects from using computed tomography (CT) may be underestimated and that one-third of all CT scans performed in the United States may not be medically necessary. They estimated that more than 62 million CT scans per year are currently done in the United States as compared to 3 million in 1980.¹ With such an increased rate Brenner and Hall speculate, based on extrapolations from cancer data derived from survivors of the atomic bombings in

defenses. This effect has been called radiation activated natural protection (ANP).² Radiation ANP includes selective removal of aberrant cells (e.g., precancerous cells) via apoptosis and stimulated immunity against cancer cells. Thus, radiation ANP can prevent some cancers (sporadic and hereditary) that would otherwise occur in the absence of radiation exposure.³

Recent papers by Bauer⁴ and by Portess et al.⁵ describe how low-dose radiation activates the selective removal of precancerous cells via apoptosis. The selective removal is mediated via intercellular signaling involving reactive oxygen and nitrogen species and specific cytokines (e.g., transforming growth factor β).

Numerous papers have been published related to low-dose radiation stimulating immunity against cancer cells.^{6–8} Because of radiation ANP, low doses and low dose-rates of x-rays and gamma rays can actually reduce rather than increase cancer occurrences.³ Conversely, high radiation doses suppress immunity and inhibit selective removal of aberrant cells via apoptosis, leading to an increase in the number of cancer cases to a rate greater than the spontaneous level.^{3,6–8}

Extrapolating Observed Radiation Effects from High to Low Doses

In order to obtain lifetime cancer risk predictions from small radiation doses such as those received from CT scans, many researchers extrapolate the risk from observed effects after moderate and high radiation doses using the LNT model. With this model, any amount of radiation is considered to cause some cancer fatalities in any large irradiated population. Doubling the radiation

“Risk of ALL was elevated in children exposed to three or more post natal x-rays...”

Diagnostic X-rays and risk of childhood leukaemia

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Accepted 17 August 2010

Background The association between diagnostic X-ray exposures early in life and increased risk of childhood leukaemia remains unclear.

Methods This case-control study included children aged 0–14 years diagnosed with acute lymphoid leukaemia (ALL, $n=711$) or acute myeloid leukaemia (AML, $n=116$) from 1995 to 2008. Controls were randomly selected from the California birth registry and individually matched to cases with respect to date of birth, sex, Hispanic ethnicity and maternal race. Conditional logistic regression analyses were performed to assess whether ALL or AML was associated with self-reported child's X-rays after birth (post-natal), including number of X-rays, region of the body X-rayed and age at first X-ray, as well as maternal X-rays before and during pregnancy (preconception and prenatal).

Results After excluding X-rays in the year prior to diagnosis (reference date for matched controls), risk of ALL was elevated in children exposed to three or more post-natal X-rays [odds ratio (OR)=1.85, 95% confidence interval (CI) 1.12–2.79]. For B-cell ALL specifically, any exposure (one or more X-rays) conferred increased risk (OR=1.40, 95% CI 1.06–1.86). Region of the body exposed was not an independent risk factor in multivariable analyses. No associations were observed between number of post-natal X-rays and AML (OR=1.05, 95% CI 0.90–1.22) or T-cell ALL (OR=0.84, 95% CI 0.59–1.19). Prevalence of exposure to prenatal and preconception X-rays was low, and no associations with ALL or AML were observed.

Conclusions The results suggest that exposure to post-natal diagnostic X-rays is associated with increased risk of childhood ALL, specifically B-cell ALL, but not AML or T-cell ALL. Given the imprecise measures of self-reported X-ray exposure, the results of this analysis should be interpreted with caution and warrant further investigation.

Keywords Childhood leukaemia, diagnostic X-rays, California

Lancet June 2012

First direct assc of CT and cancer

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

Summary

Background Although CT scans are very useful clinically, potential cancer risks exist from associated ionising radiation, in particular for children who are more radiosensitive than adults. We aimed to assess the excess risk of leukaemia and brain tumours after CT scans in a cohort of children and young adults.

Methods In our retrospective cohort study, we included patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in England, Wales, or Scotland (Great Britain) between 1985 and 2002, when they were younger than 22 years of age. We obtained data for cancer incidence, mortality, and loss to follow-up from the NHS Central Registry from Jan 1, 1985, to Dec 31, 2008. We estimated absorbed brain and red bone marrow doses per CT scan in mGy and assessed excess incidence of leukaemia and brain tumours cancer with Poisson relative risk models. To avoid inclusion of CT scans related to cancer diagnosis, follow-up for leukaemia began 2 years after the first CT and for brain tumours 5 years after the first CT.

*Increased risk of
leukemia and
brain tumors with
childhood CT*

*" 1 additional
brain tumor per
10,000 childhood
brain CTs"*

Reverse Causation

Radiat Environ Biophys (2015) 54:1–12
DOI 10.1007/s00411-014-0580-3

ORIGINAL PAPER

Risk of cancer incidence before the age of 15 years after exposure to ionising radiation from computed tomography: results from a German cohort study

L. Krille · S. Dreger · R. Schindel · T. Albrecht · M. Asmussen · J. Barkhausen · J. D. Berthold · A. Chavan · C. Claussen · M. Forsting · E. A. L. Gianicolo · K. Jablonka · A. Jahnen · M. Langer · M. Laniado · J. Lotz · H. J. Mentzel · A. Queißer-Wahrendorf · O. Rompel · I. Schlick · K. Schneider · M. Schumacher · M. Seidenbusch · C. Spix · B. Spors · G. Staatz · T. Vogl · J. Wagner · G. Weisser · H. Zeeb · M. Blettner

Received: 12 August 2014 / Accepted: 12 December 2014 / Published online: 8 January 2015
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Abstract The aim of this cohort study was to assess the risk of developing cancer, specifically leukaemia, tumours of the central nervous system and lymphoma, before the age of 15 years in children previously exposed to computed tomography (CT) in Germany. Data for children with at least one CT between 1980 and 2010 were abstracted from 20 hospitals. Cancer cases occurring between 1980 and 2010 were identified by stochastic linkage with the German Childhood Cancer Registry (GCCR). For all cases and a sample of non-cases, radiology reports were reviewed to assess the underlying medical conditions at time of the CT. Cases were only included if diagnosis occurred at least 2 years after the first CT and no signs of cancer were recorded in the radiology reports. Standardised

incidence ratios (SIR) using incidence rates from the general population were estimated. The cohort included information on 71,073 CT examinations in 44,584 children contributing 161,407 person-years at risk with 46 cases initially identified through linkage with the GCCR. Seven cases had to be excluded due to signs possibly suggestive of cancer at the time of first CT. Overall, more cancer cases were observed (*O*) than expected (*E*), but this was mainly driven by unexpected and possibly biased results for lymphomas. For leukaemia, the SIR (SIR = *O/E*) was 1.72 (95 % CI 0.89–3.01, *O* = 12), and for CNS tumours, the SIR was 1.35 (95 % CI 0.54–2.78, *O* = 7). Despite careful examination of the medical information, confounding by indication or reverse causation cannot be ruled out

FULL PAPER

BJC

British Journal of Cancer (2015) 112, 185–193 | doi: 10.1038/bjc.2014.526

Keywords: cancer risk; computed tomography; radiation protection; radiology; paediatrics; indication bias; cohort study

Are the studies on cancer risk from CT scans biased by indication? Elements of answer from a large-scale cohort study in France

N Joury¹, J-L Rehel², H Ducou Le Pointe³, C Lee⁴, H Brisse⁵, J-F Chatell⁶, S Caer-Lorho¹, D Laurier¹ and M-O Bernier^{*,1}

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Background: Recent epidemiological results suggested an increase of cancer risk after receiving computed tomography (CT) scans in childhood or adolescence. Their interpretation is questioned due to the lack of information about the reasons for examination. Our objective was to estimate the cancer risk related to childhood CT scans, and examine how cancer-predisposing factors (PFs) affect assessment of the radiation-related risk.

Methods: The cohort included 67 274 children who had a first scan before the age of 10 years from 2000 to 2010 in 23 French departments. Cumulative X-rays doses were estimated from radiology protocols. Cancer incidence was retrieved through the national registry of childhood cancers; PF from discharge diagnoses.

Results: During a mean follow-up of 4 years, 27 cases of tumours of the central nervous system, 25 of leukaemia and 21 of lymphoma were diagnosed; 32% of them among children with PF. Specific patterns of CT exposures were observed according to PFs. Adjustment for PF reduced the excess risk estimates related to cumulative doses from CT scans. No significant excess risk was observed in relation to CT exposures.

Conclusions: This study suggests that the indication for examinations, whether suspected cancer or PF management, should be considered to avoid overestimation of the cancer risks associated with CT scans.

BJC: “This study suggests that the indication for examinations, whether suspected cancer or [predisposing factors] management, should be considered to avoid overestimation of the cancer risks associated with CT scans.”

Recommendations

- **We need your help.....**

Radiation Protection: Meeting Medical Needs

- **Many needs**
- **Many opportunities**
- **Many stakeholders**
 - **Applies across ALL medical providers**
- **Will take resources**



NCRP Vision for the Future & PAC Activities



John D. Boice, Jr.

**52nd NCRP Annual Meeting
April 11-12, 2016**



Outline



- **WARP – Importance Re-emphasized**
- **Ongoing Activities**
- **Opportunities & Vision for the Future**



There are Simply Not Enough Radiation Professionals



- “Where’s Waldo”? Similar to radiation professionals it seems that even allowing GPS location on Waldo’s smartphone won’t help much – if there’s no one to answer the call!
- Where Are the Radiation Professionals (WARP) and where are you?





NCRP WARP and You



Human Capital Challenges in Health Physics (NRC RIC, March 2016), left to right: William Magwood (Nuclear Energy Agency), Richard Toohey (MH Chew), Jerry Hiatt (Nuclear Energy Institute), Kathryn Higley (Oregon State University), and Terry Brock (NRC) Photo courtesy of John Boice

Publish Today's Proceeding – Please send your suggestions – we'll publish them!

Presentations – NRC/RIC, HPS, IRPA, other – Please send your suggestions

Continue – CC 2 – Meeting the Needs of the Nation in Radiation Protection – Please send your ideas



Seven Program Area Committees (PACs)

PAC 1: Basic Criteria, Epidemiology, Radiobiology, and Risk

PAC 2: Operational Radiation Safety

PAC 3: Nuclear and Radiological Security and Safety

PAC 4: Radiation Protection in Medicine

PAC 5: Environmental Radiation and Radioactive Waste Issues

PAC 6: Radiation Measurements and Dosimetry

PAC 7: Radiation Education, Risk Communication, Outreach, and Policy



PROGRAM AREA COMMITTEE SUMMARIES

HEALTH PHYSICS

VOL 110, NO. 2, February 2016

NCRP Program Area Committee 1: Basic Criteria,
Epidemiology, Radiobiology and Risk
Kathryn D. Held and Gayle E. Woloschak

NCRP Program Area Committee 2: Operational
Radiation Safety
Eric M. Goldin and Kathryn H. Pryor

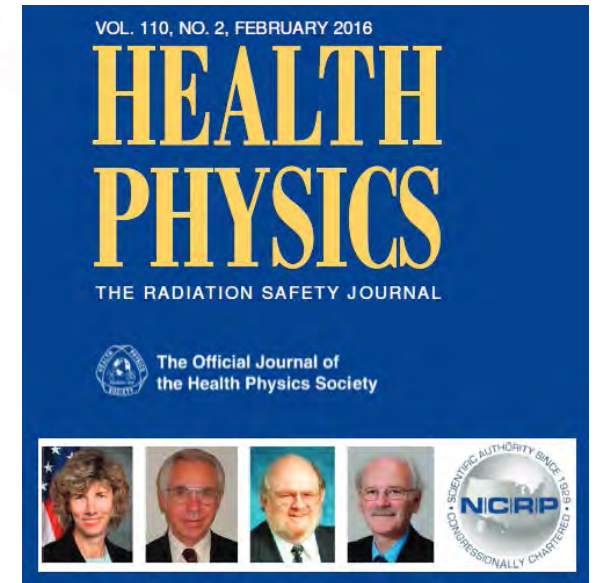
NCRP Program Area Committee 3: Nuclear and Radiological
Security and Safety
Tammy P. Taylor and Brooke Buddemeier

NCRP Program Area Committee 4: Radiation Protection
in Medicine
James A. Brink and Donald L. Miller

NCRP Program Area Committee 5: Environmental Radiation
and Radioactive Waste Issues
S.Y. Chen and Bruce Napier

NCRP Program Area Committee 6: Radiation Measurements
and Dosimetry
Steven L. Simon and Gary H. Zeman

NCRP Program Area Committee 7: Radiation Education, Risk
Communication, Outreach, and Policy
S.M. Becker and P.A. Locke





Ongoing

- PAC 1 Dose Limits for the Eye**
- PAC 1 Space Radiation & CNS**
- PAC 1 Bioeffectiveness of Low Energy Radiation**
- PAC 1 Linearity Assumption for Radiation Protection**
- PAC 2 Nanotechnology**
- PAC 2 Sealed Sources**
- PAC 3 Dosimetry for Emergency Responders**
- PAC 4 CT Dose Optimization**
- PAC 4 Dentistry**
- PAC 4 Informed Consent and Communicating Risk in Medicine**
- PAC 5 TENORM – Hydraulic Fracturing**
- PAC 6 Dosimetry for Workers and Veterans**
- PAC 7 Communicating Risks, Education and Policy**
- CC Regulation Guidance for the Nation**
- CC WARP – Where are the Radiation Professionals? A National Crisis**
Million Person Study of Low-Dose Radiation Health Effects



PAC 1: Basic Criteria, Epidemiology, Radiobiology, and Risk

The membership of PAC 1 is:

G.E. Woloschak, *Vice President*

K.D. Held, Co-Chair

S.A. Amundson

E.I. Azzam

J.S. Bedford

J. Bernstein

A.R. Kennedy

A. Kronenberg

G.A. Nelson

G. Sgouros

R.E. Shore

M.D. Story

D.O. Stram

M.M. Weil

J.P. Williams





SC 1-23: Guidance on Radiation Dose Limits for the Lens of the Eye





Co-Chairs
Leslie A. Braby,
Texas A&M University
&
Richard S. Nowakowski
Florida State University

NCRP COMMENTARY No. 25

POTENTIAL FOR CENTRAL NERVOUS SYSTEM EFFECTS FROM RADIATION EXPOSURE DURING SPACE ACTIVITIES PHASE I: OVERVIEW



Neil Armstrong
photo courtesy of
Michael Wright
Space Collection



National Council on Radiation Protection and Measurements



SC 1-24: Radiation Exposures in Space and the Potential for CNS Effects - Phase II NASA Supported





SC 1-25: Recent Epidemiologic Studies and Implications for the Linear-Nonthreshold Model



Purpose: SC 1-25 will prepare a commentary reviewing recent epidemiologic studies and evaluate whether the new observations are strong enough to support or modify the linear nonthreshold (LNT) model as used in radiation protection today.

Roy Shore, Co-Chair

L.T. Dauer, Co-Chair

John Boice

Scott Davis

Randall N. Hyer

Fred A. Mettler, Jr.

R. Julian Preston

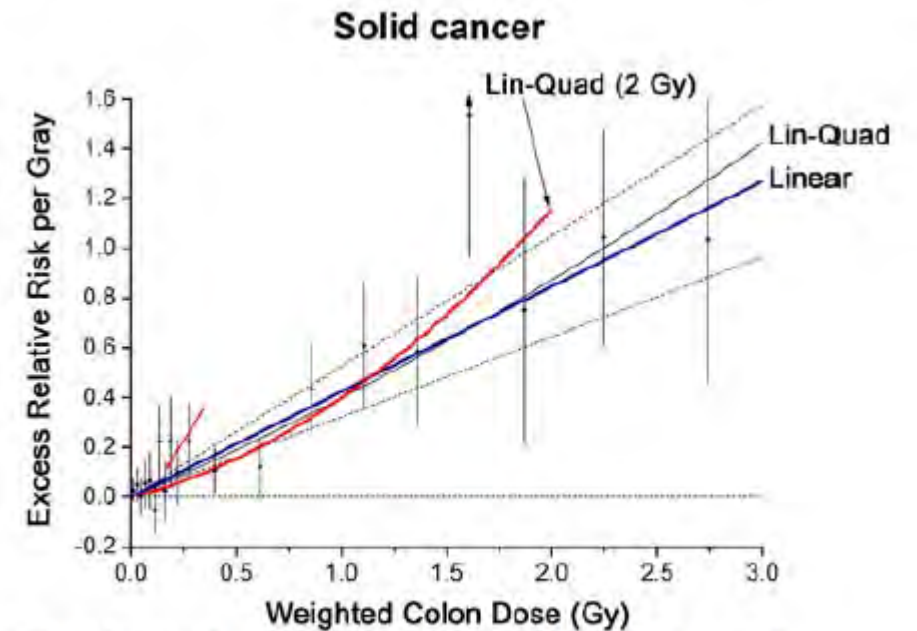
John E. Till

Daniel Stram

Richard Wakeford

Linda Walsh

Richard Vetter, Staff Consultant



Graph used with permission of K. Ozasa and Radiation Research



PAC 1 Opportunities

- **Cardiovascular Risk at Low Doses**
- **Dose and Dose-Rate Effectiveness**
- **CNS Risk following low-LET Radiation**
- **Impact of Biology on Regulatory Work**



PAC 2: Operational Radiation Safety



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E.D. Bailey

C.A. Donahue

J.R. Frazier

E.M. Goldin

M. Littleton

D.S. Myers

J.W. Poston

K. L. Shingleton

G.M. Sturchio

J. Walkowicz

J.S. Willison

J.G. Yusko



SC 2-7: Radiation Safety of Sealed Radioactive Sources

Purpose: To provide comprehensive guidance on the radiation safety aspects of sealed radioactive sources from “cradle to grave.” Recommendations will be provided on the definition of a sealed radioactive source, including design characteristics that should be considered. Guidance will be provided in the safe handling, tracking and control of sealed sources. The report will also present a set of “lessons learned” regarding what has gone wrong with sealed sources, what caused those events, and what could be done to prevent them in the future. Example procedures for confirming inventories, leak testing, labeling, safety, training, periodic inspection, and emergency response may also be provided.

K.H. Pryor, *Chair*
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C. Donahue
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M. Littleton
D.S. Myers

J.W. Poston, Sr.
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RADIATION SAFETY ASPECTS OF NANOTECHNOLOGY

Coming Soon



Mark Hoover
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R.A. Guilmette
W.G. Kreyling
G. Oberdoerster
R. Smith
M.P. Grissom, *Staff Consultant*

13th International Congress of the International Radiation Protection Association, Glasgow, Scotland

Dose Assessment Due to Inhalation of Plutonium Nanoparticles

Leigh Cash, Guthrie Miller, and Luiz Bertelli

Los Alamos National Laboratory • PO Box 1663, MS G761 • Los Alamos, NM 87545, USA • lcash@lanl.gov

INTRODUCTION

Experience has shown that nanoparticles behave differently in terms of deposition and clearance from the respiratory tract as compared to micron-sized particles. However, currently used HRTM models have not addressed the very particular aspects of inhalation, deposition and further distribution of radioactive nanoparticles in the human body. Plutonium is one of the most important radionuclides in the nuclear industry and production of it in nanoparticle form is not negligible. Therefore, this study was done to investigate deposition to the respiratory tract, clearance, and subsequent distribution to systemic organs based on animal data and human studies.



PAC 2 Opportunities

- **Safe use of handheld and portable x-ray fluorescence analyzers**
- **Update to NCRP Report No. 57, *Instrumentation and Monitoring Methods***
- **Radiation protection guidelines for industrial accelerators and irradiators**



PAC 3: Nuclear and Radiological Security and Safety

T.P. Taylor, *Vice President*
B.R. Buddemeier, *Co-Chair*
D.J. Blumenthal
L.L. Chi
C.N. Coleman
N. Dainiak
S. DeCair
J. Donnelly
J.R. Dynlacht
S.V. Musolino
A. Salame-Alfie
J. Rogers, *Consultant*
B. Stevenson, *Consultant*





SC 3-1: (1) Guidance for Emergency Responder Dosimetry (2) Implementation Guidance for Responder Dosimetry in an Emergency





PAC 3

Opportunities

- Medical response:
 - Address **biodosimetry** recommendations
 - Predict and estimate **triage** needs
- Manage the response:
 - Radiation-contaminated **fatality management**
- Characterize the incident and initial response
 - Monitor, decontaminate population in elevated backgrounds
 - Harmonize **decon and screening** criteria
 - Recommend protective and response actions for all hazards and all key phases



PAC 4: Radiation Protection in Medicine

The membership of PAC 4 is:

J.A. Brink, Vice President

D.L. Miller, Co-Chair

S. Balter

J.T. Bushberg

C.E. Chambers

D.P. Frush

R.E. Goans

M.J. Goske

M.K. Kalra

L.A. Kroger

E.G. Leidholdt

M. Mahesh

F.A. Mettler, Jr.

E. Samei

J.A. Seibert

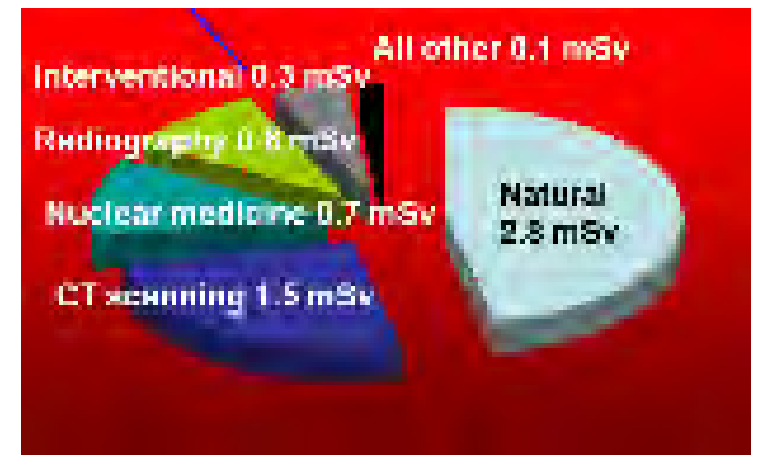
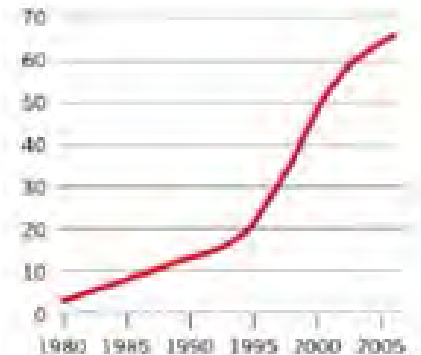
S.G. Sutlief

S.C. White

S.Y. Woo



A COMMON OCCURRENCE The graph below shows the change in the number of CT scans, in millions, performed each year in the United States, from 3 million in 1980 to more than 67 million in 2008.





SC 4-8: Improving Patient Dose Utilization in Computed Tomography

Purpose: To describe general concepts for Computed Tomography (CT) dose utilization and strategies for preventing errors in CT imaging for patients of all ages. The NCRP Report will provide an integrated set of recommendations that can be applied in routine CT practice.

M.K. Kalra, *Chair*
D.P. Frush
E.M. Leidholdt
M. Mahesh
E. Samei

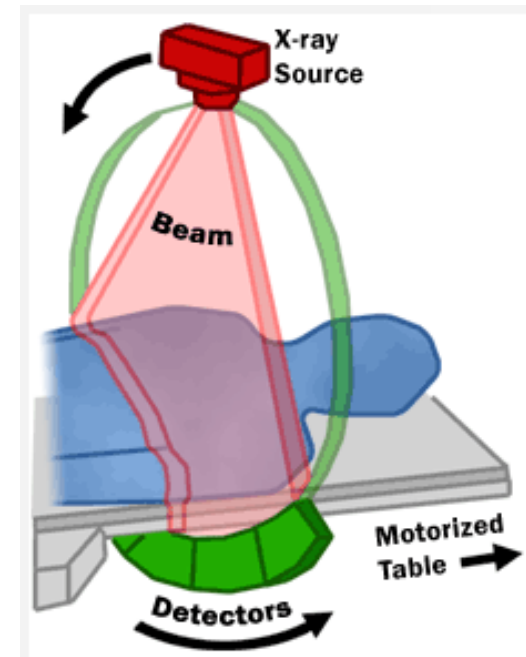


Figure 4: CT Fan Beam



SC 4-5: Radiation Protection in Dentistry Supplement: Cone Beam Computed Tomography, Digital Imaging and Handheld Dental Imaging



Purpose: The supplement will address imaging modalities that have evolved over the past 10 y and update any existing material that needs updating. New imaging modalities include, but are not limited to cone-beam computed tomography (CBCT), digital radiography, and hand-held dental x-ray units. Other topics include the use of high-speed film (80 % of U.S. dental facilities continue to use film which requires twice the radiation dose to the patient compared to high-speed dental film) and new data from the Nationwide Evaluation of X-Ray Trends (NEXT) survey.

A.G. Lurie, *Co-Chair*

M.L. Kantor, *Co-Chair*

M. Ahmad

V. Allareddy

J. Ludlow

E.T. Parks

E.D. Paunovich

R. Pizzutiello

R. Sauer

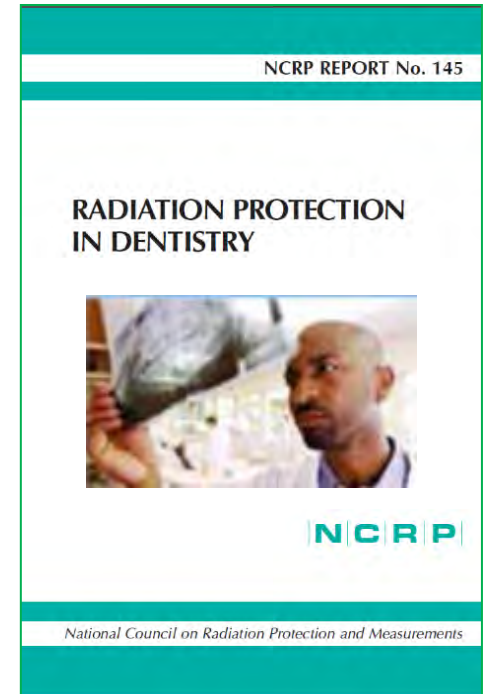
D.C. Spelic

E.M. Leidholdt, *Consultant*

W.D. McDavid, *Consultant*

D.L. Miller, *Consultant*

J.E. Gray, *Staff Consultant*





Dentistry? Are you kidding?





Tianjie Dental 'Falcon' hand held X-ray set imported from China: Summary of HPA radiation protection assessment results

Potential annual doses to operator

Assuming a simple relationship that 1 Gy is equivalent to 1 Sv, potential doses to the operator can be estimated. If the operator was to use this x ray set under a typical heavy workload of 100 exposures per week for 50 weeks of the year, using a 3 second exposure time, potential doses could be up to **40 Sv (equivalent dose) to the hands and 30 mSv (effective dose) to the body.**

**Radiological and Nuclear Terrorism:
Like It or Not, Radiology Professionals Will Be
in the Hot Seat**

**Radiological Society of North America
December 2015**

Judy Bader

Nick Dainiak

Don Frush

John Lanza

Brooke Buddemeier (2016)



PAC 4

Opportunities

- Statement on error prevention in radiation therapy
- Effect of diagnostic and therapeutic radiation doses on implantable medical devices (e.g., pacemakers and insulin pumps)
- Methods and uncertainties associated with organ dose estimation in CT
- Radiation protection for PET-CT & multimodality (hybrid) imaging systems (e.g., PET-MRI)
- Radiation protection for allied professionals and service engineers
- Compendium of resources for medical radiation protection
- Cancer survivorship in the context of radiation protection (out of field doses in pediatric patients)



PAC 5: Environmental Radiation and Radioactive Waste Issues

The membership of PAC 5 is:

S.Y. Chen, *Vice President*

B.A. Napier, *Co-Chair*

M.E. Clark

T. Hinton

E.V. Holahan

K.A. Kiel

J.A. Lipoti

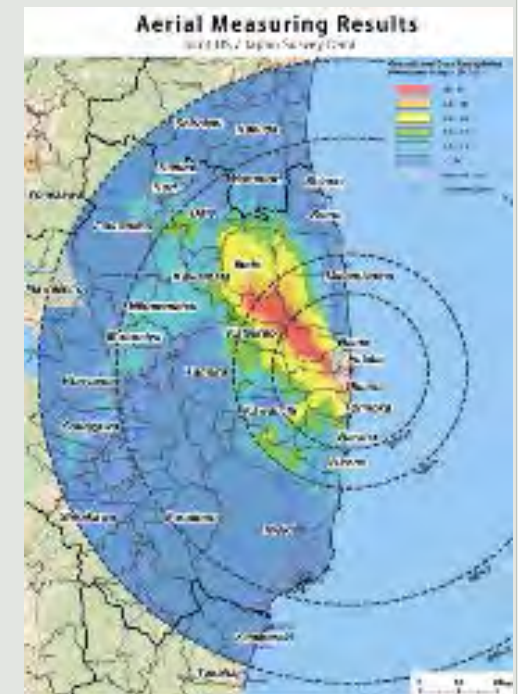
R.E. McBurney

C.J. Paperiello

B.A. Powell

A. Wallo

C.G. Whipple





SC 5-2: Radiation Protection for NORM & TENORM from Oil & Gas Recovery



WE Kennedy,
Chair
Dade Moeller



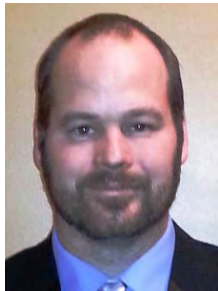
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Pennsylvania Dept of
Environmental
Protection



M Barrie
Oak Ridge Associated
Universities



P Egidi
US Environmental
Protection Agency



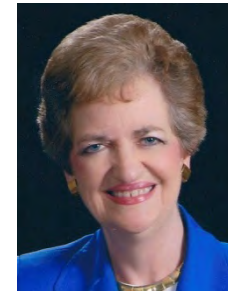
G Forsee
Illinois Emergency
Management Agency



R Johnson
Dade Moeller



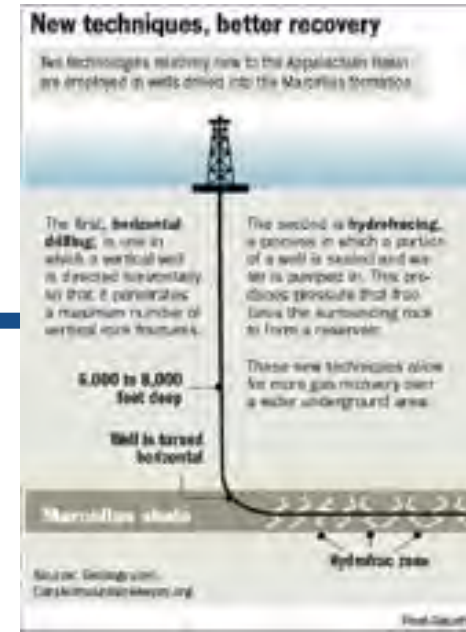
A Lombardo
PermaFix



RE McBurney
CRCPD

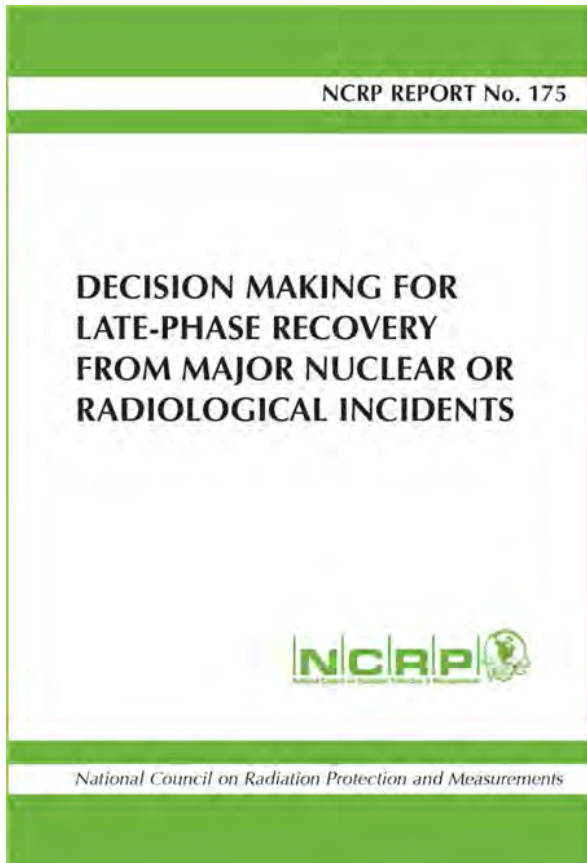


J Frazier
Staff Consultant





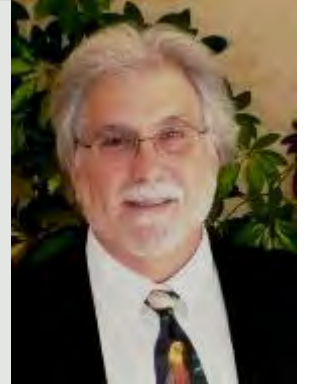
PAC 5 Opportunities



- **Follow-on work of NCRP Report No. 175 – Waste Management from Wide-Area Contamination**
- **A report on radioecology**
- **Characterizing Radionuclides of Interest to Regulatory Rulemaking**



PAC 6: Radiation Measurements and Dosimetry



The membership of PAC 6 is:
S.L. Simon, *Vice President*
L. Bertelli
W.F. Blakely
W.E. Bolch
L.A. Braby
J.F. Dicello
R.A. Guilmette
R.T. Kouzes
J.J. Whicker
G.H. Zeman



National Study of One Million U.S. Radiation Workers and Veterans



Robert Oppenheimer,
General Leslie Groves,
Enrico Fermi, Hans Bethe,
Theodore Hall

- Manhattan Project 360,000
- Atomic Veterans 115,000
- Nuclear Utility Workers 150,000
- Industrial Radiographers 115,000
- Medical & other >250,000



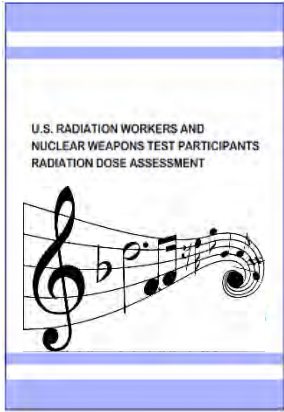
OAK (HARDTACK I), Enewetak,
8.9 MT, 28 Jun 1958





Dosimetry is Key to Good Epidemiology

SC 6-9: U.S. Radiation Workers and Nuclear Weapons Test Participants Radiation Dose Assessment



A Bouville
Chairman



R Toohy
Co-Chairman



H Beck



T Brock



L Dauer



K Eckerman



D Hagemeyer



R Leggett



B Napier



K Pryor



M Rosenstein



S Balter



J Thompson



D Schauer



S Sherbini



D Miller



D Stram



J Till



C Yoder



C Zeitlin





PAC 6 Opportunities

- **Practical methods for data collection for dose reconstruction following mass exposure events**
- **Update of NCRP Report No. 58 on radioactivity measurements**
- **Scientifically based regulatory framework for radiation biodosimetry**
- **Simulation studies of direct astronaut space exposure with simultaneous modeling of detector responses**
- **Improvements to Microdosimetry for Dosimetry in Space**
- **Eye dosimetry**



PAC 7: Radiation Education, Risk Communication, Outreach, and Policy

J.F. Ahearne
S.M. Becker
J.T. Bushberg
F.X. Cameron
H.C. Jenkins-Smith
J.A. Lipoti
P.A. Locke
C.W. Miller
W.F. Morgan
D O'Connor
D.M. Scroggs
J.E. Till
J.E.K. Timins



“People don't care how much you know until they know how much you care”

Communication of
Radiation Benefits and Risks
in Decision Making

March 8–9, 2010

Hyatt Regency Bethesda
One Bethesda Metro Center
7400 Wisconsin Avenue
Bethesda, MD 20814

The poster includes three small images: a group of people at a table, a man and a woman talking, and a woman speaking into a microphone.



PAC 7: Liaison Activities

- **CC-1 on Radiation Regulations**
- **SC 1-25 on LNT and Radiation Protection**
- **SC 3-1 on Emergency Response Dosimetry**
- **SC 5-2 on TENORM in the Oil and Gas Industry**



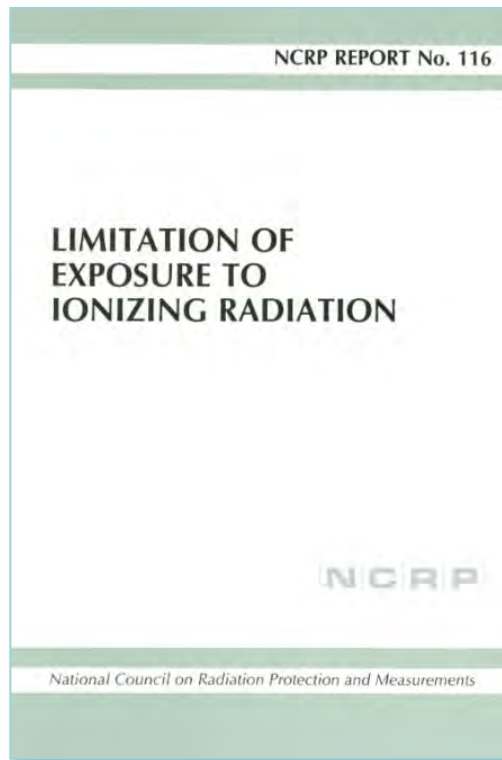
- NCRP has “communications” in the first line of its charter
- Need for lay language executive summary in every report
- Communication Fellow for NCRP
- Comprehensive review of the psychosocial effects of radiation incidents
- Comprehensive and structured approaches to communicating radiation issues



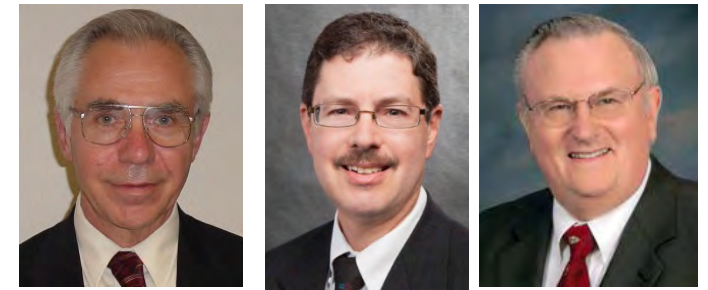
CC 1: Radiation Protection Guidance for the United States

Purpose: An NCRP report is proposed to update and expand NCRP Report 116 on Radiation Protection Guidance for the United States.

Background: Since NCRP Report 116 was published in 1993 there have been substantial advances in radiation effects knowledge as well as radiation protection understandings and culture. In these times of change, there is a pressing need to update the NCRP guidance with regard to radiation protection as it pertains to the United States.



J.D. Boice, Jr., Co-Chair
K.R. Kase, Co-Chair
D.A. Cool, Co-Chair



A. Ansari
J.T. Bushberg
L.T. Dauer
D.R. Fisher
P. Fleming
K.A. Higley

R.N. Hyer
W.E. Irwin
F.A. Mettler
D.L. Miller
R.J. Preston
G.E. Woloschak

J.E. Till, Liaison PAC 7
S.J. Adelstein, Consultant
R. Andersen, Consultant
M. Boyd, Consultant
M. Rosenstein, Staff Consultant



CC 2: Meeting the Needs of the Nation for Radiation Protection



**National Crisis:
Where are the Radiation
Professionals? (WARP)**



- **Report title:** *Where Are the Radiation Professionals-- Today, Tomorrow, and in an Emergency?*
- Statement No. 12
- CC 2 Formed – WARP Factor 2

Thanks to Ted Lazo for slide





If Not Now, When ?

- **Failure to plan, is planning to fail – Ben Franklin**
- **Those who cannot remember the past are condemned to repeat it – George Santayana**
- **If we wait until it's too late, it will be too late – JDB**

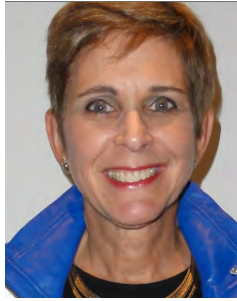




Closing Remarks

John D. Boice, Jr.
President, NCRP





2016 Annual Meeting Acknowledgments

NCRP expresses appreciation to all speakers and session chairs and to the 2015 Program Committee:

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Judith L. Bader

Kathryn H. Pryor

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Cindy L. O'Brien
Beverly A. Ottman
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- ***Kimberly Gaskins*** who sang our National Anthem
- **Joint Armed Forces Honor Guard, Washington, D.C.**
 - **Air Force**
A1C Amanda Skidmore
 - **Marine Corps:**
LCPL Alexander Happ
LCPI David Weld
 - **Army**
SGT Griffin Spires
SPC Erlyn Cueto
PFC Harley Tavernia
 - **Navy**
SN Tim Handy
 - **Coast Guard**
SN Bryan Landreth





NCRP Supporters & Volunteers

- Volunteers *HM1 Alonzo Dunkentell*, U.S. Navy and *HM3 Tomasz Kotowski* & *SGT Ravibol Nissay* from the Walter Reed National Military Medical Center
- NCRP expresses appreciation to *Dale Garbett*, *Karen Buchsbaum*, and *Koorosh Farchadi* for audiovisual services
- *Donovan Anderson*, Colorado State, for recording
- Appreciation is also extended to *Zachary Beadle* and all the staff of the Hyatt Regency Bethesda for their assistance with all arrangements for the 2016 Annual Meeting





2017 Annual Meeting: March 7-8, 2017

Emergency Preparedness for Nuclear Terrorism: What are Remaining Gaps and is There Need for Realignment of National Efforts



**Armin Ansari &
Adela Salame-Alfie,
Co-Chairs**



See You Next Year!