Council on Ionizing Radiation Measurements and Standards
25th Annual Meeting, Gaithersburg 2017

ABSTRACTS

OF

MORNING PLENARY PRESENTATIONS

AND

AFTERNOON BREAKOUT SESSIONS

Monday March 27, 2017 - Morning Plenary Sessions

CIRMS – A Retrospective and Look Forward

Dr. Bert Coursey, National Institute of Standards and Technology (NIST)

A quarter century ago the Council on Ionizing Radiation Measurements and Standards (CIRMS) was founded to give voice to the community of users of ionizing radiation and radioactivity who span different scientific and technological endeavors but share a common interest in development of measurements and standards. The decision was made by the founders that CIRMS would actively engage users from the industrial, governmental and academic fields and provide them a common forum for discussion of measurements and standards. The Scientific Committee of CIRMS through its subcommittees has produced since 1995 six reports on "Needs for Ionizing Radiation Measurements and Standards". This account will look at the evolving roles of ionizing radiation and applications of radionuclides, how CIRMS has attempted to steer the development of measurements and standards for these evolving applications, and a brief look forward at the challenges and opportunities for the CIRMS communities.

The Caswell Fellows

Larry DeWerd, PhD, FAAPM

CIRMS instituted the honorary award called the Caswell fellowship, based on Randy Caswell. Randy was the first fellow. The fellowship is to recognize distinguished achievements in the field of Ionizing Radiation Measurements and Standards. A history of the awards will be presented. Peter Almond will be recognized for our 25th year.

Calibration Standards from NIST using Secondary Laboratories as an example

Larry DeWerd, PhD, FAAPM

The radiation output of linear accelerators used for medical radiation therapy need precise calibrations. The accepted procedure is to calibrate ionization chambers on a two-year period. NIST used to calibrate all chambers but soon found that this was not feasible because of the volume. Robert Loevinger proposed to the AAPM that secondary laboratories be set up which would be directly traceable to NIST. The procedure and operation of such secondary labs will be reviewed and the methodology of maintaining traceability. A review of all the traceable quantities will be given.

Quantitative Imaging

Edward F. Jackson, PhD

Over the past decade, increasing attention has been directed toward quantitative imaging biomarkers (QIBs), which are defined as "objectively measured characteristics derived from *in vivo* images as indicators of normal biological processes, pathogenic processes, or response to a therapeutic intervention"[1], and the applications of such QIBs. To translate current qualitative imaging assessments to the use of QIBs requires the development and standardization of data acquisition, data analysis, and data display techniques, as well as appropriate reporting structures. As such, successful implementation of QIB applications relies heavily on expertise from the fields of image science, radiology, statistics, metrology, and informatics as well as collaboration from vendors of imaging acquisition, analysis, and reporting systems. When successfully implemented, QIBs will provide image-derived metrics with known bias and variance that can be validated with relevant measures, including treatment response (and the heterogeneity of that response) and outcome. Such non-invasive quantitative measures can then be used effectively in clinical and translational research and will contribute significantly to the goals of precision medicine. This presentation will focus on 1) outlining the opportunities for QIB applications, with examples to demonstrate applications in both research and patient care, 2) discussing key challenges in the implementation of QIB applications, and 3) providing overviews of efforts to address such challenges from federal, scientific, and professional organizations, including, but not limited to, the RSNA, NCI, FDA, and NIST. [1]Sullivan, Obuchowski, Kessler, *et al.* Radiology 277(3):813-825, 2015.

Medical Product Sterilization: Past, Present and Future

Kevin O'Hara, Director of Radiation Physics, Sterigenics

The medical product sterilization landscape has changed dramatically of the last sixty years. New materials make it very important to understand the effects of sterilization on end use of the device. Materials such as biodegradables, orthopedic implants, nanotechnology applications or surface modifications are all part of the orthopedic landscape. Mitigating sterilization risks by utilizing the knowledge of radiation chemistry and mechanical properties of both the packaging and device materials is a key to successful sterilization.

Many current medical devices are profoundly different with respect to materials of construction and complexity of design. In addition to metals such as titanium alloys, orthopedic implants now contain different types of polymers and engineering plastics, composites, absorbable polymers, biological materials, and embedded electronics. Most device manufacturers outsource the sterilization process to contract service providers who annually process millions of cubic feet of medical products. The sterilization of large volumes of commodity medical product may not be operationally compatible with the sterilization of lower volumes of specialized devices, but on-going collaboration between the device manufacturer and the sterilization-service provider will lead to innovative technology breakthroughs. A number of precision dose irradiators are now available for small- to medium-volume complex medical product, but a high-volume precise dose irradiator will yield the best of both worlds: reduction in sterilization costs associated with high-volume irradiation of medical product. Other processes are available for sterilization of medical devices that are based on hydrogen peroxide, peracetic acid, nitrogen dioxide, chlorine dioxide, and seeded gas plasma. Sterilization processes have evolved and new ones have been developed to meet the challenges posed by many new medical devices. For ionizing radiation, several strategies will be discussed, including: utilizing precision gamma irradiators to narrow the range of dose that products receive; optimal presentation of the device to the radiation field, and processing product at low temperature and/or under nitrogen to preserve drug/biologic attributes. Medical devices have become more sophisticated. In some cases, optimal sterilization methods have to be evaluated on a case-by-case basis, but finding the right sterilization solution takes in-depth knowledge of the product, potential constraints on the sterilization process, and collaboration between the manufacturer and sterilization service provider.

Radiation -- A Cosmic Hazard to Human Habitation in Space

Dr. Ruthan Lewis, National Aeronautics and Space Administration (NASA)

Radiation exposure is one of the greatest environmental threats to the performance and success of human and robotic space missions. Radiation "permeates" all space and aeronautical systems, challenges optimal and reliable performance, and tests survival and survivability. We will discuss the broad scope of research, technological, and operational considerations to forecast and mitigate the effects of the radiation environment for deep space and planetary exploration.

Alpha Therapy

Dr. Jonathan W. Engle, LANL/University of Wisconsin - Madison

In the last decade, clinical trials of late-stage cancer patients have established that targeted radiotherapy offers immense, untapped treatment potential. Challenges in the large-scale production of alpha- and electron-emitting radionuclides are being addressed by dedicated research efforts and federal investment. I will describe work conducted to expand the availability of these radionuclides at Los Alamos National Laboratory and the University of Wisconsin, emphasizing unanswered questions in their formation by high intensity charged particle irradiations, isolation from radiochemical impurities, and application in the treatment of human disease.

Chip-scale calorimetry for industrial dosimetry

Dr. Ileana Pazos, National Institute of Standards and Technology (NIST)

The high-dose dosimetry program supports radiation-processing applications by assuring NIST traceability of absorbed dose to a product which is often closely regulated. The firmly established alanine-based dosimetry system is an integral part of the NIST transfer service and internal calibrations based on Co-60 radioactive sources. However, many industrial and medical applications utilize accelerator-based radiation sources for which only secondary standards are available. The development of high-precision chip-scale nano-photonic calorimeters that improve spatial resolution will transform clinical and material applications where characterization of non-uniform radiation fields is critical.

Food Defense during a Radiological Emergency

Stephanie Healey, Zhichao Lin, and Patrick Regan, Food and Drug Administration

Proven analytical methods and a competent laboratory network are essential for the Food and Drug Administration (FDA) to implement food defense and safety measures under the Food Safety Modernization Act (FSMA). With growing risks imposed by global aging nuclear facilities and proliferation of radioactive materials, FDA faces increasing challenges in safeguarding the nation's food supply from radioactive contamination. In order to mitigate the imposing threats to food safety and public health, a radiological Food Emergency Response Network (FERN) consisting of federal and state laboratories was established. This network serves to strengthen the FDA's ability to respond to a nuclear/radiological incident. FDA’s decision-making during an incident will be based on large pools of data from diversified analytical methods. Ambiguous findings will inhibit FDA’s ability to take prompt action on protecting public health. Measurement capability, data comparability, and an efficient data reporting mechanism are essential for emergency response when analytical data from FERN laboratories are used for post-incident risk assessment and management.
The FDA’s Winchester Engineering and Analytical Center (WEAC) has engaged the FERN network radio analytical labs in a number of activities in recent years to assess and improve their capability and capacity. This presentation will summarize method development, proficiency testing, training, and emergency response exercises performed by the FERN radiological laboratories. Lessons learned, future activities, and the FERN’s readiness for emergency response will also be discussed.

Optoacoustics meets Ionoacoustics: 3D imaging of the Bragg peak

Dr. Vasilis Ntziachristos, Technical University of Munich, Germany

For the past 10 years we have developed optoacoustic (photoacoustic) tomography for biomedical applications. The technology illuminates tissue at multiple wavelengths, typically utilizing pulsed lasers, and records ultrasonic waves generated within tissue. By unmixing images obtained at different wavelengths, multispectral optoacoustic tomography (MSOT) can then resolve tissue physiological and molecular parameters, including angiogenesis, hypoxia, inflammation or metabolism. Recently, we adapted this technology to measuring ion beams and introduce ionoacoustic tomography based on detection of ion induced ultrasound waves. The detected ultrasonic data are treated through mathematical reconstruction to deliver 3D images of the Bragg peak inside phantoms and tissues. Ionoacoustic tomography can be therefore employed as a technique to provide measurements and real-time feedback on the ion beam profile. We show imaging in the case of 20 MeV with submillimeter accuracy and combinations with ultrasound and optoacoustic imaging.

Monday March 27, 2017: Afternoon Medical Applications Breakout Sessions

Medical Applications Breakout Session I: Radionuclides for nuclear medicine

Realistic simulation of radionuclide sources in EGSnrc: a predictive model of the Vinten ion chamber
Reid Townson, Ph.D., National Research Council of Canada

Monte Carlo simulations are widely used to evaluate experimental conditions involving radionuclides. Recently, the ability to simulate radionuclide decays based directly off the ENSDF (Evaluated Nuclear Structure Data File) format has been integrated into the EGSnrc Monte Carlo code. The new radionuclide source model includes simulation of decay chains and correlated internal transitions, allowing for detailed event-by-event analysis. This can be a powerful predictive tool of experimental conditions. In particular, a Vinten ionization chamber has been investigated.

Measurement challenges for new alpha emitter based nuclear medicine therapies
Mike Schultz, Ph.D., University of Iowa

Development of Standards for alpha emitting radionuclides for nuclear medicine *(Ra-223 and Th-227)*
John Keightley, Ph.D., National Physical Laboratory, Teddington, UK

Alpha-particle emitting radiopharmaceuticals are becoming increasingly important as cancer therapeutic agents, and dosimetry associated with their use requires accurate activity standards coupled with improvements to existing nuclear data. An Ac-227 generator (half-life 21.8 years) may be used to produce the two radionuclides Th-227 and Ra-223 (half-lives 18.7 days and 11.4 days respectively). These are ideal for transport from production facilities to clinical sites, and both radionuclides are of great recent interest in the field of Targeted Alpha Therapy. Radium-223, used as radium chloride, targets bone growth in metastases of various cancers (since radium and calcium exhibit similar chemical properties), whereas Th-227 has broader applications (as targeted thorium conjugates) due to the availability of chelates which can be attached to targeting proteins such as antibodies for delivery to tumour cells. The standardisation of these two isotopes has been the subject of considerable recent effort at National Metrology Institutes worldwide, and this is the main focus of the presentation, coupled with the determination of improved nuclear data, and the determination of appropriate dose calibrator dial factors. This important work ultimately enables the administration of accurate (and traceable) patient doses.

Medical Applications Breakout Session II: Radiation Biology and dosimetry

Current status of radiobiology dosimetry
Wesley Culberson, Ph.D., University of Wisconsin - Madison

In the past decade there has been an increased interest in the standardization of dosimetry in radiobiological experiments. For radiobiology researchers to accurately compare and reproduce studies, both accurate reporting and dosimetry calculations are imperative. The proceedings from a recent symposium on dosimetry in radiobiology research titled, “The importance of standardization of dosimetry in radiobiology” outlined the methods required for accurate radiobiology dosimetry standardization. A literature reviews by our group following this symposium showed that very few of the suggested reporting criteria are actually being reported. Radionuclide-based irradiators are slowly being phased out in favor of x-ray cabinet irradiators due to licensing requirements and expensive resourcing. Radionuclide-based irradiator dosimetry tends to be straightforward due to the predictable nature of the sources and available radionuclide-based calibrations for dosimeters. Advances in small-animal conformal irradiator technology means more complicated dosimetry. Treatment planning systems have been developed to assist in these high-tech delivery machines, but the basic measurements of output with NIST-traceability are still difficult to perform. A review of the NIST-traceable radiobiology dosimetry techniques available today will be presented as well as the challenges moving forward.

Advances in Pre-Clinical Image Guided X-Ray Irradiation
Bill McLaughlin, Precision X-Ray

Towards better repeatability and accurate dosimetry in image-guided small-animal irradiators
Adrian Treverton, Ph.D., Xstrahl Inc

Tuesday March 28, 2017: Afternoon Medical Applications Breakout Sessions

Medical Applications Breakout Session III: Real Time Imaging for Orthopedic Applications

Low dose, mini C-arm fluoroscopy for hand and foot applications
Kevin Wilson, Ph.D., Hologic

Mini C-arms typically have low scatter radiation and are used primarily by extremity orthopedic surgeons, and to a lesser extent, by podiatric surgeons and emergency physicians. The mini C-arm is especially popular with hand and foot surgeons due to its small size and ease of use. Surgeons find that these devices help reduce procedure time, tourniquet time and time spent in the operating room compared with full size C-arms. This is due in large part to their ability to operate the system themselves versus having to utilize radiology staff. Outside of the operating room mini C-arms can be used to provide immediate imaging capabilities to help diagnose and reduce fractures of the extremities, remove foreign bodies, assist in castings or intra-articular injections. While mini C-arms can record fluoroscopic images, they are primarily utilized for still radiographic images. Most modern mini C-arms are based on digital plate technology and have an image receptor area of approximately 200 cm2 and run at 30 frames per second. The FDA has special guidelines for mini C-arm x-ray fluoroscopic devices. By regulation, mini C-arms are limited to extremity imaging and must have a source to detector distance less than 45 cm and a source to skin distance of 10 cm or greater. Mini C-arm capabilities and examples of their uses will be presented with an emphasis on their applications for foot and ankle imaging.

Why Cone Beam CT can make 3D the Standard of Care in Extremity Imaging
Stuti Singh, Ph.D., Curvebeam

Cone Beam CT technology gives doctors access to 3D, dimensionally accurate images of osseous structures at the point of care at a relatively low radiation dose, where previous modalities would have been impractical primarily due to access and cost issues. The technology revolutionized the dental and maxillofacial industry, allowing for accurate assessment of conditions and planning of procedures in the specialty including orthodontic bite correction and dental implants. Presently, the recent advent of Cone Beam CT devices for upper and lower extremities has started a transformation in diagnosis, surgical planning, and post-operative analysis techniques for orthopedic doctors and podiatrists. These devices make it possible to perform 3D weight bearing imaging of the feet and knees, allowing for visualization of the biomechanics of lower extremities under load as never before. 3D weight-bearing images offer undistorted views to measure bone distances and angles as well as joint spaces. This new data is enabling specialists to challenge the conventional methods for classifying pathologies and develop new paradigms. The new Torque Ankle Lever Arm System (TALAS) analyzes the foot as a 3D tri-pod and calculates the forces that may throw this tripod out of alignment. A study of the joint spaces in the knees has helped advance the early detection of osteoarthritis. Assessment of post-operative scans allows a doctor to verify if bones have successfully fused and determine if a patient can safely bear weight on the foot. In addition, advances in the technology are providing cleaner images and new algorithms can correct for patient motion and metal artifact. Such advances will allow these devices to be viable tools for a wider pool of patients. Future advancements may even allow for bone density measurements and soft tissue visualization.

Medical Applications Breakout Session IV: Proton Relative Biological Effectiveness (RBE)

Biological Responses of Therapeutic Ionizing Radiation and Charged Particles

Ramin Abolfath, Dept. Radiation Physics – MD Anderson Cancer Center

Biological systems are exceptionally complex. In particular, cancer progression and treatment present several challenges that require multi-scale modeling. In this talk, I briefly review practical and computational approaches in modeling the interaction of ionizing radiation with biological systems. Based on recent experimental data analysis, I will discuss that extensions to conventional mechanistic approaches are necessary to interpret and fit the observed RBE's as a function of dose and linear energy transfer (LET). I will discuss the possibilities in improving the current models and introduce a novel approach to enable studies the real-time DNA damage-repair pathway in the cell-survival biological endpoint *in-silico* to quantify the radiobiological effectiveness of proton and heavy ion beams. Specific goals for potential enhancements in therapeutic applications and treatment planning will be sketched. For illustration of the methodology, the predicted population of DSBs along the proton track with the highest occurrence frequency in the Bragg peak and a quantitative comparison demonstrating the agreement between theoretical predictions and more recently reported experimental data based on $\gamma H2AX$ counting will be presented.

Proton Therapy National Ion Chamber Intercomparison

Paige Taylor, IROC Houston QA Center

With its Bragg peak dose deposition and potential for normal tissue sparing, proton therapy is rapidly increasing as a radiotherapy treatment modality. Several new proton centers open in the USA each year. The ICRU 59 report developed a calibration procedure for therapeutic proton beams, which was shortly followed by the IAEA TRS 398 calibration protocol. The ionization chamber intercomparison was an experiment with 11 proton therapy institutions. The goal was to compare various calibration protocols (ICRU 59, TRS 398, and any institution's customized calibration procedure) as well as the various ion chambers used by participating institutions. The dose per monitor unit (MU) was measured and calculated for simulated brain and prostate proton treatment fields. 11 thimble and 12 parallel plate ion chambers were used. For the ICRU 59 protocol, both the N_x and $N_{D,w}$ methods were used and dose per MU was calculated by the experiment organizers. The N_x method gave a smaller spread than the $N_{D,w}$ method (e.g. 1.0% 2σ versus 3.8% 2σ for the brain field). When institutions calculated their own dose per MU using the TRS 398 protocol, the spread of results for the same field was within 3.0%. When the organizers performed the TRS 398 calculation using the same raw data, the spread was within 2.3%. The TRS 398 protocol provides acceptable consistency for use with multi-institutional clinical trials. Several of the chambers did not have k_Q values defined by the protocols, so institutions had determined their own value or used one from a similar chamber. The spread of the dose per MU values could be reduced by using k_Q values of 1.014 for the Standard Imaging Exradin T1v2 and T1v3 thimble chambers, 1.010 for the PTW Markus TN23343 chamber, 0.997 for the PTW Advanced Markus TN34045 chamber, and 1.007 for the IBA PPC05 chamber.

Experimental investigation of RBE as a function of dose and LET

Darshana Patel[1], Lawrence Bronk[1], Fada Guan[1], Christopher Peeler[1], Dragan Mirkovic[1], David Grosshans[1], Oliver Jäkel[2], Amir Abdollahi[2,3], Radhe Mohan[1] and Uwe Titt[1]. [1]The University of Texas MD Anderson Cancer Center, Houston, TX, [2] Deutsches Krebsforschungszentrum (DKFZ), Heidelberger Ionentherapiezentrum (HIT), Heidelberg / Germany, [3] National Center for Tumor diseases (NCT), Heidelberg / Germany

Purpose: Investigate and quantify the effect of dose and LET on the RBE of Protons, Helium and Carbon ions.
Methods: A custom designed, high-throughput and high accuracy experimental design was employed to investigate the Relative Biological Effectiveness (RBE) dependence on dose and Linear Energy Transfer (LET) values for proton, helium and carbon ion beams. The experiment was conducted at the HIT facility in collaboration with the DKFZ in Heidelberg/Germany. Clonogenic assay of human lung cancer cell line, H460, was investigated in this study. The experimental setup was designed and optimized using the Geant4 Monte Carlo toolkit incorporating the horizontal beam line design available at the HIT facility. Specific points along the Bragg curve corresponding to well-defined doses and LET values were chosen by appropriate selection of the pre-absorber thicknesses.
Results: Approximately 16,000 samples of cancer cells were irradiated during 23 hours of beam time. The preliminary results of the survival curves for both cell lines show a distinct dependence on LET for a given dose with decreased survival fractions at increasing LET values, encountered at the Bragg peak and in the distal falloff.

Conclusion: Our preliminary findings are indicative of the ability of this experimental setup in providing massive amount of data using our high-throughput experimental setup. This will be leading to deeper insights into the RBE of heavy ions for possible future heavy ion therapy facilities in the US.

Multi-Ion Analysis of RBE using the Microdosimetric Kinetic Model

Michael P. Butkus[1,2] and Todd Palmer[2]; [1]Yale School of Medicine, [2]Oregon State University: Department of Nuclear Engineering

To better quantify the relative biological effectiveness (RBE) of potential ions to be used in hadron therapy, the PHITS Monte Carlo code paired with a microscopic analytical function was used to determine probability distribution functions of lineal energy in 0.3µm diameter spheres throughout a water phantom. Pencil beams of 0.6cm diameter for ^{4}He, ^{7}Li, ^{10}B, ^{12}C, ^{14}N, ^{16}O, and ^{20}Ne were simulated at energies that corresponded to physical Bragg peak depths of 50, 100, 150, 200, 250, and 300mm. The acquired probability distribution functions were scored every millimeter transversely, and in annuli with outer radius of 1.0, 2.0, 3.0, 3.2, 3.4, 3.6, 4.0, 5.0, 10.0, 15.0, 20.0, and 25.0mm and then reduced to dose-mean lineal energies and applied to a modified microdosimetric kinetic model for five different cell types to calculate RBE at the 10% survival threshold. The product of the calculated RBEs and the simulated physical dose was taken to create biological dose and comparisons were then made between the various ions. For all beams the radial fluctuations in RBE were less than 4.2% while physical dose was greater than 1% of the maximum dose. Transversely, for the 50mm depth beams ^{7}Li was seen to provide the most optimal biological dose profile. However, at higher initial energies, fragmentation reduced the biological advantages of ^{7}Li and ^{10}B was seen to provide the most optimal biological dose profile, followed by ^{12}C. The differences in these two beams reduced as initial energy was increased. Greater variance in cell-specific biological dose were seen for the more massive ions.

Monday March 27, 2017: Afternoon Radiation Protection Breakout Sessions

Radiation Protection Breakout Session I: Instrumentation

Aligning US Navy Dosimetry with NIST

Dr. Luis Benevides, Naval Surface Warfare Center, Carderock Division

The US Navy has 17 National Voluntary Laboratory Accredited Program accreditations in ionizing radiation passive Dosimetry. The US Navy utilizes a passive Thermoluminescent (TLD) dosimetry (LiF:Mg, Cu, P) manufactured by Thermo-Fisher Scientific consisting of a Harshaw 8840/8841 card and holder assembly. The NVLAP accreditation scope includes ANSI Standard 13.11-2008 category IA, IIA, IIIA, and IVAB and VCB for the whole body dosimeter. The challenge is to maintain this diverse distributed system aligned with our nation's standards. The US Navy achieves this by a rigorous program of calibration protocols, intercomparison and routine program reviews, the US Navy maintains secondary and tertiary calibrations throughout its network ensuring compliance with all applicable national standards.

IM-276/PD Next Generation Navy Battlefield Dosimeter – System Overview and Test Summary

Jeancarlo Torres, CHP, NSWCCD, West Bethesda, Md, Radiation Technology Group (RTG)

The Navy's current Battlefield Dosimeter is the IM-270/PD. As stated on the Navy's Radiation Health Protection Manual (NAVMED P-5055), the IM-270/PD dosimeter is a personnel accident dosimeter that uses metal oxide semiconductor field effect transistor (MOSFET) technology. This legacy Battlefield Dosimeter has limited capabilities such as; battery life, gamma only sensitive device, and a dynamic range that starts from 0.1 Gy (10 rads) to 10 Gy (1,000 rads). Due to ongoing battery failures and the limited radiological detection capabilities of the IM-270/PD, the Navy has recently acquired the IM-276/PD as a replacement and Next Generation Battlefield Dosimeter. An overview of the new dosimeter will be provided along with test results obtained from the ongoing acceptance testing.

The Future Direction of Passive Dosimetry

Joe Rotunda, Rotunda Scientific Technologies LLC

The concept of passive dosimetry was first discovered in 1663 and it took until the 1920s for it to be used in radiation measurements by Marie Curie during her research, just under 300 years later. Since that time many forms of passive dosimetry have been developed and commercialized. With the advent of miniature electronics, active personal dosimeters came on the scene and while the expectation that they would replace passive dosimetry they have not yet fulfilled that goal. Now the line between passive and active dosimetry is blurred with the introduction of the Direct Ion Storage devices. Other systems have now been developed that work in both passive and active mode. In this talk we will review the history and more importantly provide a vision of what the technologies and future might hold for passive dosimetry. This will include potential new requirements for Standards and calibration.

Radiation Protection Breakout Session II: Document Standards

Conformal Testing for Dosimeters against Prompt Neutron and Gamma Exposures

Dr. Chad McKee, Joint Project Leader for Radiological and Nuclear Defense; Dr. Chad Weaver, Joint Project Leader for Radiological and Nuclear Defense; Frank Andrews, SVAD, White Sands Missile Range; Dr. T. Mike Flanders, SVAD, White Sands Missile Range

Abstract: The Department of Defense has the mission not only to survive, but to operate and to win on a nuclear battlefield. For small tactical nuclear weapons (under 50 kT), the prompt radiation is one the most predominate causes of casualties, more than the blast wave and thermal (Ref. 1). Prompt neutrons result almost exclusively from the energy producing fission and fusion reactions, while prompt gamma radiation includes that arising from these reactions as well as that resulting from the decay of short-lived fission products (Ref. 1). Therefore, tactical dosimetry must accurately measure the dose from prompt events. Ensuring the dosimetry meets the

accuracy requirements is challenging because of the significant ranges of dose and spectrum, the limited number of test facilities capable of doing the tests, and the lack of rigorous traceability back to a national standard. The talk will focus on the challenges faced by the military in ensuring the accuracy of its dosimeters for such a unique radiation hazard. Reference 1. FM 8-9, NATO Handbook on the Medical Aspects of NBC Defensive Operations, 1996.

An Overview of Current US NAVY Alpha, Beta, Gamma, and Neutron Radiation Calibration Standards and the Processes Used to Ensure NIST Traceability

Keith D. Turner, P. E., NMCLANT Yorktown, VA., RADIAC Calibration Standards Program (RCSP)

U. S. NAVY Alpha, Beta, Gamma, and Neutron Radiation Detection, Indication and Computation (RADIAC) instruments and dosimetry devices require periodic calibration. The goal is to ensure both reliability and NIST traceable accuracy are evident in each calibrated RADIAC and ultimately provide end users with confidence in the device. Seven RADIAC Calibration Laboratories (RCLs) throughout the United States accomplish NIST traceable calibrations on the entire inventory of U. S. Navy RADIAC instruments. Calibrators located at each RCL are maintained and verified by the RADIAC Calibration Standards Program (RCSP) in Yorktown, VA. These alpha, beta, gamma, and neutron radiation calibrators provide data that is directly traceable to NIST. An overview of these calibrators and the processes used by the RCSP team to accomplish this goal is provided.

Pitfalls of Revising National Standards – A Portable Survey Instrument Standard (ANSI 42.17AC)

Meredith Wood, Naval Surface Warfare Center, Carderock Division

National Standards require periodic revision in order to reflect modern instrumentation characteristics and test methodologies. The revision process requires a critical eye—in addition to a thorough understanding of the original document—so that the standard can be updated to match the best practices available. Several members of the Radiation Technology Group at Naval Surface Warfare Center, Carderock Division (NSWCCD) along with representatives from commercial industry and other Government entities are developing a revised American National Standards Institute (ANSI) performance standard for radiation detection instrumentation (ANSI 42.17 AC). A discussion on the problems associated with updating a National Standard and advice for overcoming these issues will be provided within the context of the ANSI 42.17AC revision.

Tuesday March 28, 2017: Afternoon Radiation Protection Breakout Sessions

Radiation Protection Breakout Session III: Consequence Management

CDC's need for reference materials to validate analytical methods for Public Health exposure assessments after a radiological or nuclear incident

Robert Jones, Center for Disease Control

One of the key tasks of responding to a radiological or nuclear incident is the capability and capacity of rapid screening and quantitative analysis of clinical samples in order to direct short and long-term medical care. Without these rapid laboratory analytical results, exposures of health significance will likely be missed, medical treatment will be misguided and ineffective, and prevention of additional exposures will be impaired. Clinical CRMs are needed for the validation and ongoing performance testing of these analytical methods to ensure the proper estimation of radiological exposure so that the correct medical management can be applied, if needed. This will enable the decision makers to have high quality data to make sound consequence management decisions and provide for the efficient and effective use of limited medical countermeasures.

EPA's needs for radiological reference materials to support response and recovery activities following a radiological or nuclear incident

John Griggs, Environmental Protection Agency

In the event of a major radiological or nuclear incident such as multiple RDDs or an IND there will be hundreds of thousands of samples that will require laboratory analyses to protect human health and in general to support response, cleanup and monitoring activities. The samples will include typical environmental matrices such as air particulates, drinking water, waste water, soil and vegetation as well as urban matrices such as cement, brick, asphalt, etc. The demand for laboratory data to support decision making in a timely manner will be intense. Given the large number of samples involved a large number of laboratories will be called upon to analyze the samples and to provide data. It is critical that the laboratory data be both accurate, comparable, timely and defensible to support a range of response, cleanup and monitoring activities. Critical to the generation of accurate, comparable and defensible data is the availability of radiological reference materials to support method validation efforts, proficiency testing and quality control measures. It is essential that the radiological reference materials closely match the radionuclide/matrix combinations analyzed by the laboratories. In the absence of needed radiological reference materials there will be significant delays in laboratory data generation resulting in delays in decision making which could potentially negatively impact public health and result in even greater negative economic impacts due to delays in cleanup and restoration of normal operations in major cities.

An Intercomparison Study on Radiological Methods Used by FDA Food Emergency Response Radiological Laboratory Network

Stephanie Healey, Food and Drug Administration-WEAC

Proven analytical methods and a competent laboratory network are essential for the Food and Drug Administration (FDA) to implement food defense and safety measures under the Food Safety Modernization Act (FSMA). With growing risks imposed by global aging nuclear facilities and proliferation of radioactive materials, FDA faces increasing challenges in safeguarding the nation's food supply from radioactive contamination. In order to mitigate the imposing threats to food safety and public health, a radiological food emergency response network (FERN) consisting of federal and state laboratories was established. This network serves to strengthen the FDA's ability to respond to a radiological emergency. FDA's decision-making during a nuclear emergency will be based on large pools of data from diversified analytical methods. Ambiguous findings will inhibit FDA's ability to take prompt action on protecting food safety and public health. Measurement capability, data comparability, and an efficient data reporting mechanism are essential for emergency response when analytical data from cooperative laboratories are used for post-incident risk assessment and management. To evaluate different radiological methods currently used by member laboratories for food analysis, intercomparison studies were conducted using water and various food samples containing mixed several radionuclides at different radioactivity levels. This presentation details the sample preparation and verification, insightful data analysis on evaluating method performance characteristics, recommendations for developing harmonized methods for food analysis, and future needs for radiological food reference materials and standards.

Development of Rapid Liquid Scintillation Counting Method for determination of Tritium in Foods

Zhichao Lin, Food and Drug Administration-WEAC

Distillation technique was widely used as the simplest method for extraction of tritium (^{3}H) as a form of free water from various environmental, bioassay, and food samples. However, vacuum distillation of ^{3}H from foods is very time consuming and unsuitable for high throughput emergency response. This study investigated two different approaches for rapid determination of free-water ^{3}H, i.e., heating mantle distillation of food and purification of food extract by Eichrom's tritium column, followed by liquid distillation (LS) counting. A variety of fresh produce samples was spiked with ^{3}H and analyzed using the proposed procedures. For heating mantle distillation method, a total of 10 samples in each batch were distilled for approximately an hour and a half inside a radiological fume hood to further prevent the analyst from any untoward exposure to ^{3}H. Sample preparation and subsequent batch distillation process took approximately two hours for a total of 10 samples. Hence 40 samples could be prepared each day for counting. Each 8 mL sample mixed with 12 mL LS cocktail was counted for 100 minutes, well over the time required to reach the data quality objective of detection limit for ^{3}H in drinking water and food. However, for emergency response scenarios, a lower counting time would be deemed acceptable depending on the counting efficiency and background radiation level. For Eichrom's tritium column method, various food extracts were directly loaded on to the tritium column for obtaining ^{3}H counting samples. ^{3}H extracted from different food samples was determined using three different liquid scintillation spectrometers i.e., Quantulus 1220, TriCarb 3170 TR/SL, and Hidex 300 SL. Instrument settings, cocktail types, and sample parameters were studied and compared for enhancing ^{3}H analysis. Both internal and external laboratory control samples containing normal background and variable amounts of ^{3}H were analyzed to evaluate method performance characteristics. The developed method would provide an alternative approach to devise a more effective and efficient method for routine analysis and emergency response efforts.

Rapid Detection of Americium-241 in Food by Inductively-Coupled Plasma Mass Spectrometry

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The recommended intervention level for ^{241}Am in food is 2 Bq/kg (16 pg/kg) as per FDA regulatory guideline. Detection of ^{241}Am in food based on its 59 keV photon emission by gamma ray spectrometry is impractical due to high photon mass attenuation and low maximum permissible concentration. A sensitive and rapid radioanalytical method is essential for ensuring and improving food safety compliance and emergency response. A quadrupole ICPMS coupled with an Aridus II desolvation nebulizer system was applied for analyzing ^{241}Am in a wide variety of foods following a simple radiochemical separation. Quantification of ^{241}Am in food was achieved by isotope dilution technique using ^{243}Am tracer. Eichrom's DGA resin was used for separation of ^{241}Am from sample matrices and isobaric interferences after sample mineralization. A 5-fold enhanced sensitivity for ^{241}Am was achieved by using a desolvation nebulizer and optimizing ion optics for achieving maximum ion transmission. The study results showed that the method has the ability to positively detect ^{241}Am in various foods at concentration of ~1 pg/kg (0.13 Bq/kg) and to quantify ^{241}Am at 1/3 of the recommended intervention level with accuracy better than ±20%.

A Comparison of Computational Approaches for the Detection of Gamma-Emitting Radionuclides in Foods

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