Health Physics Society Midyear Meeting

"Medical Health Physics and Accelerator Dosimetry"

2013 Topical Meeting of:
Health Physics Society
(The Forty-Sixth Midyear Topical Meeting of the Health Physics Society)

Sunday 27 January - Wednesday 30 January 2013

Final Program

DoubleTree Paradise Valley Resort, Scottsdale, Arizona

S.E. INTERNATIONAL, INC.

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HPS MIDYEAR 2013

The first 50 attendees to come by our booth and mention this ad will recieve a free t-shirt!!

The Gamma PAL is a complete portable measuring system for analyzing radiation contamination in food, such as milk, meat, fish, grain, fruit, and vegetables, as well as soil, water, air and other materials. It allows users to directly and easily perform quick, reliable measurements in Bq/l or Bq/kg and identify the isotopes present in potentially contaminated material using one of three precalibrated geometries.

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- Liquid Samples
- Air Swipes
- Other Materials

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Health Physics Society Committee Meetings

All Committee Meetings are in the DoubleTree Paradise Valley Resort

Saturday 26 January 2013

FINANCE COMMITTEE
8:00 am - Noon — *Sonora*

NRRPT BOARD AND PANEL
9:00 am - 4:00 pm — *Flagstaff A&B*

HPS EXECUTIVE COMMITTEE
Noon - 5:00 pm — *Grand Presidential Parlor*

Sunday 27 January 2013

HPS BOARD OF DIRECTORS
8:00 am - 5:00 pm — *Rio Verde*

AAHP EXECUTIVE COMMITTEE
8:30 am - 5:00 pm — *Chaparral*

NRRPT BOARD AND PANEL
9:00 am - 4:00 pm — *Flagstaff A&B*

PROGRAM COMMITTEE
10:00 am - Noon — *Prescott*

Monday 28 January 2013

NRRPT BOARD AND PANEL
9:00 am - 4:00 pm — *Flagstaff A&B*

ANSI N13.1 REVISION COMMITTEE
9:00 am - 5:00 pm — *Four Peaks Room*

ANSI STANDARDS WRITING GROUP FOR ANSI N42.54
1:00 - 5:00 pm — *Saguaro Boardroom*

Tuesday 29 January 2013

NRRPT BOARD AND PANEL
9:00 am - 4:00 pm — *Flagstaff A&B*

ANSI N13.1 REVISION
9:00 am - 5:00 pm — *Four Peaks Room*

SCIENTIFIC AND PUBLIC ISSUES COMMITTEE
3:00 - 4:30 pm — *Saguaro Boardroom*

Wednesday 30 January 2013

ANSI N13.1 REVISION
9:00 am - 5:00 pm — *Four Peaks*

PROGRAM COMMITTEE
12:30 - 2:00 pm — *Prescott*

HPS Annual Meeting

Join us this summer in Madison, Wisconsin!
7-11 July 2013

HPS Annual Meeting

Call for Papers

Submission Deadline: 6 February 2013

Go to www.hps.org under Meetings to submit your abstract now!

Madison, Wisconsin 7-11 July 2013

Table of Contents

Registration Hours
Ballroom Foyer

Sunday 27 January	3:30-6:30 PM
Monday 28 January	7:30 AM-3:00 PM
Tuesday 29 January	8:00 AM-3:00 PM
Wednesday 30 January	8:00 AM-Noon

Exhibit Hours
Forum Ballroom

Monday	5:00-6:30 PM	Opening Reception
Tuesday	9:30 AM-4:00 PM	Exhibits Open
	9:45-10:15 AM	Refreshment Break
	12:00-1:30 PM	Exhibitor Sponsored Lunch
	2:30-3:00 PM	Refreshment Break
Wednesday	9:30 AM-2:00 PM	Exhibits Open
	9:45-11:15 AM	Refreshment Break
	12:30-1:30 PM	Exhibitor Sponsored Lunch

Thank you to our Sponsors:

HPS Meeting

Dan Caulk Memorial Fund

Professional Development School

Dade Moeller

Mirion Technologies

SOCIAL EVENTS

Sunday 27 January

Welcome Reception

6:00-7:30 pm **North Pool**

Plan on stopping in for the HPS Welcome Reception. There will be an opportunity to meet friends and to start your evening in Scottsdale. Cash bar light refreshments will be available.

Monday 28 January

Exhibitor Opening Reception

5:00-6:30 pm **Forum Ballroom**

Join the Exhibitors for food, a cash bar, and the latest in Health Physics equipment.

Tuesday 29 January

Complimentary Lunch in Exhibit Hall

Noon-1:30 pm **Forum Ballroom**

Wednesday 30 January

Complimentary Lunch in Exhibit Hall

12:30-1:30 pm **Forum Ballroom**

WELCOME TO SCOTTSDALE!

Scottsdale is a city of extraordinary treasures. From the rugged beauty of the sundrenched Sonoran Desert landscape and the upscale amenities, to the vibrant energy that hums through downtown both day and night, Scottsdale's many facets will intrigue, surprise and delight you. Scottsdale is home to an internationally renowned arts and culture scene with more than 100 art galleries and museums. Visitors to Scottsdale also can enjoy premier shopping, special events, beautiful year-round weather, and a multitude of outdoor adventures and activities including hot air balloon rides, off-road desert tours, horseback riding, rafting, hiking and more.

Speaker Ready Room
Prescott Room

Sunday	1:00-5:00 PM
Monday & Tuesday	8:00 AM-5:00 PM
Wednesday	8:00-10:00 AM

The 2013 Midyear Meeting
is presented by the
Health Physics Society
and co-sponsored by the
American Association of Physicists in Medicine

It is sponsored by:
the Accelerator Section of the HPS,
the Medical Section of the HPS,
and the
Arizona Joint Chapter of the HPS and AAPM

Headquarters Hotel

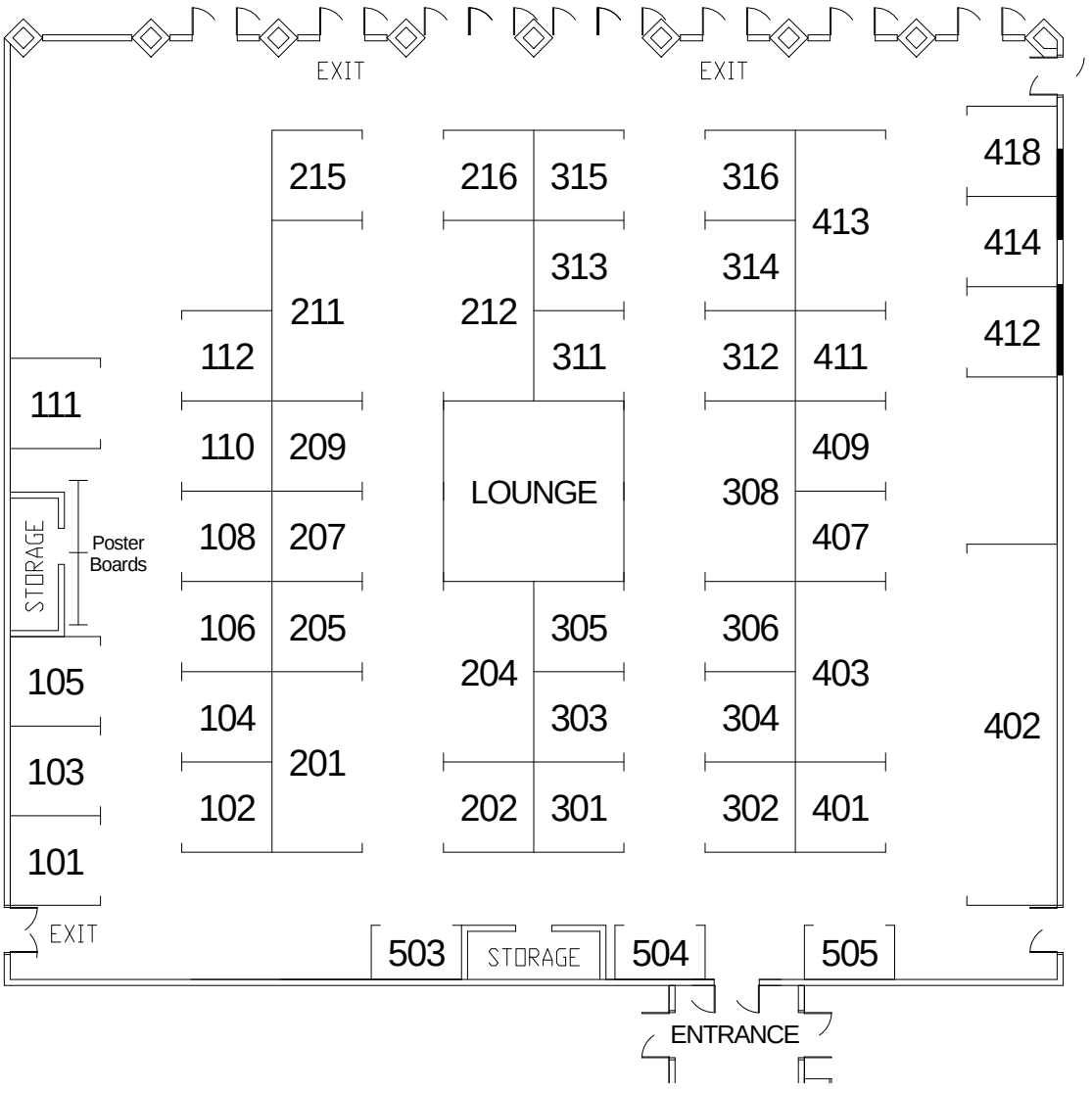
Doubletree Paradise Valley
5401 N Scottsdale Rd
Scottsdale, AZ 85250-7090
480-947-5400

2013 HPS Midyear Meeting Exhibitors

Exhibits are located in Forum Ballroom

Exhibit Hours

Monday	5:00-6:30 PM	Opening Reception
Tuesday	9:30 AM-4:00 PM	Exhibits Open
	9:45-10:15 AM	Refreshment Break/ Poster Break
	12:00-1:30 PM	Exhibitor Sponsored Lunch
	2:30-3:00 PM	Refreshment Break/ Poster Break
Wednesday	9:30 AM-2:00 PM	Exhibits Open
	9:45-11:15 AM	Refreshment Break
	12:30-1:30 PM	Exhibitor Sponsored Lunch



2013 HPS Midyear Meeting Exhibitors

Exhibits are located in the Forum Ballroom

2013 Annual Meeting **Booth: 110**
Madison, Wisconsin

2014 Midyear Meeting **Booth: 103**
Baton Rouge, Louisiana

2014 Professional Development School - **Booth: 105**
Baton Rouge, Louisiana

Ameriphysics, LLC **Booth: 401**
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Knoxville, TN 37923
800-563-7497; FAX: 865-470-4179
www.ameriphysics.com

Ameriphysics, LLC is a full service radiological and waste solutions provider. Our personnel exhibit a wide range of expertise in radiation protection, waste management and health physics consulting. From simple laboratory surveys to complex cyclotron removals and MARSSIM-based decommissioning projects; Ameriphysics has the knowledge and experience to complete your project on time and within budget.

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CANBERRA is the leading supplier of innovative and cost-effective nuclear measurement solutions and services used to maintain safety of personnel, assess the health of nuclear facilities and safeguard the public and the environment. Applications for CANBERRA offerings include health physics, nuclear power operations, Radiation Monitoring Systems (RMS), nuclear safeguards, nuclear waste management, environmental radiochemistry and other areas.

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www.ezag.com

Eckert & Ziegler Analytics supplies high quality, NIST-traceable radioactive reference and calibration sources and standardized solutions for the calibration of radiation measurement instruments. Eckert & Ziegler Analytics provides the customer service for the complete Isotrak brand product line including all reference and calibration products manufactured at Isotope Products (IPL), Analytics and Nuclitec GmbH. We operate 3 accredited calibration laboratories, 2 in the USA and one in Germany. Radiochemical performance eval-uation samples are provided quarterly for effluent and environmental monitoring programs. Isotrak products include anodized wide area reference sources and a range of instruments including the Teletector 6112B/M and RAD60/DoseGUARD dosimeter.

Energy Solutions **Booth: 403**
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Salt Lake City, UT 84101
801-649-2102; FAX: 801-413-5690
www.energysolutions.com

EnergySolutions is an international nuclear services company headquartered in Salt Lake City with operations across the United States, Canada, the United Kingdom and other countries around the world. EnergySolutions is a global leader in the safe recycling, processing and disposal of nuclear material. We provide integrated services and solutions to the nuclear industry, the United States Government, the Government of the United Kingdom, along with various medical and research facilities. EnergySolutions offers a full range of services for the decommissioning and remediation of nuclear sites and facilities, management of spent nuclear fuel, the transportation of nuclear material and the environmental cleanup of nuclear legacy sites. We're committed to reasserting America's leadership in the global nuclear industry and helping the United States and the United Kingdom countries achieve energy security in a way that reduces carbon emissions and protects the environment.

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www.fjspecialty.com

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FLIR develops leading edge radiation detection and identification devices. We offer a complete line of handheld systems ranging from small belt-worn spectroscopic pagers to large highly sensitive devices capable of rapidly locating and precisely identifying radioactive material. Our stationary, high performance identification systems can monitor and analyze possible radiation sources within seconds and are adaptable for a wide range of applications.

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Fuji Electric Corp. of America (FEA) provides a wide range of radiation monitoring instruments and system for medical facilities, national laboratories, educational institutions and nuclear facilities. Our innovative neutron survey meter is extremely light (4.40 lbs.) and much easier to carry than the conventional neutron survey meters.

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800-933-8501
www.gocorp.com

G/O Corporation is a supplier of both nuclear and industrial safety equipment. G/O provides health physics supplies, rad-waste reduction items, many custom signage and barrier products.

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Hi-Q Environmental Products Co. **Booth: 302**
7386 Trade St
San Diego, CA 92121
858-549-2820; FAX: 858-549-9657
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HI-Q Environmental Products Company has been a leading Manufacturer of Air Sampling Equipment, Systems & Ac-

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770-667-5770; FAX: 770-667-7539
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Hopewell Designs, Inc. provides systems and solutions for irradiation applications, X-ray inspection, and radiation shielding. We offer standard products and custom designs to meet our customers' requirements.

HPS Journal **Booth: 111**

HPS WebOps **Booth: 106**

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800-323-8830; FAX: 708-755-7016
www.landauer.com

Landauer, the global leader in radiation science and services, provides solutions to determine occupational, environmental and patient radiation exposure, servicing over 1.6M people. Global Physics Solutions, a wholly owned subsidiary, provides Medical Physics Services, including clinical physics support, equipment commissioning, testing, accreditation support and educational services that support the safe application of radiation for diagnosis and treatment of patients.

Laurus Systems **Booth: 414**
3460 Ellicot Center Drive, Suite 101
Ellicott City, MD 21043
410-465-5558; FAX: 410-465-5257
www.laurussystems.com

LAURUS Systems, located in Ellicott City, Maryland, is a private, 100% woman-owned small business specializing in radiation detection instrumentation, maintenance/calibration services, software, and training. LAURUS Systems is proud to present the new Rad-DX Mesh-Networked Area Monitor; the size of a smoke detector and just as easy to use. See it as well as many other new and featured instruments. All of our equipment and services are available through the GSA Advantage and HIRE Contracts

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Sweetwater, TX 79556
800-622-0828; FAX: 325-235-4672
www.ludlums.com

Ludlum Measurements, Inc. (LMI) has been designing, manufacturing and supplying radiation detection and measurement equipment in response to the worlds' need for greater safety since 1962. Throughout its 5 decade history, it has developed radiation detection technologies and instruments in support of enhancing the safety of personnel and the environment. It offers one of the largest lines of radiation detection instrumentation available from any one company.

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303-660-5247; FAX: 303-496-6000
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Mazur Instruments develops and manufactures handheld survey meters used by professionals and organizations to detect, measure and monitor nuclear radiation. Made in the USA, the company's instruments are competitively priced and offer ruggedness, high reliability, outstanding battery life, autonomous data-logging, abundant I/O, inline statistics and a multilanguage (English/Japanese) text interface.

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770-432-2744; FAX: 770-432-9179
www.mirion.com

Mirion Technologies (MGPI), Inc. provides a full range of instrumentation and engineering services for health physics and radiation monitoring systems for all nuclear facilities and civil defense markets. We are #1 in North America in electronic dosimetry. Mirion Technologies Dosimetry Services Division is a worldwide leader in radiation dosimetry services. Offering the broadest array of dosimetry products in the marketplace, under the Global Dosimetry Solutions brand, we are fully accredited through several organizations.

MJW Technical Services Inc. **Booth: 104**
243 Root Street
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Olean, NY 14760
716-372-5300; FAX: 716-372-5307
www.mjwts.com

MJW Technical Services, Inc. provides quality, timely calibrations and repairs for portable radiation detection equipment. MJWTS is the Ludlum Measurements Authorized Eastern U.S. Service Center, and SAIC Dosimeter Service Center. With our state-of-the-art calibration facility strategically located in the northeastern U.S., we can quickly and efficiently service our customers. In addition to instrument calibrations, MJWTS is a Sales distributor for RAE Systems radiological products. Please visit our website at www.mjwts.com or call toll free 1-866-300-2MJW (3659) for more information.

NRRPT **Booth: 112**
PO Box 3084
Westerly, RI 99336
www.nrrpt.org
401-637-4811; FAX: 401-637-4822

Nuclear Risk Specialists **Booth: 312**
5435 Bull Valley Road
Suite #228
McHenry, IL 60050
815-331-8272; FAX: 847-242-8178
www.nurisk.net

Nuclear Risk Specialists (NRS) operates as an insurance and risk services firm dedicated exclusively to the nuclear technology industry. NRS provides Decommissioning Surety Bonds to Materials Licensees and Professional Liability protection for Health Physicists. Details of each of these products can be found at booth 312 in the exhibit hall.

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865-483-2124; FAX: 865-425-1380
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ORTEC has over fifty years of experience providing solutions for a wide variety of Nuclear Detection Applications. Our team of highly qualified scientists and engineers is dedicated to providing measurement system solutions for Homeland Security, Waste Management, Personal Monitoring, In-Situ measurements, and Radiochemistry Laboratory Applications. Visit our booth today and allow us to assist you with your Nuclear Detection needs.

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Idaho Falls, ID 83401
888-523-5557; FAX: 208-524-8470
www.qaltek.com

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603-778-2871; FAX: 603-778-6879
www.radsafety.com

Established in 1989, RSCS, Inc. is a small business that offers expertise in all aspects of radiation safety and measurement applications. Our company specializes in operational and decommissioning services for nuclear power plants as well as for industrial, medical, and government radiological facilities. Our core services include health physics consulting, training, software, instrumentation (including design, installation, calibration, and repair), emergency planning, and specialized

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Radiation Solutions **Booth: 306**
386 Watline Ave
Missauga, ON L4Z 1X2 Canada
905-890-1111; FAX: 905-890-1964
www.radiationsolutions.ca

Radiation Solutions Inc (RSI) is a manufacturer of low level radiation detection instruments. Products include handheld nuclide identification (RIID) units, mobile systems for land vehicle, marine, airborne and stationary monitoring. Applications range from environmental, emergency response, security and geological mapping. The various systems offer Survey/Search , ID, Mapping and Directional capabilities. In addition, vehicle portal monitoring systems are also produced primarily for the scrap metal recycling industry.

RSO, Inc. **Booth: 313**
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Laurel, MD 20725-1450
301-953-2482; FAX: 301-498-3017
www.rsoinc.com

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Summertown, TN 38483-0039
800-293-5759; FAX: 931-964-3564
www.seintl.com

S.E. International, Inc. is the manufacturer of the Radiation Alert® product line offering handheld ionizing radiation detection instruments for surface and air contamination. Proven to be reliable in the environmental industry, laboratory, research, Health physics and educational fields. The Gamma PAL is a complete portable measuring system for analyzing radiation contamination in food, such as milk, meat, fish, grain, fruit, and vegetables, as well as soil, water, air and other materials.

Technical Associates **Booth: 202**
7051 Eton Avenue
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www.tech-associates.com

Recent additions to TA's Health Physics instrument line include air and area monitors, which are smarter, more sensitive and more rugged than previously available, in addition to pipe and plume and the latest advances in portables.

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Radiation detection instruments and systems used by the nuclear industry, DoE National laboratories, National and international safeguard organizations, defense and law enforcement agencies. Pioneering radiation technologies paired with state-of-the-art electronics that allow use to easily make informed decisions when evaluating radiation levels.

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Tracerco offers a range of Intrinsically Safe Radiation/ Contamination Monitors (Class 1 Division 1) that are ATEX & FM compliant to protect the workforce from exposure and environmental contaminants. Tracerco's latest technology featured is our Personal Electronic Dosemeter (PED) that can be used in potentially explosive environments such as Class 1, Div 1.

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As a provider of handheld radiation detection instruments, WB Johnson Instruments, formerly William B Johnson, is a leader in the manufacturing of the most reliable and durable radiation detection products in the industry. Since recently acquired in September 2011, the product line has been expanded to a brand new line of digital and analog survey as well as Portable and Fixed portal monitors. Check out our new line at www.jradmeters.com

Final Technical Program

If a paper is going to be presented by other than the first author, the presenter's name has an asterisk (*)

Sessions will take place in the DoubleTree Paradise Valley Resort

MONDAY

7:00-8:00 am **Four Peaks**
CEL 1 How We Make Decisions for Radiation Safety and are Prone to Errors
Ray Johnson

7:00-8:00 am **Chaparral**
CEL 2 Interpreting the Dose Index in Diagnostic Imaging
Rebecca Marsh

8:15 AM - 12:15 PM **Grand Ballroom**

MAM-A Developments in Medical/ Accelerator Technology and Regulation

Chair: Armin Ansari

8:15 am **Introductions/Welcome**
Armin Ansari, HPS President

8:30 am **Opening Remarks**
Mayor Jim Lane, Mayor of Scottsdale

8:45 am **MAM-A.1**
The Role of Risk Communication and Stakeholder Engagement in NRC Medical Policy Issues
Ostendorff, W.
US Nuclear Regulatory Commission

9:45 am **MAM-A.2**
Health Physics Society: Impacts of Recent Medical and Accelerator Developments on Staff and General Public Radiation Protection
Vetter, R.
Health Physics Society

10:15 am **BREAK**

10:45 am **MAM-A.3**
The Impact of New FDA Regulations for PET Drug Manufacturing on Radiation Protection Topics
Zigler, S., Moroney, W.
PETNET Solutions

11:15 am **MAM-A.4**
Impacts of Developments in Medical and Accelerator Technology on Regulation
Bruedigan, L.
Conference of Radiation Control Program Directors

11:45 am **MAM-A.5**
AAPM Society: Impacts of Recent Medical & Accelerator Developments on Patient Radiation Protection
Ezzell, G., Seibert, J.
Mayo Clinic Arizona, University of California, Davis

1:30 PM - 4:45 PM **Grand Ballroom**

MPM-A Issues in Diagnostic Studies

Co-Chairs: V. Morris, L. Dauer

1:30 pm **MPM-A.1**
Six Sigma and Informatics - Tools for Patient Dose Reduction
Pavlicek, W., Paden, G., Boltz, T., Tollefson, C., Panda, A.
Mayo Clinic Arizona

1:45 pm **MPM-A.2**
Six Sigma Tools for Patient Dose Reduction with PET Imaging
Paden, R., Boltz, T., Tollefson, C.
Mayo Clinic Arizona

2:00 pm **MPM-A.3**
Bismuth Shield Usage in Multi-Detector Computed Tomography (MDCT) Thoracic Scans: Organ Dose vs. Image Quality
Januzis, N., Nguyen, G., Lowry, C., Yoshizumi, T.
Duke University

2:15 pm **MPM-A.4**
Statistical Approach to Medical Image Errors Analysis
Aceil, S.
Alcorn State University

2:30 pm **MPM-A.5**
Measurements of CT Exposure Doses during Diagnostic Whole Body PET/CT Scans in a Hospital
Lai, Y.C., Chen, Y.W., Lee, C.S.
Kaohsiung Medical University, Kaohsiung Medical University Hospital

2:45 pm **BREAK**

3:15 pm **MPM-A.6**
Radiation Safety and Regulatory Issues for Development of a Radioactive Seed Localization Program
Sheetz, M., Steiner, C., Mannella, K.
University of Pittsburgh

3:30 pm **MPM-A.7**

Radiation Safety Issues for Use of an Automatic Injector for Epilepsy Ictal Brain SPECT

Mannella, K., Steiner, C., Sheetz, M.
University of Pittsburgh

3:45 pm **MPM-A8**

Monitoring Computed Tomography Examinations for Radiation Dose Control and Quality Assurance

Paden, R., Pavlicek, W., Boltz, T., Loprino, S., Wellnitz, C., Hara, A., Kriegshauser, J., Mango Kaiser, J., Leyk, L., Ledoux, E.
Mayo Clinic

4:00 pm **MPM-A.9**

VA Initiative for Radiation Safety in Medical X-ray Imaging

Huston, T., Burkett, D., Williams, G., Leidholdt, E., Anderson, C.
US Department of Veterans Affairs

4:15 pm **MPM-A.10**

Correlation of Digital Mammography Compression Force, Patient Pain Threshold, and Image Quality

Peter, M., Panda, A., Pizzitola, V., Pavlicek, W.*
Mayo Clinic, Arizona

4:30 pm **MPM-A.11**

Finalizing Radiation Protection Guidance for Diagnostic and Interventional X-Ray Procedures

Keith, L., Sears, S., Hamdy, R., Leidholdt, E., Miller, D., Paunovich, E., Torring, E., Bower, M., Boyd, M., Fletcher, D.
DHHS, ATSDR, US Navy, Department of Veterans Affairs, Food and Drug Administration, US Army, Environmental Protection Agency

5:00-6:30 pm **Forum**

Exhibitor Opening Reception

Be sure to stay and see
TPM-C Special Presentation
by the Dade Moeller Lecturer,
Lawrence Krauss

Tuesday
6:00-8:00 pm
Grand Ballroom

TUESDAY

7:00-8:00 am **Grand Ballroom**

CEL 3 The Current FDA Regulation of Radioactive Drug Products Used for Positron Emission Tomography

Dennis Swanson

7:00-8:00 am **Chaparral**

CEL 4 How to Detect and Suppress Fuel Failures at Boiling Water Reactors

Joshua Vajda

9:45 AM, 2:30 PM **Forum**

Poster Session

Stop by the Forum during coffee breaks to talk with the authors about their posters

P.1 Behavioral Monitoring Methods For Fluoroscopy ALARA Programs

Boltz, T.F., Pavlick, W., Paden, R.G.
Mayo Clinic Arizona

P.2 Just In Time Training Reminders For Fluoroscopy Safety

Jones, S., Bushberg, J., Kroger, L., Seibert, J., Boone, J., Leidholdt, E.
University of California, Davis Health System, Veterans Health Administration National Health Physics Program

8:15 AM - 12:00 PM **Grand Ballroom**

TAM-A Issues in PET/Cyclotron & cGMP Part 1

R. Moroney, D. Banghart

8:15 am **TAM-A.1**

Current Challenges in Radiation Protection For Production of PET Radiopharmaceuticals

Moroney, W., Krueger, D.
Siemens

8:30 am **TAM-A.2**

PET Cyclotron Contamination Hazards from Routine Target Maintenance

Banghart, D., Rostel, E.
Stanford University

8:45 am **TAM-A.3**

New ISO Standard - Monitoring Emmissions of Radioactive Gas From Medical PET Cyclotron Facilities

Rivers, J.
Lab Impex Systems Inc

9:00 am **TAM-A.4**

NRC Experience in Licensing Cyclotrons under the Energy Policy Act - 'Licenses for Production of Radioactive Material Using an Accelerator'

Null, K., Roldan, L., Ullrich, E.
USNRC Region III, USNRC Region IV, USNRC Region I

9:15 am **TAM-A.5**

NRC Experience in Licensing and Inspection of Commercial Radiopharmacies that Distribute Accelerator-Produced Radiopharmaceuticals

Null, K., Roldan, L., Ullrich, E.*
USNRC Region III, USNRC Region IV, USNRC Region I

9:30 am **TAM-A.6**

NRC Financial Assurance Requirements for Licenses for Production of Radioactive Material Using an Accelerator

*Null, K., Roldan, L., Ullrich, E.**
USNRC Region III, USNRC Region IV, USNRC Region I

9:45 am **BREAK IN EXHIBIT HALL**

10:15 am **TAM-A.7**

Implementation of Current Good Manufacturing Practices (cGMPs) for the Submission of Abbreviated New Drug Applications (ANDAs) for PET Radiopharmaceuticals

Soffing, M., Divgi, C., Koren, A., Wills, E., Akhtiorskaya, Y.
Columbia University

10:30 am **TAM-A.8**

Obtaining NRC License for Cyclotron Production in a University Setting

Langhorst, S.M.
Washington University in St. Louis

10:45 am **TAM-A.9**

Health Physics & Medical Physics: A Common Purpose

Kennedy, Jr., W., Merwin, S., Vaughan, J., Barry, T.
Dade Moeller, Physics Services, Inc.

11:00 am **TAM-A.10**

Occupational Exposure of PET Radiopharmacy Staff: A Case Study

Gillenwalters, E., Kinne, C.
Ameriphysics, LLC, Triad Isotopes, Inc

11:15 am **TAM-A.11**
Measurement of Collection Efficiency in Activated Charcoal Cartridges for Air Samples of Volatile F-18 Releases from PET Radiopharmaceutical Manufacturing
Krueger, D.
PETNET Solutions, Inc.

11:30 am **TAM-A.12**
Positron Emission Tomography Radiotracer Production in Clinical Research and United States Pharmacopeia <823>
Mason, N.S., Kendro, S.E., Mathis, C.A.
University of Pittsburgh

11:45 am **TAM-A.13**
Radiation Safety Issues with At-211 Production at the NIH Cyclotron Facility
*Roberson, M.P., Hull, S.L.**
National Institutes of Health

Noon - 1:30 pm **Forum**

Complimentary Lunch for Registered Attendees

1:30 PM - 2:15 PM **Grand Ballroom**

TPM-A Issues in PET/Cyclotron & cGMP Part 2

Co-Chairs: M. Williamson, S. Konerth

1:30 pm **TPM-A.1**
The Radioactive Drug Research Committee Approval Process for Basic Research Studies Involving Non-Approved Radioactive Drugs, Part I
Swanson, D.P.
University of Pittsburgh

1:45 pm **TPM-A.2**
Activity Thresholds for Patient Instruction and Release for Positron Emission Tomography Radionuclides
Williamson, M., Dauer, L.
Memorial Sloan-Kettering Cancer Center

2:00 pm **TPM-A.3**
The Radioactive Drug Research Committee Approval Process for Basic Research Studies Involving Non-Approved Radioactive Drugs, Part II
Swanson, D.P.
University of Pittsburgh

2:30 pm **BREAK IN EXHIBIT HALL**

3:00 PM - 4:15 PM **Grand Ballroom**

TPM-B Issues in Radiation Transport Codes and Shielding

Co-Chairs: K. O'Brien, R. Metzger

3:00 pm **TPM-B.1**
Layered Shielding in PET Clinics
Metzger, R., Van Riper, K.
RSE, Inc, White Rock Science

3:15 pm **TPM-B.2**
Dose to Non-Targeted Tissues of the Eye During Stereotactic Radiosurgery
Cantley, J., Chell, E., Hanlon, J., Bolch, W.
University of Florida, Oraya Therapeutics, Inc.

3:30 pm **TPM-B.3**
Attenuation Evaluation of 0.5 and 0.75mm Lead Protective Glasses
Snyder, D., Young, L., Yorks, P., Simpson, D., Wieand, E.*
Geisinger Health System, Bloomsburg University of Pennsylvania

3:45 pm **TPM-B.4**
Experience with Electrodeposited Cf-252 Ion Sources
Baker, S., Butala, S., Greene, J., Levand, A., Moore, E., Pardo, R., Savard, G.
Argonne National Lab

4:00 pm **TPM-B.5**
Evaluation of Shielding for a Proton Treatment Room by Monte Carlo Calculations
Van Riper, K.A., Moyers, M.F.
White Rock Science, Consultant

6:00 PM - 8:00 PM **Grand Ballroom**

TPM-C Special Presentation: The Interface Between Elementary Particle Physics and Cosmology

Chair: Armin Ansari

6:00 pm **TPM-C.1**
Life, the Universe and Nothing...A Cosmic Mystery Story
Krauss, L. (Dade Moeller Lecturer)
Arizona State University

WEDNESDAY

7:00-8:00 am **South Ballroom**
CEL5 Achieving & Maintaining Compliance - a PET cGMP Primer
Mark Soffing

7:00-8:00 am **North/Center Ballroom**
CEL6 ANSI N43.1 - Radiation Safety for the Design and Operation of Particle Accelerators
Scott Walker

8:15 AM - 10:45 AM **North/Center Ballroom**

WAM-A Role of the RSO

Co-Chairs: S. King, D. Elder

8:15 am **WAM-A.1**
Developing a Partnership Between Radiation Safety and Risk Management
Elder, D., Stephens-Wallman, L.
University of Colorado Hospital, University of Colorado Denver

8:30 am **WAM-A.2**
Mutual Benefits of a Health Physics Presence in a Radiation Therapy Department
Erdman, M.C., King, S.H.
Penn State Hershey Medical Ctr

8:45 am **WAM-A.3**
Replacement of a Gamma Knife Radiotherapy Treatment Unit
Erdman, M.C., King, S.H.
Penn State Hershey Medical Ctr

9:00 am **WAM-A.4**
Radiological Safety Lessons Learned Associated with the Therapeutic Use of Yttrium 90
Mis, F.
Universtiy of Rochester, Rochester, NY

9:15 am **WAM-A.5**
Challenges with US Food and Drug Administration (FDA) Oversight Matters at a Positron Emission Tomography (PET) Cyclotron Research Center
Stemen, T.
Yale University

9:30 am **WAM-A.6**
A Primer on Written Directives and the Curious Case of Three Non-Medical Events
Banghart, D., Kwofie, J.
Stanford University

9:45 am **WAM-A.7**
Why Medical Patients Accept the Words 'Deadly Radiation' as the Truth
Johnson, R.H.
Radiation Safety Counseling Institute

10:00 am **WAM-A.8**
Magnetic Resonance Safety: A Health Physics Approach
Quinton, A.
Geisinger Health System

10:15 am **WAM-A.9**
Shielding Considerations and Challenges Associated with Relocation of Gamma Knife Unit to a New Facility
Strzelczyk, J., Henderson, J.
Rocky Mt Gamma Knife, LLC

10:30 am **WAM-A.10**
That's a Do Over-Evaluating Repeats, Rejects and Misdministration in Nuclear Medicine
Mozzor, M., Gerard, P., High, M.
NYMC/Westchester Medical Center, Westchester Medical Center

10:45 am **BREAK**

8:15 AM - 12:30 PM **South Ballroom**

WAM-B Emerging Issues in Accelerator and Medical Physics

Co-Chairs: M. Grissom, M. Bues

8:15 am **WAM-B.1**
A Review of Staff Radiation Protection Issues for Electron, Proton, and Heavy Ion Accelerators
Grissom, M.
MPG—HP, Inc.

8:45 am **WAM-B.2**
Conventional PTV-Based Optimization Lacks Robustness for IMPT Head & Neck (H&N) Planning
Liu, W., Frank, S., Li, X., Zhu, R., Mohan, R.
MD Anderson Cancer Center

9:00 am **WAM-B.3**
National Laboratory Qualification Program
Voss, J.
Voss Associates

9:15 am **WAM-B.4**
Dose Calibrators - How Low Can You Go?
Williamson, M., Dauer, L.
Memorial Sloan-Kettering Cancer Center

9:30 am **WAM-B.5**
A Low-Dose-Rate Environment for Biological Samples
Uhlemeyer, J., Bi, R., Ford, J., Perez, D.
TAMU

9:45 am **BREAK**

10:15 am **WAM-B.6**
Photo-Nuclear Production of Ac-225
Rane, S., Starovoitova, V., Harris, J.
Idaho State University

10:30 am **WAM-B.7**
Safety Systems and Event Reporting in Radiation Therapy
Ezzell, G.
Mayo Clinic Arizona

10:45 am **WAM-B.8**
Assessment of Timer Error of a Small Animal X-Ray Irradiator: Derivation of the Ramp-up Exposure and Stable Exposure Rate
Wang, C., Yoshizumi, T.
Duke University

11:00 am **WAM-B.9**
Development of a Computational Eye Model for Use with Whole-Body Phantoms
Rhodes, A., Fiedler, D., Caracappa, P.
Rensselaer Polytechnic Institute

11:15 am **WAM-B.10**
Preventing Y-90 Microsphere Medical Events
Gates, V.L., Pflug, M., Salem, R.
Northwestern Memorial Hospital

11:30 am **WAM-B.11**
Experiences Building an In-House Supercomputing Cluster for Monte Carlo Particle Transport Code
McBeth, R., Oertli, D., Johnson, T., Brandl, A.
Colorado State University

11:45 am **WAM-B.12**
Publishing in Health Physics and Operational Radiation Safety
Ryan, M., Little, C., Ryan, M.G., Baker, D.
HPS Journal

12:00 pm **WAM-B.13**
A New Method of Reducing the Patient Dose Equivalent from Photoneutrons Produced by High Energy Medical Linacs
Hashemi, S., Raisali, G., Jafarizadeh, M., Taheri, M.
Agricultural, Medical and Industrial Research School, Radiation Applications Research School, Atomic Energy Organization of Iran

12:15 pm **WAM-B.14**
Evaluation of Neutron Contamination on the Patient Plane of Three Linac Using Three Passive Techniques
Badreddine, A.W., Imatoukene, D., Ait-ziane, M., Mebhah, D., Yennoun, A., Hattali, B., Lounis-Mokrani, Z., Boucenna, A.*
Nuclear Research Centre of Algiers, Algiers, Mohamed Essighir Nekkache Hospital, Algiers, Anti-Cancer Center, Ferhat Abbas University, Setif

11:15 AM - 12:00 PM **North/Center Ballroom**

WAM-C Issues in Brachytherapy and Radionuclide Therapy

Co-Chairs: J. Nunn, S. Saparetto

11:15 am **WAM-C.1**
Experiences in Establishing and Managing an I-131 MIBG Therapy Program
Lorenzen, W., Walsh, M., Liddle, C.
Boston Children's Hospital

11:30 am **WAM-C.3**
Anatomy of Stanfordís Yttrium-90 Microsphere Program
Amoroso, L., Kwofie, J.
Stanford University

11:45 pm **WAM-C.4**
Discriminal Analysis of the Total Scatter Factor in Water Phantom for Photon Dose Calculation Using the Eclipse Treatment Planning System
Al-Ayed, M., Moftah, B.
King Saud University, Saudi Arabia

12:30 - 1:30 pm **Forum**

Complimentary Lunch for Registered Attendees

Continuing Education Lectures

CELs take place in the DoubleTree Resort Paradise Valley

Monday 28 January 7:00-8:00 am

CEL1 How We Make Decisions for Radiation Safety and are Prone to Errors

Ray Johnson

Have you found yourself puzzled by people's decisions and reactions about radiation? Have you felt that their decisions were not rational or based on any real understanding of radiation risks? How much do workers or the public really know about radiation risks when they express concerns for radiation safety? Are you willing to accept that radiation fears are OK, when the basis of those fears seems to be mythology which is not technically defensible? Psychologists tell us that all feelings (fears) are OK. We have survived as a species by paying attention to our fears. While our subconscious minds are programmed from birth for certain universal fears, such as fear of the dark, heights, snakes, spiders, closed spaces, and submersion, we are not naturally programmed for fear of radiation. However, we seem to be in an era where radiation fears are instinctive. Perhaps hearing repeatedly about "deadly radiation" our subconscious minds have included radiation along with snakes and spiders. Our programmed response to imminent physical dangers is to fear first and think second. While an instinctive immediate reaction is appropriate to avoid a striking snake, this response mechanism does not do well for issues such as radiation safety. However, studies in neurosciences are showing that we have learned how to make decisions and cope with dangers for which we have little understanding. The author, David Ropeik, describes Bounded Rationality as our approach to making decisions when we do not have all the data, time to acquire more data, or the intellectual ability to process the data. Ropeik shows that we are constantly making judgments without perfect knowledge, but doing the best that we can at the time. We process, sort, compare, categorize, and analyze information in relation to our immediate circumstances, experiences, and life factors, such as health, wealth, traditions, and lifestyles. With all these inputs we can come up with instant judgments. Such quick judgments are crucial to our survival. However, because they are based upon limited information, these decisions may not always be best for us in the long run.

CEL2 Interpreting the Dose Index in Diagnostic Imaging

Rebecca Marsh

There is an increased interest in monitoring the radiation dose patients receive from diagnostic imaging exams, particularly in Computed Tomography (CT) and interventional procedures performed under X-ray guidance. When an imaging exam is performed, the system reports a dose index. While this information can be valuable in assessing the risk associated with an imaging exam, there is often confusion about how these metrics relate to patient dose and how this information can be used when making decisions about patient care.

This presentation will discuss the dose metrics most commonly reported in CT – the Computed Tomography Dose Index (CTDI) and Dose Length Product (DLP) – and those most commonly reported in interventional X-ray procedures, including Air Kerma and Dose Area Product. The relationship between these values and patient dose will be discussed, along with how these values relate to the risk of stochastic and deterministic effects. Also discussed will be the role of the Physicist in working effectively to help clinicians use these metrics when making decisions regarding patient care and follow-up.

Tuesday 29 January 7:00-8:00 am

CEL3 The Current FDA Regulation of Radioactive Drug Products Used for Positron Emission Tomography

Dennis Swanson

The U.S Food and Drug Administration (FDA) has recently issued regulations specific to the regulatory approval processes and manufacturing of radioactive drug products used for Positron Emission Tomography (PET). Effective June 12, 2012, all PET drug products sold commercially or prepared within a medical facility for clinical (i.e., patient care) use must be manufactured in accordance with the PET cGMP regulations at 21 CFR Part 212, and the respective production facility must register with the FDA and submit a New Drug Application or Abbreviated New Drug Application for the PET drug product. Medical facilities that purchase PET drug products from an external vendor for subsequent clinical use should obtain documentation from the vendor that these requirements have been addressed. The submission of a corresponding Investigational New Drug (IND) application or, when applicable, approval by a FDA-registered Radioactive Drug Research Committee (RDRC; 21 CFR Sec. 361.1) is required for PET drug products being used or evaluated in human research studies; unless the PET drug product is currently FDA-approved for commercial marketing and its research evaluation for an "off-label" use meets the FDA regulatory criteria (21 CFR Sec. 312.2(b)(1)) for an IND exemption. Non-approved PET drug products being used or evaluated under an IND application or

RDRC approval must be manufactured in compliance with either the PET cGMP regulations or United States Pharmacopeia (USP) Chapter , "Positron Emission Tomography Drugs for Compounding, Investigational, and Research Uses". With enactment of these regulations, the "compounding" of PET drug products under the practices of pharmacy and medicine should be limited to only special circumstances such as temporary non-availability of the FDA-approved product or the need to modify the FDA-approved drug product to address concerns (e.g., allergy to a certain component of the approved drug product) related to a specific patient.

CEL4 How to Detect and Suppress Fuel Failures at Boiling Water Reactors

Joshua Vajda

The primary responsibility of all nuclear utilities is to protect the fuel and preserve fuel integrity. It is important to know what factors affect fuel integrity and how these factors can be controlled. Operators must be able to determine if fuel integrity has been compromised, how to determine the location of failed fuel, and how to minimize further degradation of the fuel defect. This presentation will detail how to identify a fuel failure, the methods used to identify the location in the reactor core of the failure, and methods used to minimize degradation and spread of radioactivity throughout the plant.

Wednesday 30 January 7:00-8:00 am

CEL5 Achieving & Maintaining Compliance - a PET cGMP Primer

Mark Soffing, Columbia University Medical Center

The FDA's regulatory authority over PET radiopharmaceuticals was solidified with the passing of June 12, 2012. The FDA's regulation of PET Drugs is the result of over 20 years of consideration of the issue. FDA actions reflect the increasing numbers of PET drug production facilities and PET imaging facilities. More specifically, commercial PET Drug --- all FDG, NaF and NH3---manufacturers MUST register and file NDAs or ANDAs for these compounds. While the FDA has established product-specific cGMPs for other industries—thermally processed low-acid foods in hermetically sealed containers and acidified foods—this is the Agency's first foray into type-specific drug cGMPs.

Today's session identifies PET establishment requirements and appropriate efforts to implement them by addressing the issue of regulatory compliance. This session will discuss preparations that your facility can take to make your operations and processes more capable of fulfilling FDA expectations. Furthermore, we will move into how the staff can prepare themselves for FDA visit through a simple self-auditing method. Finally, we will review some common and recent audit observations, referred to as 483s

Outline

1. Review the Quality Systems expectations from the FDA perspective and suggest approaches to meet them
2. Explain how to be prepared for an FDA visit
3. Understand some areas that the FDA has focused during recent site visits

CEL6 ANSI N43.1 - Radiation Safety for the Design and Operation of Particle Accelerators

Scott Walker

The CEL for ANSI N43.1 is an overview of the recently approved Accelerator Safety document that replaces the 1985 version of the standard. Each section of the new standard is highlighted as well as the five Appendixes. Several new sections were added that were not included in the old standard. These include: Radiation Safety Program, Radiation Safety System, Access Control System, Radiation Control System and Accelerator Operations. The Appendixes address: Development of Safety Assessment Document (SAD), Interlocked-Type Access Control Systems, Decommissioning Program, Measurements of Radiation and Radioactivity, and Safety Standards for Commercially Available and/or Production-Type Accelerators. The last appendix is normative (not optional) and was written to summarize the requirements for small industrial accelerators.

MAM-A.1 The Role of Risk Communication and Stakeholder Engagement in NRC Medical Policy Issues

Ostendorff, W.C.; US Nuclear Regulatory Commission; Andrea.Kock@nrc.gov

The Commissioner will provide his regulatory philosophy and perspectives on current NRC medical policy issues, including the release of patients treated with I-131 and the ongoing revisions to 10 CFR 35. The focus of his presentation will be the importance of risk communication, education, and engagement of stakeholders on these policy issues. Current NRC activities in the area of risk communication and education and the role of the NRC and the HPS in enhancing current practices will be discussed.

MAM-A.2 Health Physics Society: Impacts of Recent Medical and Accelerator Developments on Staff and General Public Radiation Protection

Vetter, R.J.; Health Physics Society; rvetter@mayo.edu

Utilization and sophistication of medical radiation devices and radiopharmaceuticals continue to evolve at a rapid pace resulting in new and often increasing opportunities for radiation exposure of medical staff, patients, and the public. At the same time the International Commission on Radiological Protection has recommended a decrease in radiation exposure limits. Not everyone agrees on the level of risk from low doses of radiation; thus, some experts disagree on the benefit/risk of exposure and on radiation limits. The Health Physics Society has developed a number of positions that address radiation protection of staff and the general public. The procedure for development of positions and position papers will be reviewed. This presentation will include a brief discussion of several of the position papers issued by the Health Physics Society, which address risk from low doses of radiation and protection of staff and the public from medical radiation sources.

MAM-A.3 The Impact of New FDA Regulations for PET Drug Manufacturing on Radiation Protection Topics

Zigler, S., Moroney W.; PETNET Solutions; steve.zigler@petnetsolutions.com

With the Food and Drug Administration's (FDA) implementation of 21 CFR 212, Current Good Manufacturing Practices (CGMP) for Positron Emission Tomography (PET) Drugs, the production of PET drugs has moved from compounding under the practice of pharmacy according to United States Pharmacopeia (USP) standards to drug manufacturing under FDA oversight. This change impacts radiation protection professionals in several ways, mostly as the subject matter experts in radiation detection instrumentation used for manufacturing and quality control testing, as well as Authorized User (AU) qualifications for radioactive materials licenses. For example, dose calibrators, which are used to assay unit doses dispensed to patients and thus subject to Nuclear Regulatory Commission (NRC) regulations in 10 CFR 32.72(c), are now also used for important assays during the PET drug manufacturing process. The FDA requirements in 21 CFR 212.60(e) state that equipment "…must be suitable for its intended purposes and capable of producing valid results." Thus, dose calibrators must meet requirements in both regulations. The change from the practice of pharmacy to drug manufacturing also affects the staffing model in PET drug manufacturing sites. For example, 21 CFR 212.10 requires "…personnel with the necessary education, background, training, and experience to perform their assigned functions." This allows for the supervision of drug manufacturing activities outside the scope of nuclear pharmacy. Thus, in addition to the existing utilization of Authorized Nuclear Pharmacists, this change creates the possibility of non-pharmacists as AU's to supervise the use of radioactive materials in the manufacturing of drugs for human use. These topics and others will be presented along with potential solutions.

MAM-A.4 Impacts of Developments in Medical and Accelerator Technology on Regulation

Bruedigan, L.; Conference of Radiation Control Program Directors; lisa.bruedigan@dshs.state.tx.us

Changes in the technology, diagnostic and therapeutic capabilities, and computer software of radiation machines, as well as the development of mixed modality machines, have brought about the need for consistent and appropriate radiation safety standards for the new modalities and technological advancements. Most radiation machines are regulated at the state level rather than federal level. In order to promote consistency and save scarce state and local resources, the Conference of Radiation Control Program Directors (CRCPD) provides regulatory tools to radiation control programs to address emerging issues and rapidly changing technologies. These include model state regulations addressing the use of diagnostic and therapeutic radiation machines and accelerators, and credentialing of users and operators. In addition CRCPD provides white papers to address emerging issues and

newer technologies, inspection guidance, and training of regulatory personnel on the new modalities. Some states in which newer accelerator and mixed modality units are introduced earlier than other states have, out of necessity, modified their regulations and inspection guidelines to address the use of these devices. In some instances, these have formed a basic model for other radiation programs to follow. Approaches to development of up-to-date consensus regulations and radiation safety guidelines for medical and accelerator technologies are discussed.

MAM-A.5 AAPM Society: Impacts of Recent Medical & Accelerator Developments on Patient Radiation Protection

Ezzell, G.A., Seibert, J.A.; Mayo Clinic Arizona, University of California, Davis; ezzell.gary@mayo.edu

AAPM primarily focuses on the use of radiation for medical treatment and imaging. Advances in treatment technology have allowed a reduction in unwanted dose delivered to healthy tissues. Intensity modulated and image guided radiotherapy with photon beams have become the standard of care for many treatments and reduce unwanted dose by permitting the reduction of margins. Proton radiotherapy reduces the unwanted dose more dramatically by eliminating downstream dose; scanning proton beams also reduce upstream dose compared to scattered beams. All of these advances reduce long term complications, including the development of secondary malignancies. On the imaging side, technological advances including digital imaging, iterative and time of flight reconstruction techniques, and PET detector enhancements provide better images with reduced dose. Dose reduction in imaging also requires providers and patients to make informed choices. AAPM is working with other societies to reduce the radiation dose used for imaging through the Image Gently and Image Wisely initiatives, dose summits, and recommended CT protocols.

MPM-A.1 Six Sigma and Informatics - Tools for Patient Dose Reduction

Pavlicek, W., Paden, G., Boltz, T., Tollefson, C., Panda, A.; Mayo Clinic Arizona; pavlicek.william@mayo.edu

Six Sigma quality improvements are made possible with the introduction of software applications coupled to patient dose related informatics. The basics of Six Sigma and selected examples are given to show the use of the Define, Measure, Analyze, Improve and Control (DMAIC) process. While the defined Six Sigma approach (3.4 defects per million) is well known and implemented in many industries, the DMAIC approach has only recently been applied to patient dose prescriptions. Fundamental to the success in lowering patient dose is the compelling need to establish standards of dose for the intended diagnostic use, restrict the variability of the prescription of dose to that which is desired and to fully understand the basis of non-ideal results. Newly available software informatics provides the tools to accomplish this in everyday complex medical care. Examples are provided of Six Sigma use.

MPM-A.2 Six Sigma Tools for Patient Dose Reduction with PET Imaging

Paden, R.G., Boltz, T., Tollefson, C.; Mayo Clinic Arizona; pavlicek.william@mayo.edu

Diagnostic PET imaging with F-18 can be a technical challenge with the potential for higher than expected patient and technologist exposures. The basic elements of SIX SIGMA, employing the DMAIC prinicples were used in analysis of the expected sources of patient and operator exposures. A new facility was developed using DMAIC analysis of an existing outside mobile PET facility with the goal of optimizing patient flow and reduced dose prescription. The result of this effort demonstrated that reduced prescription of F-18 is possible when the delivery system allows consistent quantities of prescribed radioactive F-18. Room shielding, spatial positioning of uptake, bathroom and scan room collectively reduce variability in patient dose which controls technologists exposure.

MPM-A.3 Bismuth Shield Usage in Multi-Detector Computed Tomography (MDCT) Thoracic Scans: Organ Dose vs. Image Quality

Januzis, N., Nguyen, G., Lowry, C., Yoshizumi, T.; Duke University; naj@duke.edu

To study Bismuth (Bi) shielding for the breast, organ dose and image quality were compared under the following conditions: (1) tube current modulation (TCM), (2) TCM with a Bi shield placed after topogram, and (3) manually reduced tube current (RTC) with no Bi. All measurements were performed with a 64-slice scanner at 120 kVp. Organ dose was measured with MOSFETs using an adult male anthropomorphic phantom with supine breast attachments. The reference exposure and reduced exposure (with 4-ply Bi shield) were measured with an ion chamber located at the level of the breast. The reference tube current (mA) was the average mA across 22 slices in the z-axis at the location of the breasts. The mA was reduced by normalizing the reference mA to the ratio of the reduced exposure to the reference exposure. Image quality was measured using a high contrast insert placed in the

lung. Regions of Interest (ROIs) were drawn in thoracic organs to measure signal-to-noise ratio (SNR), percent contrast (%Contrast), noise, and HU values. Organ doses (mGy) for the three scans (TCM, TCM with Bi, and RTC) were 11.1, 6.89, and 6.04 to the breast; 8.83, 8.01, and 7.62 to the lung; and 8.20, 7.36 and 8.40 to the heart, respectively. HU increase was greatest in the TCM with Bi scan for organs closest to the shield. The SNRs were 37.6, 34.1, and 43.3 and the %Contrast values were 349.2, 326.3, and 354.3 for TCM, TCM with Bi, and RTC, respectively. For thoracic CT, this RTC method provides a dose reduction to the breast similar to that of the TCM with Bi. Some organs located in thinner sections of the body (i.e. thyroid and thymus) experienced an increase in dose for the RTC scan due to the constant mA across the entire scan. Decrease in SNR and %Contrast in the TCM with Bi scan was expected due to decrease in photons reaching the detectors and beam hardening from the shield, respectively. Increased SNR in RTC scan was due to the increased mA compared to TCM scan at the level of measurement.

MPM-A.4 Statistical Approach to Medical Image Errors Analysis

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Medical imaging has been viewed as the window to the body, but, no window reveals everything. The process of medical image, as a means of pathological diagnoses, involves three major steps; image preparation, image viewing conditions, and the performance of the observer. To have quality in this process, the three stages of quality namely quality of organization, quality of process and quality of performance are the requirements. The quality of a medical image is determined by the imaging method, the characteristics of the equipment, and the imaging variables selected by the operator. Image quality is not a single factor but a composite of at least five factors: contrast, blur, noise, artifacts, and distortion. The relationships between image quality factors and imaging system variables are complex and often confounded. Contrast can be verbalized as the difference in light intensities, or colors in the image. It is considered the most fundamental characteristic of an image. There are many systematic and random sources of error in image noise, and their amount depend on many factors including imaging method.(1,2,3) The known sources of errors are stochastic in nature and follow the rules of statistics and even could be simulated using Monte Carlo techniques. Using statistical approach, the root mean square of errors can be determined by computing the standard deviation for each factor in the parameters error space. The image error then will be computed by Erms = [ƒÃni=ƒ¡ƒãi2]1/2.

MPM-A.5 Measurements of CT Exposure Doses during Diagnostic Whole Body PET/CT Scans in a Hospital

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Whole body CT exposure doses during diagnostic PET/CT scans have been directly measured in our hospital by using a water phantom and vintage pocket dosimeters. Total radiation body burden associated with PET/CT scans consist of a PET scan internal dose that is evaluated by the positron-emission radiopharmaceutical administered and a whole body external CT scanner dose that is mostly affected by the X-ray instrument settings (e.g. shown in CTDIvol values). In this measurement study, various pocket dosimeters (Stephen¡¦s) have been selected and cross-calibrated that all have accuracies of less than 7% at full scale reading. The isotopic cross-calibration was conducted by using a Tc-99m reference source (E□×ƒnat 140 keV) in a calibration fixture and a certified pressurized ion chamber. The selected pocket dosimeters would have to add a lead-tubing attenuator, thickness of 0.81 mm, to optimize the integral dose for a maximum on-scale reading. The Pb-tubing attenuation coefficient is determined previously with another less sensitive pocket dosimeter (Bendix) by using an identical CT exposure configuration during the experiments. The routine adult PET/CT whole body diagnostic exams in our hospital use the following settings: 140 kVp, 80 mA, 105 cm and 18 seconds for the CT X-ray high voltage, current, scan length and exposure time, respectively. During the CT dose measurement tests, three Pb-shielded pocket dosimeters are masking-taped around the surface of the water phantom (20 cm OD x 21 cm), with 120 degree separation from each other, to simulate the patient CT whole body exposure. Based on 10 test runs, the CT dose per scan is then calculated to have an average value of 5.2 +/- 0.4 mSv. The overall quadrature sum uncertainty is estimated to be about 15% that includes a Tc-99m isotopic cross-calibration error (+/- 5.5%) and the Pb-attenuation factor uncertainty (+/- 10.6%).

MPM-A.6 Radiation Safety and Regulatory Issues for Development of a Radioactive Seed Localization Program

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Advances in screening mammography have led to the increased detection of microscopic breast lesions. The traditional method of localizing non-palpable lesions for surgical excision is Wire Localization Breast Biopsy (WLBB). Utilization of the Radioactive Seed Localization (RSL) technique, developed over 10 years ago, is increasing with studies showing clinical benefits of RSL over WLBB. RSL is regulated under 10 CFR 35.1000 or the equivalent Agreement State regulations. The Nuclear Regulatory Commission (NRC) has issued licensing guidance "I-125 and Pa-103 Low Dose Rate Brachytherapy Seeds Used for Localization of Non-palpable Lesions" on the applicable regulations and specific conditions it considers necessary for RSL. Since Broad Scope licensees are exempt from filing an amendment for 35.1000 uses, strict compliance with the NRC licensing guidance is not required. This presentation highlights the University of Pittsburgh's experience in the development of its RSL program, which has performed over 600 RSL cases during the past 15 months. Specific policies and procedures, developed under our Broad Scope license to address regulatory compliance, are presented and contrasted with the NRC licensing guidance, including Authorized User training and experience, Written Directives, surveys and instrumentation, verification of seed activity and Medical Event criteria.

MPM-A.7 Radiation Safety Issues for Use of an Automatic Injector for Epilepsy Ictal Brain SPECT

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The most challenging technical problem in ictal brain SPECT for localization of an epileptogenic focus is obtaining a timely injection of the radiopharmaceutical. The current practice is to manually inject the radiopharmaceutical into a patient's pre-established IV, followed by flushing, once a seizure has started. In our institution, an automatic injector (MEDRAD Inc., Pittsburgh, PA) has been utilized in the pediatric epilepsy unit in conjunction with video and EEG monitoring to provide a rapid injection at the initial onset of a seizure. This presentation highlights the technical aspects of the injector system, how it is set up and utilized in the patient room, and our two year experience with its use in over 100 patients. Use of the automatic injector has resulted in fewer contamination incidents than manual injection and improved overall quality of ictal SPECT scans by decreasing injection time, number of repeated studies, and number of days of patient hospitalization.

MPM-A.8 Monitoring Computed Tomography Examinations for Radiation Dose Control and Quality Assurance

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The Joint Commission has stated that doses for Computed Tomography (CT) examinations should follow As Low As Reasonably Achievable (ALARA) principles and that facilities are responsible for establishing appropriate radiation dose ranges for procedures. The dose ranges need to take into account the purpose of the study, body region, and patient size, among other considerations. At our institution, a CT Protocol Committee with membership comprised of Radiologists, Technologists, Physicists and Administrators provides guidance regarding protocol change management, dose considerations, and introduction of new technologies. Using protocol naming conventions, size-adjusted protocol charts, and knowledge-based experiments, this group advises the CT section concerning methods to fulfill the Joint Commission requirements. DICOM Radiation Dose Structured Reports are sent to a DICOM tracking database for extraction and storage of exam data. Naming conventions provide a means for comparing volume Computed Tomography Dose Index (CTDIvol) values for examinations of the same body regions but for different indications. For 520 routine abdomen pelvis exams performed in 2012, the average CTDIvol is 14.3 mGy, with a range of 5.9 to 38.4 mGy, and the Dose Length Product (DLP) is 707 mGy*cm with a range of 241 to 2977 mGy*cm. 79 abdomen pelvis exams for enterography averaged 12.1 mGy, range 5.0 to 37.8 mGy, and 602 mGy*cm, range 216 to 1951 mGy*cm, for the same time period. Patient size-adjusted protocol charts take advantage of automatic exposure control technology as well as enhanced iodine contrast provided by scanning at lower x-ray beam energies. For the 79 enterography patients, 9 were scanned at 80 kVp, 47 at 100 kVp, 22 at 120 kVp, and 1 at 140 kVp. A Protocol Committee and dose tracking database provide a means for monitoring dose control and quality assurance.

MPM-A.9 VA Initiative for Radiation Safety in Medical X-ray Imaging

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The average radiation dose from medical imaging to the population of the US has increased about five-fold since 1980. The US Department of Veterans Affairs (VA) has the largest integrated health care system, including 152 medical centers, in the US. In the VA, radiation doses to patients from x-ray imaging are not subject to regulation from outside the agency, although doses to staff are regulated by OSHA. The VA has launched an initiative to minimize the doses to patients from medical x-ray imaging, consistent with clinical care, and to better reduce dose to staff. This initiative includes promulgating a mandatory policy document for fluoroscopy, requiring review and optimization of CT imaging protocols, providing additional training for medical facility radiation safety officers, and performing site visits to individual medical facilities to assess implementation of policies and best practices. Lessons learned will be discussed. These include the importance of additional training for key staff, coordination among all health care providers at a medical facility who perform or use diagnostic imaging, leadership by imaging physicians, management support for the increased safety initiatives, and the benefits to patients resulting from successful efforts to decrease doses from imaging procedures.

MPM-A.10 Correlation of Digital Mammography Compression Force, Patient Pain Threshold, and Image Quality

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Proper breast compression allows for improved image quality, reduced radiation dose, and uniform anatomic viewing. However, excessive compression can lead to patient pain, which can result in image quality degradation as well as patients skipping mammograms. Exploring and understanding the correlation between compression force, patient pain threshold (PPT), and image quality, holds potential for improving the breast imaging practice and patient care. A retrospective study was performed on 500 Full-Field Digital Mammography (FFDM) scans (mean patient age: 63 yrs; range: 35-92 yrs). The mean compressed breast thickness was 55 mm (range: 18-111 mm), and a mean compression force of 86 N (range: 30-190 N) was used for image acquisition. The mean number of images/views per exam was 4.62 (range: 4-9), with a mean Average Glandular Dose per image of 1.24 mGy (range: 0.74-5.77 mGy). Immediately after the exam the patients completed a survey documenting the pain level that they felt (PPT) during their mammogram. The survey values ranged from "0" for "No Pain" to "10" for "Agonizing/Worst Pain Possible". Next, the radiologists participating in this study assigned one of the three "Image Quality Scores" to each mammogram during interpretation (1 = Poor Image Quality, 2 = Average Image Quality, 3 = High Image Quality). The study yielded a mean "Image Quality Score"; of 2.27 and mean PPT of 1.88 (range: 0-9). In only 7 out of 500 exams a PPT level greater than 5 was recorded. Since most of the patients reported feeling very low pain during the exam, no significant correlation was observed between the PPT level and "Image Quality Scores". Continued monitoring of the cases with high PPT levels (e.g. values greater than 5) is needed to better understand parameter relationships, and to implement performance criteria to optimize the proper image quality-patient dose balance.

MPM-A.11 Finalizing Radiation Protection Guidance for Diagnostic and Interventional X-Ray Procedures

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Since the 1970s, there has been a movement away from film and toward digital imaging for diagnostic and interventional x-rays. This shift has enhanced image quality and yielded a broader use of medical, dental, and veterinary x-rays. These new uses have increased the radiation dose for some procedures while decreasing it for other procedures while adding new procedures that were not useful in the film era. The medical use of x-rays is steadily increasing, and in 2006 was estimated to deliver 36% (2.23 mSv) of the 6.2 mSv radiation dose a member of the public receives each year from all sources. Growth estimates indicate that x-rays will account for over 42% (3.3mSv) of a more than 7.2 mSv total in 2012. The current U.S. Federal guidance on medical x-rays was published in 1976 and only addresses the uses in practice during the time of film imaging. The Interagency Steering Committee on Radiation Standards Medical Workgroup has drafted guidance for both diagnostic and interventional approaches to film and digital imaging, covering radiog-

raphy, computed tomography, interventional fluoroscopy, and bone densitometry in medical, dental, and veterinary practice. Each modality is presented in terms of equipment, testing and quality assurance, personnel, and procedures, while endorsing procedure justification and dose/image optimization. This draft document was reviewed by Federal agencies, cleared by the Office of Management and Budget, and released for public comment according to a communications plan jointly developed by EPA and DHHS. The purpose of this public comment period is to obtain feedback from the professional community, manufacturers, states, and public. Once those comments are addressed, an updated guidance document will be published by the EPA. The goal of this effort is to provide guidance suitable to medical facilities to help assure that the patient receives a justified imaging procedure that produces an adequate image quality at appropriately low dose.

P.1 Behavioral Monitoring Methods For Fluoroscopy ALARA Programs

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Fluoroscopy ALARA programs have well established radiation best practices but often lack methods for tracking the behaviors that achieve radiation best practices. Our work utilizes exposure specific radiation parameters to reverse engineer the behavioral practices of personnel administering fluoroscopy exams. The purpose of our efforts is to empower physicists and fluoroscopists with graphical representations of how personnel behaviors align with ALARA radiation best practices. Our behavioral monitoring method extracts data from the DICOM Structured Report and graphs radiation dose parameters of interest. One behavioral monitoring graph shows the position of the patient skin entrance, x-ray tube, detector, and interventional reference point for every radiation event in a fluoroscopically guided exam. Using a graph like this, recommendations can be made for minimum table height above the interventional reference point on specific equipment, or recommendations can be made to specific fluoroscopists as to better table height and/or detector positions on future exams. Another behavioral monitoring graph shows the protocol name, dose rate, copper filtration, mA, kVp, and pulse width for every radiation event in a fluoroscopically guided exam. This graph can be combined with an image quality metric like CNR to establish the optimal default equipment settings and track when the optimal settings are not being used. With behavioral monitoring methods in place, ALARA education can emphasize issues that are unique to the fluoroscopist, the protocol, and/or the equipment involved in order to lower patient and personnel radiation dose with ALARA radiation best practices.

P.2 Just In Time Training Reminders For Fluoroscopy Safety

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The number, variety, and complexity of fluoroscopically-guided interventional medical procedures (FGIP) have greatly increased during the past decade. FGIP are usually less invasive and costly than conventional surgical procedures and are performed by a wide variety of medical specialists (e.g., radiologists, cardiologists, vascular surgeons, orthopedic surgeons, and pain medicine physicians) with the assistance of medical support staff. Radiation safety training requirements for fluoroscopy vary greatly. Some States require physicians to have training, pass credentialing examinations, or demonstrate proficiency through board certification (e.g., by the American Board of Radiology) whereas others have no requirements at all.

While the use of ionizing radiation during FGIP greatly benefits the patients, there are risks to both the patients and the staff involved. Although the vast majority of FGIP are performed without radiation injury to the patient, unfortunate incidents occasionally occur. Many excellent resources provide information on methods to reduce radiation exposure of patients and staff (e.g., Image Gently and Image Wisely campaigns, NCRP Report No. 168, VHA Fluoroscopy Safety Handbook, IAEA https://rpop.iaea.org/RPOP/RPoP/Content/Additional Resources/Posters/index.htm).

Even when initial training is required, there may be no retraining required and, over time, many of these radiation safety principles may be forgotten. To address this potential gap in training, a poster (modeled after IAEA training posters) was developed to consolidate and reinforce key radiation safety principles. This poster can be used to provide just-in-time training that will reduce the risk of skin injury to the patient and reduce doses to the patients and staff. Eighteen key safety messages are presented using concise text and graphics. This information is organized into a standard 11” x 17” format that facilitates printing and posting.

TAM-A.1 Current Challenges in Radiation Protection for Production of PET Radiopharmaceuticals

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Providing Radiation Protection support at today's PET radiopharmaceutical manufacturing facilities requires a wide range of skills in areas such as licensing, instrumentation, effluent assessment, and dose reduction, among others. Licensing of these facilities has changed radically in non-Agreement and some Agreement States; accurate monitoring of positron-emitting radionuclides in air effluent requires careful consideration of sources of radiation as well as calibration difficulties; and the potential for a decrease to 20 mSv per year in the annual dose limit will require innovative solutions to radiation exposure during accelerator maintenance. Most facilities dedicated to producing PET radiopharmaceuticals are typically staffed by four to six employees who are responsible for operation and maintenance of the cyclotron, manufacture of radiopharmaceuticals from the raw radiochemical, quality control testing of the finished product, and the preparation and packaging of the finished drug for transport to licensed recipients. Presented here is a brief overview of these areas with potential solutions.

TAM-A.2 PET Cyclotron Contamination Hazards from Routine Target Maintenance

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Stanford University's GE PETtrace produces F-18 and C-11 for both clinical PET imaging and for medical imaging research. Target maintenance is performed in a workshop adjacent to the cyclotron vault on a designated workbench without the use of a hood or other ventilated enclosure. Stanford's radiation compliance survey team conducts surveys in the cyclotron suite every quarter. Because most of the radioisotope use on the campus is with beta emitting isotopes such as P32 and S35, the survey swipes are counted on a liquid scintillation counter. Contamination began to routinely show up on the low beta energy channel from swipes taken in the workshop. It became apparent that target cleaning and rebuilds caused contaminated dust that easily dispersed throughout the workshop. The survey methods used by the cyclotron staff did not detect the contamination. Gamma counting of the swipes found typical isotopes from the Havar foil and the targets (e.g., Cd-109, Co-56, Mn-54). This paper will discuss the challenges and pitfalls of working in a poorly designed work space and the methods used to detect and mitigate activated metallic dust particulate.

TAM-A.3 New ISO Standard - Monitoring Emmissions of Radioactive Gas From Medical PET Cyclotron Facilities

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There is a new ISO Standard at draft stage "Monitoring Emissions of Radioactive Gases from Medical PET Cyclotron Facilities". This standard is a tailored version of N13.1 "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities" and ISO 2889 "Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities". The need has been identified for a standard to fill the specific requirements of designers, builders and operators of medical cyclotrons, the two previously mentioned standards N13.1 and ISO2889 cover a wide scope of aerial discharge monitoring and sampling much of which is not pertinent to this industry sector. The draft document has been ongoing for the last two years under the leadership of John Glissmeyer of PNNL as the working group convenor. As the work package will still be at the draft stage at the time of the meeting, interested parties have been and will be invited to offer opinions and comments on the draft document.

TAM-A.4 NRC Experience in Licensing Cyclotrons under the Energy Policy Act – "Licenses for Production of Radioactive Material Using an Accelerator"

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The Energy Policy Act of 2005 gave NRC new regulatory authorities, one of which was for accelerator-produced radioactive materials (but not for the accelerator or its operation). The NRC established a unique license program code and guidance for activities that take place once radioactive materials are produced by the accelerator which include material in the target and associated activation products, to the point of transfer of the radioactive material to another license or licenses for the preparation of the final product. Since that time, the NRC has issued XX licenses for production of radioactive materials at a cyclotron. This presentation will discuss license reviewer experience with using the NRC guidance for licensing radioactive material that is produced by an accelerator

production accelerators, the common technical areas where additional information was requested from applicants, and other technical lessons learned from the regional license application reviews. NRC inspection experience also will be discussed.

TAM-A.5 NRC Experience in Licensing and Inspection of Commercial Radiopharmacies that Distribute Accelerator-Produced Radiopharmaceuticals

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The Energy Policy Act of 2005 gave the NRC new regulatory authorities, one of which was for accelerator-produced radioactive materials, most of which are used as radiopharmaceuticals for medical studies. The NRC revised its licensing and inspection guidance for radiopharmacies to include accelerator-produced radioactive materials. This presentation focuses on those radiopharmacies that were not previously licensed by the NRC because only the accelerator-produced materials were in use; typically, if these facilities were licensed by a State agency, both the cyclotron and pharmacy activities were under the same license. The presentation will review experiences in the licensing and inspection of the radiopharmacies that distribute the radiopharmaceuticals labeled with accelerator-produced radioactive materials.

TAM-A.6 NRC Financial Assurance Requirements for Licenses for Production of Radioactive Material Using an Accelerator

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The Energy Policy Act of 2005 gave NRC new regulatory authorities, one of which was for accelerator-produced radioactive materials (but not for the accelerator or its operation). Most applicants for licenses to produce radioactive materials using an accelerator were required to provide a decommissioning funding plan and a financial assurance instrument because of the associated activation products in the accelerator, targets, and associated shielding. This was an areas of confusion for most license applicants. This presentation will focus on the radionuclides at production facilities which are of concern for financial assurance, and information gathered about the cost estimates for decommissioning funding for such accelerator facilities.

TAM-A.7 Implementation of Current Good Manufacturing Practices (cGMPs) for the Submission of Abbreviated New Drug Applications (ANDAs) for PET Radiopharmaceuticals

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The Food and Drug Administration's (FDA's) regulatory authority over radiopharmaceuticals manufactured for Positron Emission Tomography (PET) was solidified on June 12, 2012. We present the critical processes and procedures that were established by our PET facility for proper alignment with FDA cGMP expectations. A detailed implementation plan, with a sharp focus on quality systems, including continual improvement and the prevention of nonconformity, is essential to consistently providing product that meets/exceeds clinician and regulatory requirements. This quality systems plan encompasses oversight of ALL documented production and manufacturing activities performed by core production staff and conducted under FDA filings. Written and approved procedures and documentation, maintained under careful change control parameters, ensure that all critical paths are examined and that every deviation and discrepancy is identified and properly explained. Our facility created a detailed implementation schedule that provided the necessary time for proper implementation of the following: (1) effective and well-documented training program; (2) detailed maintenance and calibration program for all production equipment and analytical instrumentation; (3) well-defined batch and test records, where all steps, equipment and results are initialed and verified; (4) thorough and timely investigation of all deviations, out-of-specifications (OOS) results and any other incidents; and, finally, (5) quality assurance and quality improvement processes for comprehensive recall systems, effective self-inspections and robust corrective action and preventative action CAPA) programs. It was imperative that our PET manufacturing staff understand the FDA's Quality Systems expectations. We, therefore, focused our efforts on the thoughtful analysis of all processes and successfully established the appropriate program that lead to the timely submission of ANDAs for Fludeoxyglucose F18, Sodium Fluoride F18 and Ammonia N13 .

TAM-A.8 Obtaining NRC License for Cyclotron Production in a University Setting

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With the enactment of the Energy Policy Act of 2005, life as a Radiation Safety Officer overseeing a growing PET-production program in a non-Agreement State was about to change. Washington University in St. Louis (WU) began cyclotron-production of radioactive materials in the early 1940s, established the first cyclotron at a U.S. medical center in the early 1960s, developed PET-imaging in the 1970s, and remains a research and clinical leader in the production and use of PET isotopes and radiopharmaceuticals. Developing a new license application with NRC Region III licensing staff for a long-standing cyclotron-production program that did not fit the mold of a radiopharmacy license or a manufacturing and distribution license proved challenging. Working to consider new regulations, regulators unfamiliar with different cyclotron-production models, continued growth of the cyclotron production and use programs, higher occupational doses coming under 10 CFR 20 limits, and decommissioning considerations, as well as re-training of authorized users, radiation workers, radiation safety staff, and management, has demanded much RSO effort and shifts in how the WU radiation safety program functions. Specific challenges have been explaining to authorized users and management why this regulatory change has been such a "big deal" when their colleagues at universities and hospitals in Agreement States say they have not had any change in regulations, sorting out with Missouri State regulators what radioactive materials still come under their regulations, and adjusting to parallel regulatory changes implemented by the Food and Drug Administration.

TAM-A.9 Health Physics & Medical Physics: A Common Purpose

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The American Association of Physicists in Medicine (AAPM) defines four subfields of medical physics: therapeutic medical physics, diagnostic (imaging) medical physics, nuclear medical physics, and medical health physics. Of these, medical health physics is obviously the most closely related to activities typical of Health Physics Society members, as it includes activities such as ensuring compliance with radiation protection policies, procedures, and regulations; development and management of radiation safety programs; and assessing radiological hazards associated with the use ionizing radiation or radioactive materials. However, the other three subfields have experienced increasing commonality with typical health physics objectives due to significant, adverse events or increasing scrutiny by regulatory agencies and advisory groups. Consequently, typical health physics principles such as ALARA and protection of both workers and the public from the adverse effects of ionizing radiation are being applied more routinely and consistently throughout the field of medical physics. It is well known that medical exposures account for the great majority of radiation doses outside of natural background radiation, and it is clear that processes are becoming more widely established to control these exposures to optimal levels commensurate with the associated benefits and risks. In this paper we will discuss these processes and the recent events that have stimulated their deployment.

TAM-A.10 Occupational Exposure of PET Radiopharmacy Staff: A Case Study

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This case study investigates occupational doses to the whole body, eye, and extremities for PET radiopharmacy staff. Staff are responsible for all stages of production of PET radiopharmaceuticals, such as Fluorine-18 Fluorodeoxyglucose (F-18 FDG), from cyclotron start up through radiopharmaceutical drug dispensing, and delivery. Pharmacy staff is careful to utilize time, distance, and shielding through the use of tongs, lead containers, tungsten vial shields, drawing of doses inside of shielded hot cells, shielded L blocks, as well as personal planning, speed, and efficiency. Despite these best efforts, many of these tasks are performed by specific staff members multiple times throughout a single work shift resulting in occupational doses being received. This case study will present the cumulative findings on occupational dose with a comparison to the federal occupational dose limits and industry norms.

TAM-A.11 Measurement of Collection Efficiency in Activated Charcoal Cartridges for Air Samples of Volatile F-18 Releases from PET Radiopharmaceutical Manufacturing

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Manufacture of F-18 radiopharmaceuticals often results in volatile compounds being generated. Typically, very expensive stack monitoring systems are

used to monitor these releases. This paper discusses using activated charcoal cartridges impregnated with TEDA (triethylene diamine) and two separate pump systems that can be used for duct or ambient air sampling. The key to utilizing such a system is to determine the collection efficiency for the F-18 compounds on these cartridges. To determine the collection efficiency, H F-18 gas was generated and passed through a series of cartridges. The fraction collected on the first and subsequent cartridges is analyzed to assess the percentage collected on each cartridge.

TAM-A.12 Positron Emission Tomography Radiotracer Production In Clinical Research and United States Pharmacopeia <823>

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The Food and Drug Administration (FDA) published 21 CFR Part 212 (current Good Manufacturing Practices for Positron Emission Tomography (PET cGMP)) in December 2009. PET cGMP regulations became effective as of December 12, 2011 with the FDA announcing exercise of enforcement discretion until June 12, 2012. The provisions of USP <823> "Radiopharmaceuticals for Positron Emission Tomography-Compounding (USP 32/NF 27)(2009)" will continue to apply when PET radiopharmaceuticals are produced under either an Investigational New Drug Application (IND) or Radioactive Drug Research Committee (RDRC) approval. The University of Pittsburgh (UP) PET facility produces >20 PET radiopharmaceuticals for human use under USP <823> (both IND and RDRC protocols). The general approach to these radiosyntheses is illustrated by the operational and documentation approach utilized in the production of [C-11]PiB, a beta-amyloid tracer. The UP PET facility has produced [C-11]PiB for human use > 1000 times over its eight year history of use in average radiochemical yield of 19-29% (decay-corrected) and total synthesis times of 40-45 minutes (including quality control testing) with chemical and radiochemical purities > 95% and specific activities of 120 +/- 45 GBq per micromole at end of synthesis. A common documentation approach (Drug Master File and Master Batch Record) as well as a robust validation process and common quality control testing elements provides the basis for PET radiopharmaceutical production. These common quality control testing elements include, visual inspection, determination of pH, radiochemical identity, radiochemical purity, chemical purity, determination of specific activity, organic volatile impurity analysis, radionuclidic identity analysis, endotoxin testing, membrane filter integrity testing, and sterility testing. Acknowledgements: This work was supported by AG18402 and AG25204. CM declares a conflict of interest arising from PiB technology licensed to GE Healthcare.

TAM-A.13 Radiation Safety Issues with At-211 Production at the NIH Cyclotron Facility

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The National Institutes of Health (NIH) is the federal government's premier biomedical research facility. The NIH opened its Cyclotron Facility in 1986. In addition to supporting a Positron Emission Tomography Department in the NIH Clinical Center, the Cyclotron Facility makes nuclides for other research applications. One of these nuclides is Astatine-211 (At-211) which is a volatile alpha emitter. The monitoring system that had been in place for many years had not detected any At-211 releases because of the monitor's configuration and masking by F-18. Since an internal target under vacuum was being used, At-211 releases were not really expected as this is a closed system. When a new temporary monitoring method was put into place in 2010, it was discovered that small amounts of At-211 were being released. Although the amounts were small compared with F-18 and C-11, the low effluent release limit for At-211 made it prudent to investigate the cause of the releases and implement operational changes in the At-211 production procedure to ensure that NIH did not exceed annual effluent limits. These changes have greatly reduced the At-211 released in a production run and enabled the NIH Cyclotron Facility to make At-211 more frequently.

TPM-A.1 The Radioactive Drug Research Committee Approval Process for Basic Research Studies Involving Non-Approved Radioactive Drugs, Part I

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The U.S. Food and Drug Administration's (FDA's) Radioactive Drug Research Committee (RDRC) approval process (21 CFR Sec 361.1), which is particularly amenable to the research use of Positron Emission Tomography drug products for biomarker applications, is presented. To qualify for RDRC approval, the research study must be intended to obtain basic information on metabolism (including kinetics) of the radioactive drug or regarding human physiology, pathophysiology, or biochemistry. The RDRC approval

process is not, however, applicable to studies directed at obtaining diagnostic or therapeutic information or to determine the safety or effectiveness of the radioactive drug for such purposes. The radioactive drug must be known, based on prior valid human studies, to not cause any clinically detectable pharmacologic effects at the administered mass dose. For a single study, the radiation dose to adult subjects cannot exceed 30 mSv to the whole body, active blood-forming organs, lens of the eye, and gonads (the sensitive organs); or 50 mSv to any other organ. For multiple studies conducted within a given year, the cumulative radiation dose cannot exceed 50 mSv to the sensitive organs, or 150 mSv to any other organ. For research studies involving children, the radiation dose limits are 10% of the adult limits. The research study must be approved by a quorum of the RDRC membership to include individuals with expertise in radiation dosimetry, the formulation of radioactive drugs, and nuclear medicine. The RDRC approval of research studies involving children or more than 30 adult subjects must be reported immediately to the FDA; and all RDRC-approved studies must be reported to the agency on an annual basis. Approval of the radioactive drug research study by an institutional RDRC avoids the additional FDA regulatory requirements and oversight associated with the submission of an Investigational New Drug Application.

TPM-A.2 Activity Thresholds for Patient Instruction and Release for Positron Emission Tomography Radionuclides

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The use of "nonstandard" radionuclides for positron emission tomography (PET) is becoming more prevalent in both nuclear medicine diagnosis and therapy. Many of these nuclides are produced in cyclotrons or are further eluted from generators. Although half-lives from many of these unconventional PET radionuclides are considered relatively short and the intent of their use is often as a diagnostic imaging agent, patient radiation safety instruction and patient release criteria are rooted in estimated dose to a member of the public. Use of current regulatory guidance can readily provide thresholds for patient instruction and release. Use of this model is prudent as a primary screening technique while estimate dose to a member of the public from patient release. This project; reviews a method routinely referenced for patient release criteria as found in US NRC guidance; estimates fundamental quantities used in the method, compares estimated quantities with the published literature, and calculates patient radiation safety instruction and release criteria for several novel PET radionuclides used in nuclear medicine.

TPM-A.3 The Radioactive Drug Research Committee Approval Process for Basic Research Studies Involving Non-Approved Radioactive Drugs, Part II

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See TPM-A.1 for details.

TPM-B.1 Layered Shielding in PET Clinics

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Shielding design for PET/CT clinics is frequently difficult as many of the facilities are being retrofitted into existing imaging centers and hospitals where space is cramped. The patient quiet rooms , the hot lab, and the scanners are commonly positioned in close proximity to uncontrolled areas where the non-occupational dose limits apply. Of particular concern are the ceilings and floor shields for the quiet rooms and the scanner as these are constructed using the existing concrete ceiling and floor decks and sheets of lead. The attenuation provided by these layered shields are difficult to calculate by point kernel methods, yet much of the cost of the shielding in a PET/CT clinic is driven by the installation costs of these shields. In this work we develop a three dimensional MCNP model of a typical PET quiet room and scanner room and use this model to calculate the attenuation provided by common thicknesses of concrete and layers of lead used for ceiling and floor shields. The model of the quiet room consists of a small room with a MIRD phantom placed in a reclining position in the center. The phantom is the source term with 555 MBq (15 mCi) of 18FDG equally distributed between the brain and the bladder in the phantom. The scanner room is derived from common plans of scanner rooms in PET/CT facilities and again uses a MIRD phantom placed supine in a PET/CT scanner. The source term for this model is the phantom with 277 MBq (7.5 mCi) of 18FDG. The scanner was modeled as double cylinders of iron rings corresponding to the dimensions and attenuation provided by a modern PET/CT unit. The base plates for the scanner and lead isolation rings between the PET and CT gantries were also modeled. Since the source terms and the geometry for these models are complex, mesh tallies were used above and below the rooms to determine the area of maximum dose rate for the floors above and

below. The results are compared to the methods used in the AAPM Guide for Shielding PET clinics.

TPM-B.2 Dose to Non-Targeted Tissues of the Eye During Stereotactic Radiosurgery

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Age-related macular degeneration (AMD) is a leading cause of vision loss for the elderly population of industrialized nations. AMD has both a dry and a wet form, with 80% of vision loss cases resulting from the wet form of the disease. Oraya Therapeutics, Inc. has developed a low-voltage stereotactic treatment system, the IRay. Using a three-beam delivery system, the IRay delivers a total dose of 24 Gy to the macula, while attempting to limit dose to other tissues within the eye. Using NCRP Report 130 as a basis, a series of five eye models was created with axial lengths ranging from 20 to 28 mm in 2 mm increments. These models were imported into the Monte Carlo radiation transport package MCNPX to simulate treatment of the IRay system. In addition to varying eye size, the polar beam angle of the IRay delivery system was varied from 18 to 34 degrees in 2 degree increments. All treatment combinations of eye size and polar beam angle were simulated using MCNPX, and dose to five non-targeted tissues was assessed: lens, distal tip of the central retinal artery (CRA), optic nerve, non-targeted portion of the retina (retina), and the ciliary body. Results show small variations in doses to the five structures as eye size increases, suggesting that eye size has little influence on dose to non-targeted tissues. Little variation is seen in the optic nerve and CRA as the polar beam angle changes. As the polar beam angle increases, dose to the lens and ciliary body decreases, while dose to the retina increases. Polar beam angles less than 24 degrees (IRay minimum) result in point doses to the lens greater than 700 cGy. This work was sponsored by Oraya Therapeutics, Inc.

TPM-B.3 Attenuation Evaluation of 0.5 and 0.75mm Lead Protective Glasses

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The purpose of this study was to determine the relationship between the lead equivalent thickness of protective eyewear and its attenuation properties in order to determine the safest and most cost effective thickness of eyewear interventional fluoroscopists should utilize. A secondary assessment of lens dose adjustment (or lens dose equivalent, LDE) as a dose of record is desired. An anthropomorphic phantom was utilized to both simulate an operator (eyewear mounted on anthropomorphic head) lens dose as well as the scattering medium (anthropomorphic patient, torso). Landauer nanoDots® were utilized to collect both incident and transmitted x-rays from an interventional fluoroscopy machine (thereby inferring attenuation of the leaded eyewear) during various angular projections using different eyewear manufacturers (and lead equivalencies). The measured attenuation values are relatively similar, showing very little change with respect to lead thickness (0.5 mm versus 0.75 mm lead equivalency). The average attenuation for all AP (anteroposterior) and LAT (lateral) projections for both 0.5 mm and 0.75 mm lead equivalencies is 83.2%. The minimum attenuation value was measured with 0.75 mm lead equivalent lenses for the angled (operator head tilted away from the patient toward the monitor bank) AP projection (74.6% attenuation). The maximum attenuation value was measured with 0.75 mm lead equivalent lenses for the straight-on (operator looking down at the patient) AP projection (88.0% attenuation). Considering the difference in lens thickness equivalency, projection (AP versus LAT) and viewing of patient versus monitors, the overall difference between minimum and maximum attenuation is therefore 13.6%. Cost and comfort factors versus attenuation properties must be considered when purchasing leaded eyewear.

TPM-B.4 Experience with Electrodeposited Cf-252 Ion Sources

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Fission fragments from an electrodeposited Cf-252 source [average strength 2.2 GBq (60 mCi)] were collected, selected, and accelerated in the Argonne ATLAS accelerator for commissioning the CAlifornium Rare Ion Breeder Upgrade (CARIBU) ion source. This source had sufficient strength for Q-value measurements using fragments stopped in a Penning trap, but not enough for experiments using accelerated beams. Failure of the source cover foil occurred during the commissioning runs. Efforts made to understand and correct that problem are described. Recently an 18 GBq (500 mCi) Cf-252 source electrodeposited in a hot cell at ORNL was transferred to the CARIBU shielding cask and then into the gas catcher at Argonne in preparation for use of its fission fragments as neu-

tron-rich heavy ion projectiles for astrophysics experiments. This source is half the requested design source strength, but it will provide sufficient reaction rates for studying many neutron-rich nuclei. The dose rate was measured at 30 cm from the shielding cask with the stronger source inside and agreed with the MCNPX calculations. In addition, a small leak from the cask resulted in measurable gamma immersion dose from the Xe radionuclides released. The monitoring systems, measurements, and releases are discussed. *This work is supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

TPM-B.5 Evaluation of Shielding for a Proton Treatment Room by Monte Carlo Calculations

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The Mayo clinic is constructing a proton therapy center for cancer treatment. We were commissioned to evaluate the effectiveness of the shielding and entrance maze for a treatment room and to calculate the dose equivalent rates in occupied areas adjacent to the treatment room. The Monte Carlo transport calculations were made using MCNPX version 2.7.0. The Moritz program was used in preparing the three-dimensional geometry model and in displaying the results. In addition to the treatment room, the model includes surrounding corridors and office space. Dose response functions convert the calculated flux to dose equivalents. The results (tallies and their statistical errors) are presented as mesh tallies in which the dose equivalent rates are calculated in the cells of a rectangular grid. Visualization of the tallies is by a color wash together with contour lines. The source is a beam of 200 MeV protons directed at a water cube. The work week averaged source rate is 770 million protons per second. We considered 2 gantry angles: 180 degrees (vertical upwards beam) and 90 degrees (horizontal beam). In addition to the protons, the calculation followed neutrons and photons produced by the interactions of the source particles. Biasing by importance splitting enabled penetration of the thick concrete walls and accurate results exterior to the treatment room using 30 to 300 million particle histories. We show details of the model setup and the dose equivalent rates throughout the model. No regions of external high dose were found for the two beam directions, either by penetration of the walls or by leakage through the entrance maze. At all locations outside the treatment room the dose equivalent was less than 0.1 mSv/week without accounting for use factors or occupancy factors.

TPM-C.1 Life, the Universe and Nothing…A Cosmic Mystery Story

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Over the past decade, new observations have led to a revolution in cosmology. The standard model of cosmology established over the last 100 years is now dead. Its replacement may be far more bizarre, leading to the biggest unsolved mystery in modern physics. In this talk, I will first describe the remarkable developments that have changed what we know about the Universe, and then address several key questions that have arisen as a result of discovering that the dominant energy of the universe resides in empty space. Are the laws of physics tailored for the existence of life? What might science in the far future tell us?

WAM-A.1 Developing a Partnership Between Radiation Safety and Risk Management

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The goals of Radiation Safety Officers and Risk Management Professionals have a lot of overlap, but there is often a lack of communication and coordination between the two departments. The mission of the Radiation Safety Program is to ensure that the use of radiation sources and radioactive materials is safe and in compliance with the regulations. Risk Management professionals have a broader responsibility for patient safety and compliance with regulations and accreditation agency standards. They also work to minimize the financial risk to the organization from incidents. Recent events within our organization highlighted the previous lack of communication between these departments and led to an improved patient safety agenda with regard to radiation safety. Progress has been made to develop a strong working relationship between the Radiation Safety Officer and the Risk Management and Quality Improvement specialists. One outcome of this partnership is a systemic review of I-131 policies and clinical procedures and improvement in processes from both radiation safety and patient care perspectives.

WAM-A.2 Mutual Benefits of a Health Physics Presence in a Radiation Therapy Department

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In its first three decades of growth, the Penn State Hershey Medical Center's Health Physics (HP) Office

had minimal interaction with the Radiation Therapy (RT) department. Beyond radioactive materials management and personnel dosimetry, most radiation safety functions were performed by RT's medical physics staff. During the 1990's, the HP Office became progressively more involved with all RT treatment modalities, and helped assure continuity of the regulatory aspects of the clinic. A Health Physicist was assigned a liaison role, to establish a closer working relationship with RT staff. In 2003-2005, we experienced a nearly complete turnover in RT physicians and physicists, and planning also commenced for a new Cancer Institute. As the RT department expanded, the liaison effort paid off, and the HP Office provided critical support in all regulatory areas, including licensing, authorizations, medical event reporting, Increased Controls functions, training, audits, and shielding verification. Health Physics has also been able to provide a sense of historical fluidity for the new medical physics staff, as well as details of construction and shielding during equipment and structural upgrades. This talk presents experiences, lessons learned, and benefits gained from the interaction of a Health Physics Office and a Radiation Therapy department.

WAM-A.3 Replacement of a Gamma Knife Radiotherapy Treatment Unit

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The Gamma Knife is a radiation therapy device designed for gamma stereotactic radiosurgery. It is used for non-invasive treatment of cranial tumors, both benign and malignant, such as neuromas and atriovenous malformations. An array of approximately 200 Co-60 sealed sources, each an IAEA Category 1 source, is housed within a treatment device weighing over 20 tons. Since the time needed to deliver a given dose doubles nearly every five years, physicians generally deem it expedient to refresh the source inventory after five to ten years of use. This can be accomplished by reloading the Gamma Knife in place, or alternatively by replacing the entire machine with a more advanced model. The Penn State Hershey Medical Center recently undertook the latter approach. We review the planning and preparation required to accomplish the task within a tight schedule, including architectural and engineering evaluations, working with renovation and rigging crews, coordinating licensing and other regulatory concerns, and ensuring security throughout the entire project.

WAM-A.4 Radiological Safety Lessons Learned Associated with the Therapeutic Use of Yttrium 90

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The use of Yttrium 90 (Y-90) as a therapy drug associated with liver lesions has had some interesting radiological consequences. Yttrium 90, a very high beta emitter, (beta maximum energy of 2.28 MeV, beta average energy of 0.9348 MeV) is very effective in the treatment of liver lesions due to the high amount of energy deposition in a small area. Its radiological consequences for the user can be a challenge, in particular if the pharmacist is required to draw a precise dose from a small volume. Activity of up to 10 GBq are required to be applied to the lesions in order to achieve the planned results, resulting in doses of 8 mSv/hr from the Bremsstrahlung X-rays. New York State and Federal regulators require notification and a response plan if the therapy exceeds by 20% the planned application. This initially caused the therapy dose planners to request a very small error margin on the draw which subsequently became a challenge for the Nuclear Pharmacist to meet those goals, and still keep their dose ALARA. Improved draw techniques, more flexibility in the therapy planned dose limits, more aggressive radiological support and more rapid handling by the staff have reduced the exposure risk substantially. This paper will describe the radiological risks associated with the Y-90 use, the effective dose consequences and the processes that were changed to achieve this success.

WAM-A.5 Challenges with US Food and Drug Administration (FDA) Oversight Matters at a Positron Emission Tomography (PET) Cyclotron Research Center

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In a university PET cyclotron research facility where novel radiopharmaceuticals are developed and used in human and animal research studies, and where operations are heavily regulated by a myriad of agencies, where does FDA oversight fall? The Institutional Review Board (IRB), Human Research Protection Program (HRPP), office of Environmental Health and Safety (EHS), Authorized User, office of Research Compliance, Radiation Safety Office, Responsible Principal Investigator, Radiation Safety Committee (RSC), and Radioactive Drug Research Committee (RDRC) all have overlapping responsibilities for oversight and protection of employees, human research subjects and the institution. From protocol reviews and audits and inspections, to incident investigations

and dealing with regulators, many overlapping issues emerge. These issues and others related to one university's experience with trying to manage FDA oversight at a PET cyclotron research center are shared, explored and discussed in this presentation. The Memorandum of Understanding that exists between the US Nuclear Regulatory Commission (NRC) and the FDA is considered, along with United States Pharmacopeia (USP) chapters 823 and 797, the FDA's RDRC guidance and the FDA's current Good Manufacturing Practices (cGMP) requirements. Experience with a comprehensive external audit commissioned specifically to look at FDA compliance matters at our university PET cyclotron research facility is also shared.

WAM-A.6 A Primer on Written Directives and the Curious Case of Three Non-medical Events

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The Nuclear Regulatory Commission (NRC) views a written directive as a "prescription", signed and dated, by an NRC approved physician, prior to administration. A written directive is required when using over 30 uCi of I-131, or for a therapeutic dose which uses radiation (unsealed, sealed, teletherapy) intended for curing disease or for palliative care. The Health Physics Medical Group at Stanford University guides the correct use of a written directive, audits required documentation, and provides training for the medical center's residents and authorized user physicians. This paper will walk through key NRC written directive requirements and end with a discussion of three examples of therapies which at first appeared to be medical events but after further analysis were not reportable.

WAM-A.7 Why Medical Patients Accept the Words "Deadly Radiation" as the Truth

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How often have you been puzzled or frustrated by people who make instant decisions about "deadly radiation" with little or no data? How can people make such quick judgments about radiation with limited knowledge? The answer has to do with the way our subconscious mind processes information for our protection. Our subconscious mind is constantly scanning all information and sensory inputs to detect anything not normal and predict dangers to be avoided. This process functions by quickly associating such inputs with all previous experience and memories to predict what is coming next. We are not aware of this process which is completely automatic and requires no conscious effort. Our subconscious is continually updating answers to key questions. Is anything new happening now? Is there any threat? Should my attention be redirected? Is more conscious effort warranted for some task at hand? Our subconscious is at ease when things seem normal. We will have a greater sense of ease based on familiarity of words that we have often heard before. Since the media has reported the words "deadly radiation" for over 60 years most people are now unconsciously primed to hear those words as familiar. Because of familiarity most people will not be inclined to evaluate the meaning of those words which requires conscious effort. Therefore those words carry an "illusion of truth" and the conscious mind will proceed on that impression without further questions. To survive in a dangerous world we have learned to react cautiously to any novel stimulus. The words "deadly radiation" are not novel and people do not expect to hear about radiation other than "deadly." Efforts to leave out or modify the word "deadly" may in fact invite suspicion. Our subconscious mind is at ease when we see the environment as normal. For most of the world, normal means "deadly radiation." Someone trying to tell us that radiation is not deadly may be seen as not normal.

WAM-A.8 Magnetic Resonance Safety: A Health Physics Approach

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While Magnetic Resonance Imaging (MRI) does not have the same hazards that are associated with Ionizing Radiation, there are still safety concerns that need to be addressed. The hazards of MRI were exposed to the world in 2001 when a child was killed when an oxygen tank became a projectile from the force of the ever-present magnetic field. As a result of this accident and many others the American College of Radiology (ACR) has issued a guidance document which outlines a safety program for MR. This document in its most recent form, the ACR Guidance Document for Safe MR Practices: 2007, includes "Safety Zones" (areas with different degrees of security), methods on how to screen individual for hazardous situations, and many other suggestions for maintaining safety in the MR environment. The ACR Guidance Document can be compared to the NRC's NUREG Guidance Documents. If a facility follows these guidelines they will be in compliance (NRC), or have a safe environment (ACR). However if they are not able to meet the guidelines, which

is often the case in MR, they have to take other measures to ensure that a safe environment is maintained. Other similarities can be found such as postings, restricted/un-restricted areas, safety training, auditing, etc. As these fundamental ideas are the basis of any comprehensive radiation safety program, it demonstrates why the health physics community is so well suited to step into the MR safety world. The number of incidents in MR has risen, and regulators have begun to notice. This is where the health physics community can step up and apply their skill sets to a new field. At a Geisinger Health System, the Medical Health Physics Department has assumed the responsibility for MR Safety. In the last year they have coordinated with the Radiology department to review and standardize the MR Safety Policy, set-up an auditing program, and develop and conduct training.

WAM-A.9 Shielding Considerations and Challenges Associated with Relocation of Gamma Knife Unit to a New Facility

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The Leksell Gamma Knife Perfexion is a radiosurgery system used in the stereotactic irradiation of intra-cranial structures. It utilizes 192 Co-60 sources with initial activities 1132.2-1202.5 gigabecquerel (30.6-32.5 Curies). The sources are confined within the protective housing and primary beams focus on the prescribed target during the treatment. While previously observed anomalous "escape" of primary radiation from older style Leksell units has been eliminated through housing design changes, we opted for a conservative shielding design for the new facility. Our decision was influenced by the proximity of Gamma cameras in the adjacent Nuclear Medicine Department and by the presence of an In-Vitro Fertilization Laboratory one floor above the new Gamma Knife facility. Survey results confirmed the appropriateness of this approach. The design also incorporated a need for removable portion of external access wall in order to accommodate initial delivery and installation of the unit as well as future source exchanges. The timing of relocation of the unit was planned to coincide with the exchange of sources thus removing transportation concerns and simplifying compliance with increased controls requirements.

WAM-A.10 That's a Do Over-Evaluating Repeats, Rejects and Misdministration in Nuclear Medicine

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In keeping with ALARA principles, all administrations of nuclear medicine should result in a diagnostic result. There are occasions that, due to a variety of reasons, the administration of nuclear medicine do not result in the desired study being performed. This paper describes a method for documenting, categorizing, and analyzing these events. Root cause analysis is performed for each event. Based on the root cause, corrective actions are specified. Corrective actions range from increased attention to detail, additional technologist training to better patient screening prior to isotope administration. The "avoidable dose" is also calculated to add to the patient's medical record, provided to the referring physician, and provided to the technologist. The avoidable dose is the effective dose to the patient from the study that did not result in any useful information. The avoidable dose is also calculated to determine whether any misadministrations are reportable medical events. An analysis of events, root cause, and avoidable dose provide a useful tool in educating technologists, managers, and physicians to help minimize the re-occurrence preventable medical errors. An analysis of events, root cause, avoidable dose, and corrective actions implemented is also presented for a 600 bed tertiary care hospital.

WAM-B.1 A Review of Staff Radiation Protection Issues for Electron, Proton, and Heavy Ion Accelerators

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A review of the radiation protection issues for staff and members of the general public from the operation of medical therapy accelerators will be provided. Elements will include the fundamental methods of operation of the accelerator systems, exposure controls, and shielding, interlocks and instrumentation. Specific HPS ANSI and AAPM Task Force Reports related to operations of accelerator facilities will be cited. Sample problems reported through regulatory and other agencies will be identified. This is Part I of the introductory presentation for the session "Issues in Proton, Heavy Ion and Electron Accelerator Therapy."

WAM-B.2 Conventional PTV-Based Optimization Lacks Robustness for IMPT Head & Neck (H&N) Planning

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The robustness and, therefore, effectiveness of IMPT may be significantly degraded by range and patient setup uncertainties. The purpose of this study was to evaluate the ability of robust optimization methods to desensitize H&N IMPT plans to uncertainties and their impact on plan optimality. Robust optimization automatically reduces the contribution from the most sensitive field to uncertainties: the P-A field. Furthermore, robust optimization considerably reduces high dose gradients within each of the three fields. Robust optimization improves IMPT plan robustness to uncertainties and results in patient-specific, optimizer-determined reduced margins compared to the conventional PTV approach for H&N cancer.

WAM-B.3 National Laboratory Qualification Program

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ORGANIZATION - The NLQP is composed of laboratories and users of laboratory services and is a Non-profit 501(c) organization. The Board of Directors consists of 3 members, 2 represent member laboratories and 1 represents the users of laboratory services (the user may also be a member laboratory representative). Members of the organization are volunteers except for the independent auditing agency. The organization consists of a pool of experts who can assist candidate laboratories to become qualified and to be re-qualified. QUALIFICATION - Radiation instrument calibration, radioactive source calibration, and radiological testing laboratories are eligible to become qualified. There is a 5-year re-qualification period. Laboratories must demonstrate compliance with ANSI/IEC/ISO 17025 and must participate in round-robins annually and meet the stated acceptance criteria to become qualified and to re-qualify. PURPOSE - Qualification of a laboratory increases public confidence in that laboratory's services. The program establishes consistency of analytical results between participating laboratories. The program is a pathway for laboratories to achieve international recognition as qualified laboratories. The members participate in the development of national and international standards with a common viewpoint. A long-term purpose is to achieve "accreditation" of participating laboratories.

WAM-B.4 Dose Calibrators – How Low Can You Go?

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Previous US regulation and guidance documents offered minimum and maximum activity levels for performing dose calibrator linearity tests. In lieu of bounds for activity, revisions to US NRC regulations stated conformance to nationally recognized standards or the manufacturer's instructions. Some manufacturer instructions on linearity tests include continued evaluation of the source until the activity is below the minimum assayed in normal operations or over the entire range of activities reasonably anticipated. For some licensees, anticipated activities may be less than 370 kilo Becquerels (10 micro Curies) e.g., when evaluating the residual activity from administration of alpha emitters and breakthrough estimates of select generators. We estimate the minimal detectable activity of a dose calibrator based on various background levels of activity and determine the impact on the evaluation of residual radiopharmaceuticals.

WAM-B.5 A Low-Dose-Rate Environment for Biological Samples

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The aim of this effort was to create a uniform radiation environment with a dose-rate below 1 mGy/h. Three cobalt wires activated in the 1MW Triga Mark I reactor at the Texas A&M Nuclear Science Center for nine hours and cooled for four days, resulting in 23 mCi of Co-60 activity over the one meter length of each wire. These wires were evenly spaced at points one meter away from a CO2-jacketed incubator. After an MCNPX simulation and two physical experiments with TLDs over a period of 30 days, it was determined that the radiation environment was uniform within the standard error of the measurement instruments used. Furthermore, the actual dose-rate had a range from 0.298 to 0.696 mGy/h uniform through the irradiated area, meeting the initial design criteria.

WAM-B.6 Photo-Nuclear Production of Ac-225

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The feasibility of producing Ac-225 through the photo-nuclear reaction Ra-226(gamma,n) Ra-225 →; Ac-225 has been theoretically demonstrated in this

study. Radium needles, which were once employed in the treatment of cancer, are now no longer used due to the production of radon and its leaking concern, thus constituting a radioactive waste problem due to their long half life of 1600 years. The purpose of this research is to investigate the possibility of reducing the spent radium sources in a small scale by bombarding Ra-226 with high energy photons from a 44 MeV Linear accelerator to produce Ra-225 which undergoes beta decay to Ac-225. Ac-225 can be used as an alpha emitter for targeted radio-immunotherapy or as a generator system to produce Bi-213 for use in alpha radio-immunotherapy as well. The activity of Ra-225 depends on the photon flux, which in turn depends on the target geometry and current. Monte Carlo N-Particle Transport (MCNPX) software was used to simulate the photon flux for various target geometries and different beam energies and also to find the optimum irradiation conditions to maximize the Ra-225 yield. Using the MCNPX simulated fluxes and the evaluated (gamma,n) cross section of Ra-226 (gamma,n) Ra-225 reaction, the production yield calculation of Ra-225 was performed. The mother-daughter relationship of the photo-neutron product Ra-225 and Ac-225 was also explored in this study by calculating Ac-225 activity as a function of the irradiation and decay time of Ra-225 . Maximum yield, of around 20 mCi/g of Ra-225 was reached at incident electron beam energy of 35 MeV, 10 kW power and 7 hours of irradiation.

WAM-B.7 Safety Systems and Event Reporting in Radiation Therapy

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Radiation therapy treatments are becoming increasingly sophisticated and complicated, with concomitant opportunities for things to go wrong. This talk will highlight the efforts taking place within the medical physics community to bring in techniques in safety systems and process control that have been well known in other industries. A primary topic will be the development of event reporting systems. A number of facilities have published descriptions of their systems and some of the lessons learned. AAPM and ASTRO are collaborating to create a national event reporting system in conjunction with an established Patient Safety Organization; this system will primarily receive reports of incidents and "near misses" that do not need to be reported to regulators but can lead to process improvements. This talk will describe the status of that effort.

WAM-B.8 Assessment of Timer Error of a Small Animal X-Ray Irradiator: Derivation of the Ramp-up Exposure and Stable Exposure Rate

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A biological x-ray irradiator (X-RAD 320; Precision X-ray, Inc. North Branford, CT) is frequently used for biomedical research at our institution. The system's users rely on the single quantity of exposure rate to calculate the time needed for a target dose. However, it is observed that, at the start of exposure, the mA level takes approximately one second before reaching a plateau level, at which time the timer initiates the exposure count-down. This manifests as a timer error and potentially leads to over-exposure for short exposures times. The purpose of this study is to quantify the "ramp-up exposure" (exposure during the mA ramp-up) and the "stable exposure rate" (plateau-region exposure rate) for various settings of this irradiator. A 0.18 cc ion chamber was used to measure the in-air exposures at various exposure times, kVp (120, 250 and 320 kVp) and mA (1, 5, 10, 12.5 mA) levels. For each kVp and mA setting, measured exposures of different exposure times were analyzed to derive the ramp-up exposure and the stable exposure rate. Our measurement and analysis yielded that, for each of the settings studied, the ramp-up exposure is approximately equivalent to one second of stable exposure; for instance, at 320 kVp and 12.5 mA, the stable exposure rate is 4.48 ± 0.02 R/s and the ramp-up exposure is 4.43 ± 0.30 R. In addition, at a fixed mA (12.5 mA), a quadratic correlation was observed between the ramp-up exposure and the kVp level; at a fixed kVp (320 kVp), a linear correlation was observed between the ramp-up exposure and the kVp level. The results of this study depict the significance of the timer error on the clinical use of this particular x-ray irradiator, especially for short exposures times. To correct for the timer error, both quantities, the ramp-up exposure and stable exposure rate, will be necessary to achieve accurate dose delivery.

WAM-B.9 Development of a Computational Eye Model for Use with Whole-body Phantoms

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The use of interventional radiology and cardiology has increased annually over the past two decades. Among the concerns associated with these procedures is the absorbed dose to the lens of the eye received

by physicians and medical support staff. This concern has been enhanced by the release of ICRP Publication 118, which significantly reduced the recommended dose to the eye lens: 20-mSv per year averaged over 5 years with no year to exceed 50-mSv. Modern methods of calculating dose to the tissues of the body utilize Monte Carlo radiation transport simulations with whole-body computational phantoms, which are typically in the form of a regular voxel lattice. However, due to the limitations in many software systems on the total number of lattice elements, the resolution of the phantoms is limited to no less than a few millimeters, which cannot realistically represent the shape of the eye lens with overall dimensions of 9.6-mm across and 4.2-mm thick, and a radiosensitive lens epithelium that is a fraction of a millimeter thick. Here we present the development of a high-resolution eye model that can be incorporated into whole-body phantoms, leading to improved eye dosimetry with negligible impact on computational efficiency. Comparisons with dose conversion coefficients from ICRP Publication 116, which are based upon a stylized eye model, are discussed.

WAM-B.10 Preventing Y-90 Microsphere Medical Events

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According to a presentation to the Nuclear Regulatory Commission from the Medical Radiation Team (9/23/2011), there were 49 medical events reported for the year 2010 and 58 medical events reported for the year 2011. Of the reported events from 2011, 19% involved issues with Y-90 microspheres, which is a slight increase from the year 2010 (14.3%). Although not trivial, the number of reports involving Y-90 microspheres was less than the reports involving patients treated with radioactive sealed sources and external beam radiation (65.5% for 2011). The causes of the medical events involving Y-90 microspheres were retrospectively reviewed for any trends and possible prevention techniques are described. Of the 11 reported medical events from the year 2011, six of the reports indicated issues with the written directive and five reports involved technical issues with the delivery of the microspheres. Nine medical events could have been prevented through improved communication of the written directive or by simply following the manufactures recommended procedures. For the year 2011, 82% of the medical events involving Y-90 microspheres could have been prevented by incorporating the procedures and recommendations of the manufacturers into the institutions program and through incorporating a check system prior to administration of the microspheres.

WAM-B.11 Experiences Building an In-House Supercomputing Cluster for Monte Carlo Particle Transport Code

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Monte Carlo simulation code has a long history of being an effective tool for accelerator and medical health physics dose calculations. Although Monte Carlo simulations are highly effective, high number particle runs needed to obtain statistical significance of results are usually time intensive. As researchers use advanced techniques, such as heavy ion particle tracking code or low energy radiobiological microdosimetry, the processing power needed only increases. Expensive dedicated supercomputers or advanced computational techniques, such as graphics processor based calculations, are often used to shorten computation time and allow users to gain the desired results. However, the expense and complexity of such methods may limit their usefulness. The Health Physics department built a cheap and powerful supercomputing cluster. Computation times were decreased significantly by utilizing the networked faculty and student computer resources already in place. Many investigators could benefit from and implement such methods to increase computational ability in order to quickly and accurately calculate dose for radiation safety and shielding applications.

WAM-B.12 Publishing in Health Physics and Operational Radiation Safety

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This presentation will focus on the complete publication process from manuscript development to final publication. The session will be interactive, and journal staff will be available to respond to questions from participants. This session will be useful for first-time authors or anyone who has questions about the online publication process. Handouts will be available.

WAM-B.13 A New Method of Reducing the Patient Dose Equivalent from Photoneutrons Produced by High Energy Medical Linacs

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One of the important problems in the way of using high energy linacs at IMRT is the production of photoneutrons. High energy photon beams from medical linacs produce, besides the clinically useful photon beams, secondary neutrons. These phtoneutrons increase patient dose and may cause secondary malignancies. The effect of PMMA shield on reduction of photoneutron dose equivalent produced by a high energy medical linac at patient plane is investigated in this study. To determine the photoneutron dose equivalent by a Varian linac working at 18 MV photon mode, Polycarbonate (PC) films was used. Measurements done at distances 0, 10, 20, 50 cm from the center of the x-ray beam for open field and after inserting PMMA shield in the x- ray field. After electrochemical etching (ECE) of the PC films, the neutron dose equivalent was calculated. The results show that by increasing the distance from the center of the X-ray beam towards the periphery, the photoneutron dose equivalent decreases rapidly for both the open and shielded fields and that by inserting the PMMA shield in the path of the x-ray beam, the photoneutron dose equivalent was decreased obviously comparing to open field. Results show a PMMA shield, can significantly reduce photoneutron dose equivalent to patient. These results can be readily generalized to other models of medical linacs. It may be concluded that using this kind of shield can help more safe and efficient reemployment of high energy linacs in radiotherapy and IMRT.

WAM-B.14 Evaluation of Neutron Contamination on the Patient Plane of Three Linac using Three Passive Techniques

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According to Algerian health sector plan, more than fifteen new radiotherapy facilities will be built around the country in the next five years. Most of these new facilities will be equipped with dual-energy linear accelerators with high photon energy; nowadays, most medical accelerators produce beams with a maximum energy of 18 MeV or 25 MeV. However, the use of high energy electron and photon beams is accompanied by the generation of undesired neutrons produced by photoneutron reaction (γ,n) between photon and target nuclei in and round the machine. Neutron measurements on the patient plan and in side the primary beam are difficult because of photon interference. Moreover, neutron detection is spread over many decades of energy ranging from thermal energies to several MeV. No single detection system can accurately measure neutron fluence or dose equivalent over the entire energy range. In the present study, thermal and fast neutron fluencies on the patient plane and round the machine are determined at three medical linear accelerators : Varian 2100C, Siemens Primus, and Electa, using three passive techniques: the phosphorous pentoxide, thermoluminescent detectors (TLD600 and TLD700), and CR-39 detectors (with PE converter). A comparison between the results on neutron contamination obtained around the three linear accelerators with the three techniques is presented and discussed.

WAM-C.1 Experiences In Establishing And Managing an I-131 MIBG Therapy Program

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The use of I-131 MIBG is being used for the treatment of relapse neuroblastoma in a wider number of locations and clinical studies. The planning and initial start-up of requires the involvement of a number of areas and resources from within an institution and typically will include the need for approval of external regulatory agencies. The process of initial planning, financing, construction, and staffing are all important components to the creation of an integrated and successful process and program. Specific emphasis on radiological safety and control are required to ensure adequate training, monitoring, and protection of staff and caregivers as well as the design of facilities and procedures that satisfy clinical and regulatory requirements. The oversight and feedback on programatic weaknesses and patient specific deviations to protocol are necessary for the execution of safe and effective treatments. Establishing comprehensive programs of training, in-services, and post therapy safety instructions are all necessary components to effective management and compliance with patient, clinical and regulatory need.

WAM-C.3 Anatomy of Stanford's Yttrium-90 Microsphere Program

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The role of a medical health physicist in a hospital environment involves routine work such as instrument calibration and room surveys. At a university medical center the medical health physicist may also be a collaborative partner in cutting edge therapies. In the case of Yttrium-90 microsphere therapies many hospital departments participate and have a role. The multi disciplinary approach for microsphere therapies varies from institution to institution. This presentation will review Stanford University's procedures and collaboration between twelve different departments. These departments include Interventional Radiology, Health Physics, Nuclear Medicine, and Clinical Coordinators. Topics discussed will include an introduction to microsphere therapy; the radioactive material license amendment process (Yttrium-90 microspheres actually a "device" as opposed to radioactive material); Stanford's review and approval of authorized users (can be an ever-changing process); written directive documentation developed to meet both the need of doctors and regulators. Lastly, training requirements will be reviewed.

WAM-C.4 Discriminal Analysis of the Total Scatter Factor in Water Phantom for Photon Dose Calculation using the Eclipse Treatment Planning System

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In this work, an extensive set of measured data was developed to verify the accuracy of a photon dose calculation algorithm for the Eclipse treatment planning system (TPS). Test cases included square fields, rectangular fields, fields having different source-to-surface distances, wedged fields, irregular fields, obliquely incident fields, asymmetrically collimated fields with wedges, multileaf collimator-shaped fields. The data set was used to validate the photon dose calculation algorithm in the Eclipse TPS. The monitor unit tests revealed that the 6 MV open square fields, rectangular fields, wedged fields, oblique incidence, source-to surface distance variation, mantle field, half beam block, and oblique incidence with wedge test cases did not meet the TG-53 criteria all the time. The results can be used also to establish standards of acceptance for the demonstration of the correct working of the TPS in regular QA-checks. The algorithm must accurately calculate dose distributions for a variety of clinical beam configurations. It was concluded that the generally stated goal of accuracy in dose delivery of within 5% cannot be met in all situations using this beam model in the Eclipse TPS. Although Eclipse is more accurate than measured reading for total scatter factor in water phantom, it is recommended to improve the accuracy of the treatment planning process, e.g. with the incorporation of the Monte Carlo calculation method to the latest version of Eclipse. Key words: photon dose calculations, accuracy, Eclipse, radiotherapy.

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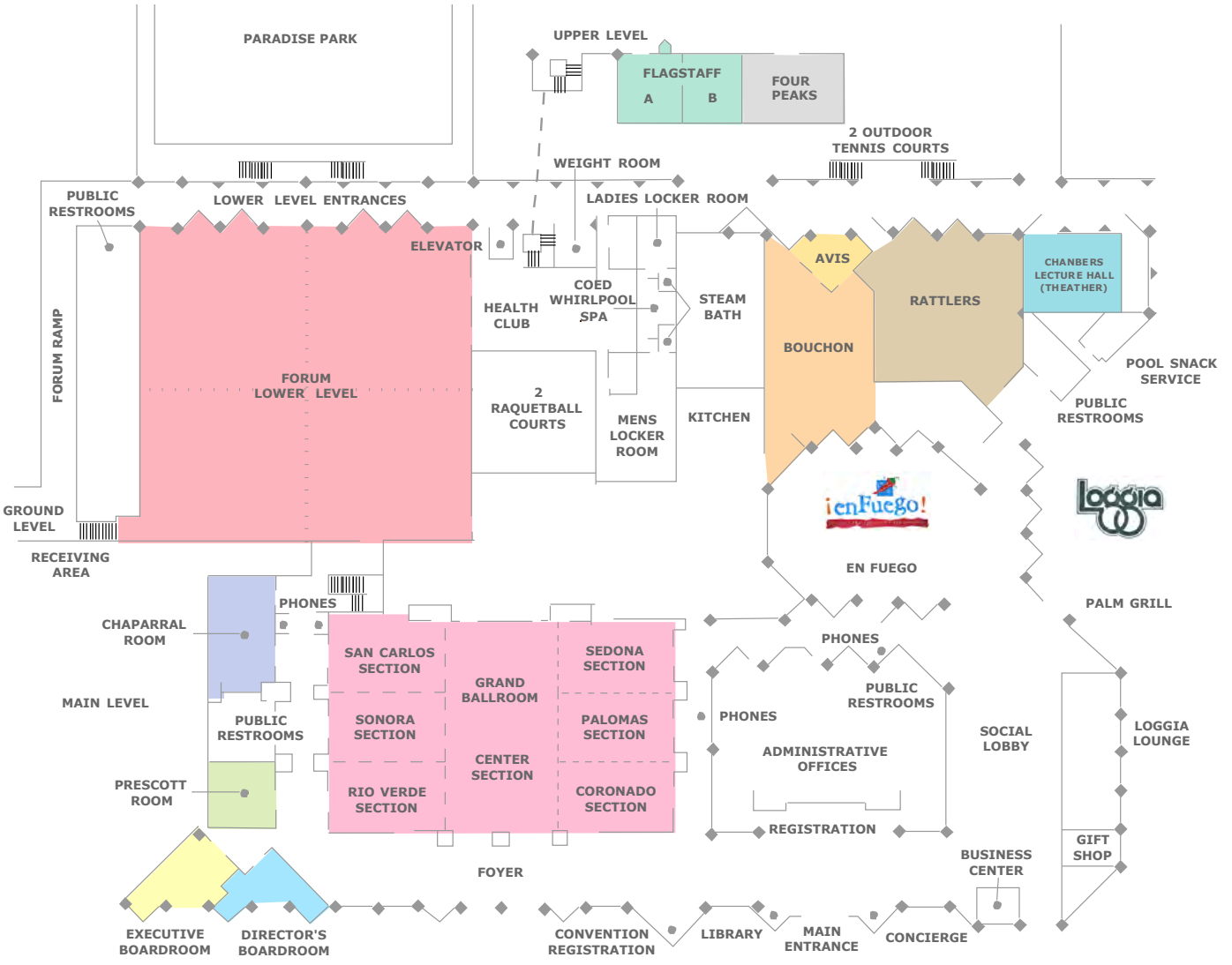

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