Radiation Countermeasures Research and Development

SAM Therapy Scientific Symposium AAPM 2016

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Disclosures

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- BARDA/Argentum Medical, HHSO10020130019C

Radiation Countermeasures Research and Development

Initiatives by NIAID, BARDA, DOD, NASA, and NCI to develop Medical Radiation Countermeasures to address:

- Radiation-induced injury from radiation and nuclear events
- Radiation risks incurred during and after travel in space
- Radioprotectors and mitigators to improve outcome of radiation treatment

Strategies include repurposing of agents as countermeasures

Medical Countermeasures Against Radiation

In response to large-scale event, for risk reduction of long-term space flight, for prevention and treatment of treatment morbidity

https://www.medicalcountermeasures.gov/


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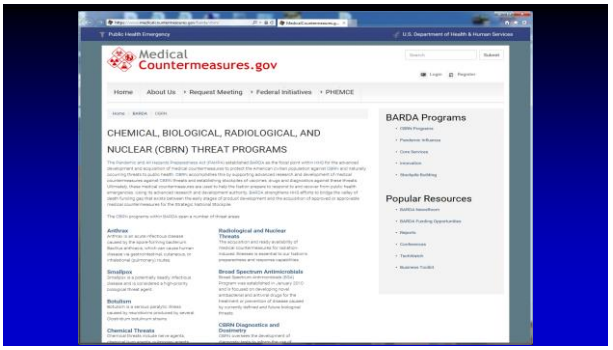
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CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR (CBRN) THREAT PROGRAMS
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BARDA Programs
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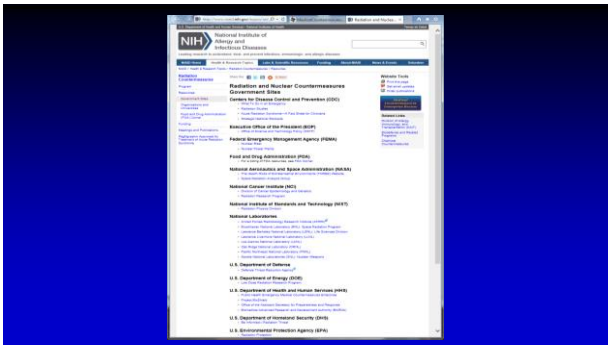

NIH
National Institute of Allergy and Infectious Diseases
Radiation and Nuclear Countermeasures Government Sites
Centers for Disease Control and Prevention (CDC)
Executive Office of the President (EOP)
Federal Emergency Management Agency (FEMA)
Food and Drug Administration (FDA)
National Aeronautics and Space Administration (NASA)
National Cancer Institute (NCI)
National Institute of Standards and Technology (NIST)
National Laboratories
U.S. Department of Defense
U.S. Department of Energy (DOE)
U.S. Department of Health and Human Services (HHS)
U.S. Department of Homeland Security (DHS)
U.S. Environmental Protection Agency (EPA)

Symposium Speakers

Physics and Dosimetry for Radiation Countermeasure Research
JD Bourland, Ph.D., Professor, Radiation Oncology, Wake Forest University

The NIAID Radiation/Nuclear Medical Countermeasures Program
Lanyn P. Taliaferro, Ph.D., Program Officer, RadNucMed CMs Program, NIAID

The BARDA Chemical/Radiological/Nuclear Countermeasures Effort
Tom Hu, Ph.D., Senior Program Analyst, BARDA, ASPR, HHS

Radiation Countermeasures and the NCI Radiation Research Program
Pat G. Prasanna, Ph.D., Program Director, Radiotherapy Devel Branch, NCI

Radiation Countermeasures and the NASA Space Radiation Program
Janice L. Huff, Ph.D, Dep Element Scientist, NASA Space Radiation Program

Symposium Learning Objectives

1. Review US national radiation countermeasure activities.
2. Review the roles for medical physicists in radiation countermeasures research and development.
3. Understand specific physics challenges in radiation research that need solutions.

Physics and Dosimetry For Radiation Countermeasures Research

- Physicists and their (our) physics are integral to RCM work
- Understand the hypothesis or intent of study
- Communicate radiation physics principles and safety
- Devise specific research irradiation geometries
- Devise quality assurance procedures
- Oversee and validate delivered research procedures and dose
- Analyze and communicate results

Radiation Response Sequence

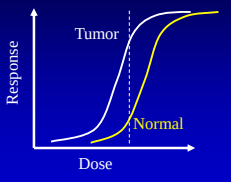
Physical
↓
Chemical
↓
Biological
↓
Clinical

Physicists must know research intent for the length of this chain

Radiation Biology and "Treatment"

Radiobiology of Tumor and Normal Tissues

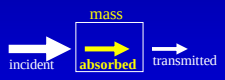
- Radiation Biology "is complicated"
- Sigmoidal dose-response curve
- Response is dependent on
  - Total radiation dose
  - Fractionation regimen (# of fractions, dose per fraction)
  - Dose rate
  - Radiosensitivity of target
  - Radiosensitivity of nearby normal and/or critical structures, etc



Communication Challenge

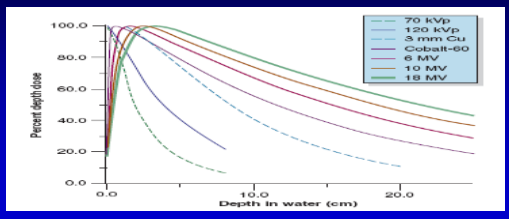
Radiation Dose: E / mass

- Dose: energy absorbed per unit mass
  - Unit: rad 1 rad = 100 erg/g
  - SI Unit: Gray 1 Gy = 1 J/kg
  - Conversion: 100 rad = 1 Gy
- Measured by ionization, calorimetry, or chemical
- Calibration protocols defined
- Great detail in practice
- See your local physicist



Communication Challenge

MV and kV Radiation Beam Depth Dose Curves

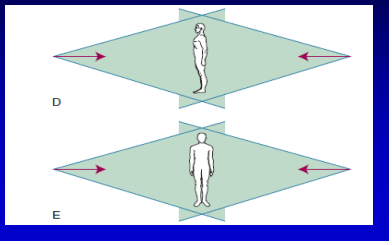


Physics Challenge

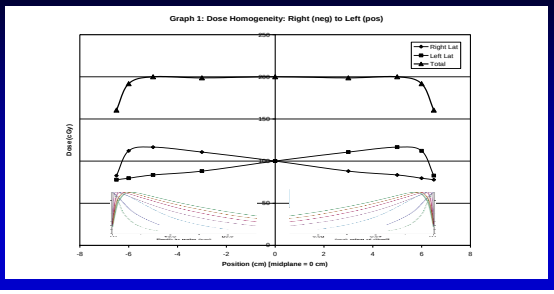
Whole Body Irradiation Geometry

Two Most Commonly Used

- Which technique is best?
- Animal species in use?
- Photon energy?
- Dose calc point?
- Dose rate?
- Y/N Buildup?
- Y/N Compensation?
- Overall dose homogeneity?
- Dose monitoring?



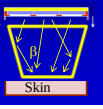
6MV Dose Homogeneity: 14cm diameter

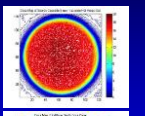


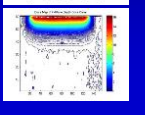
Physics Challenge

CRI Study: Create unique β Irradiation Device

- Custom and specific design for CRI research irradiations: BARDA funded
- Array of 7 Sr-90 β-ray sources, commercial grade, 1.5 cm ϕ disks
- ~40 mm diameter field: 10 cm^2 area per CDC, no field corners
- Steep dose gradient, high superficial dose [Sr-90 β-rays: $\bar{E} \sim 1MeV$]
- Aluminum construction, low bremsstrahlung, simple, ON / OFF operation

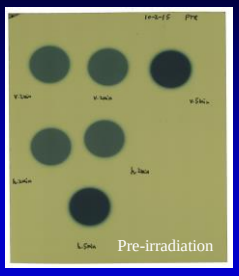


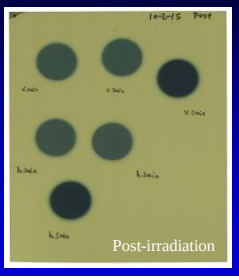




Physics Quality Assurance

Day of Irradiation Quality Assurance

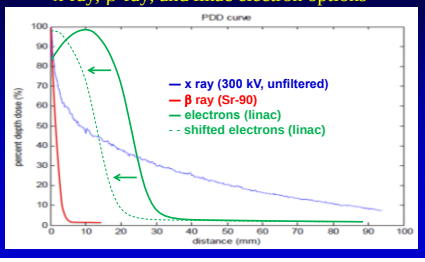




Physics Challenge

Radiation Type And Depth Dose For CRI

x-ray, β-ray, and linac electron options



Physics and Dosimetry For Radiation Countermeasures Research

Summary

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Funding agencies are requiring physics aspects

NIH Example – Physics Criteria & Factors

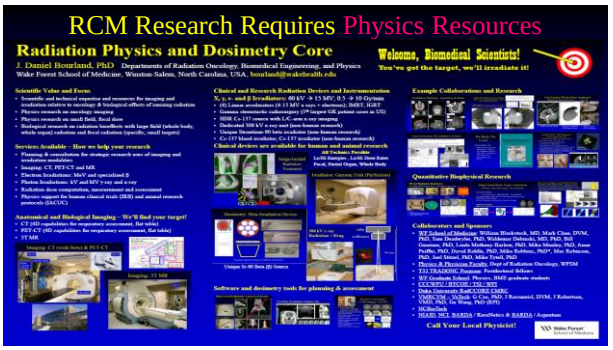
FOA Number: PAR-16-111

Coop Agreement to Develop Targeted Agents for Use with Systemic Agents Plus Radiotherapy (U01)

- "Ensuring accuracy and consistency of irradiation protocols through NIST-traceable dosimetry testing and on-going validation, and detailed, translatable reporting of irradiation set-up details (standard operating procedures) for *in vitro* and *in vivo* studies"
- "A minimum of $50,000 direct costs need to be budgeted to fulfill cooperative agreement requirements for NIST traceable dosimetry of all radiation producing equipment"
- "letter(s) documenting ongoing physics support for all proposed radiation sources"
- "letter of agreement with a certified dosimetry lab for provision of NIST-traceable dosimetry for the duration of the project"
- "What strategies are in place for obtaining NIST-traceable dosimetry of irradiators and ongoing physics support? What standard operating procedures are in place and are these transferable between laboratories?"

AAPM ADCLs are now aware

RCM Research Requires Physics Resources



And Collaborators and Partners

- WF School of Medicine
  - Sue Appt, DVM
  - Dave Caudell, DVM, PhD
  - Mike Chan, MD
  - Mark Cline, DVM, PhD
  - Sam Deadwyler, PhD
  - Waldemar Debinski, MD, PhD
  - Rob Hampson, PhD
  - Bob Kraft, PhD
  - Linda Metheny-Barlow, PhD
  - Mike Munley, PhD
  - Anne Peiffer, PhD
  - Tom Register, PhD
  - Mac Robinson, PhD
  - Carol Shively, PhD
  - Mike Tytell, PhD
  - Jeff Willey, PhD
- WF Graduate School
  - Physics, SBES grad students
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  - Postdoctoral fellows
- WFU Radiation Oncology
- CCCWFU / BTCOE / TSI
- Duke Univ RadCCORE
  - Postdoctoral fellows
  - CMCR, NIAID
- VMRCVM - VaTech
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  - J Robertson, VMD, PhD
- NCBioTech
- NIH, NCI, NIAID, BARDA, DOD

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