Council on Ionizing Radiation Measurements & Standards

CIRMS Poster Blitz

Session 2

Tuesday April 14

Advancing Neutron Shielding Evaluation Through LET Measurement and Spectrum Reconstruction with MCNP, FLUKA, and Neural Networks

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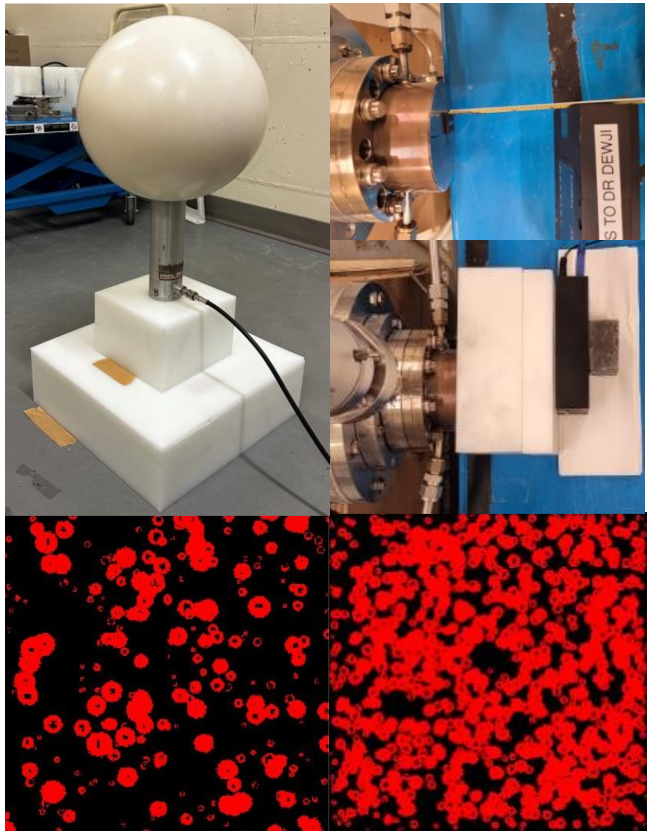
Georgia Tech Nuclear and Radiological Engineering and Medical Physics
Woodruff School of Mechanical Engineering

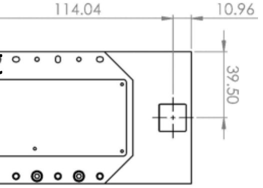
RED2 Radiological Engineering, Detection, and Dosimetry

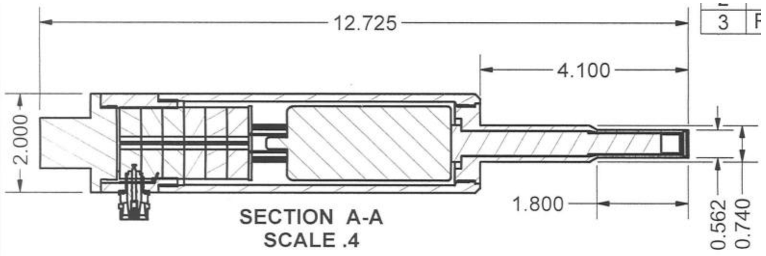
Challenge: Neutron spectrum unfolding amplifies measurement uncertainty and is computationally intensive

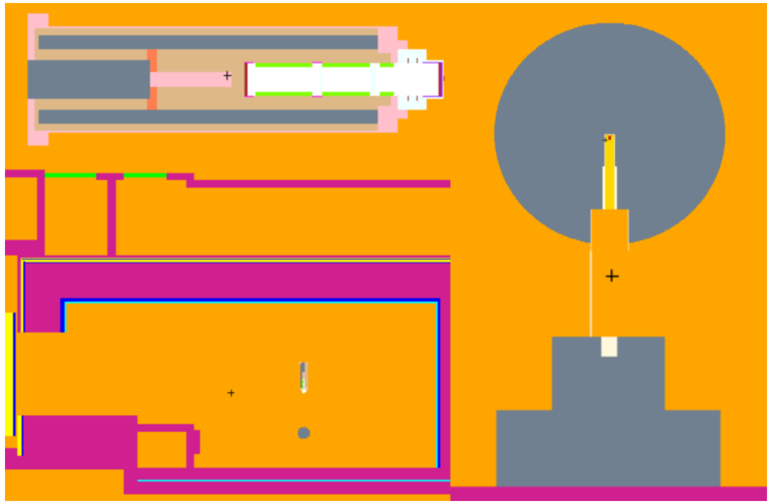
Impact: ML and Timepix3 enables rapid spectrum reconstruction and direct LET quantification



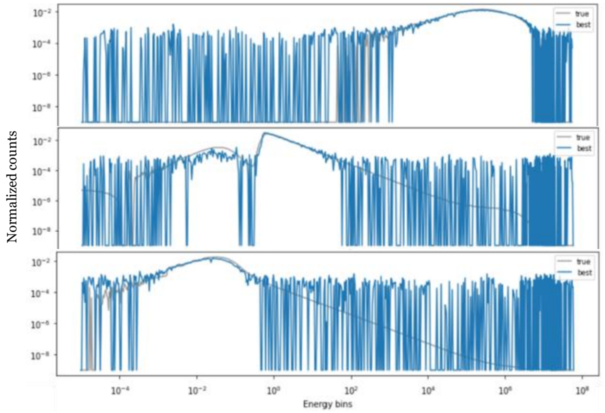
Experiments

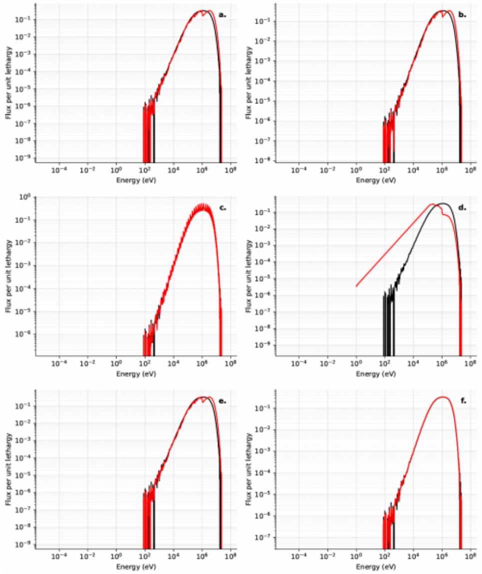






Simulations
MCNP/FLUKA





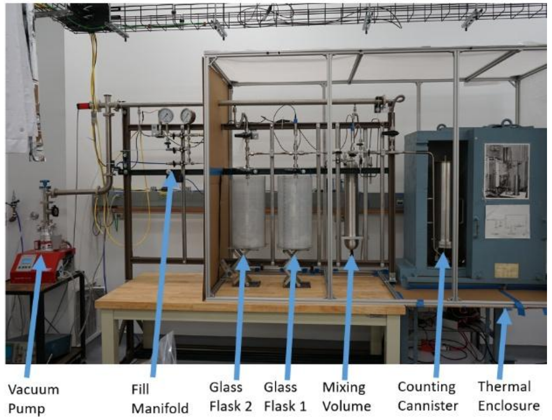
Machine Learning

Quantitative Gas Transfer for Re-Establishing Gaseous Source Measurements at NIST

Max Carlson

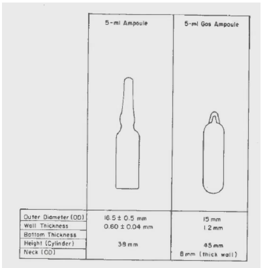
Physical Measurements Laboratory, National Institute of Standards and Technology, Gaithersburg, MD, 20899-8462

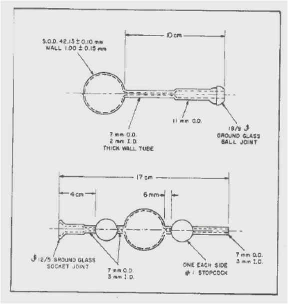
max.carlson@nist.gov



Gas Counting System

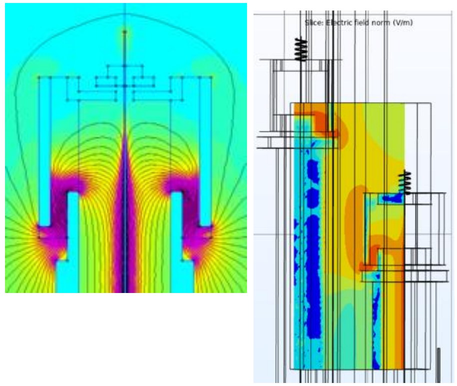
Sample Containers



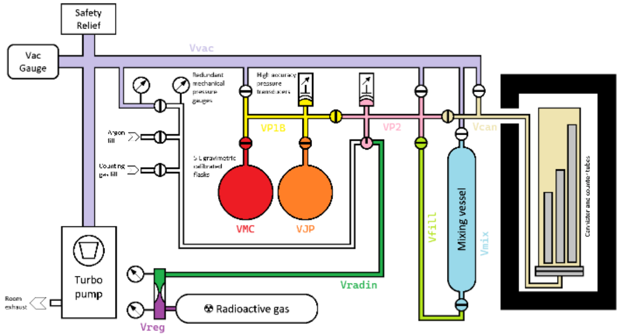


Volume Calibration

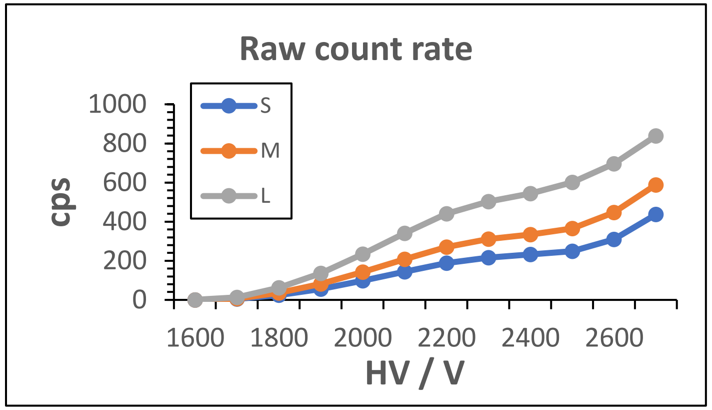
Electrostatic Simulation

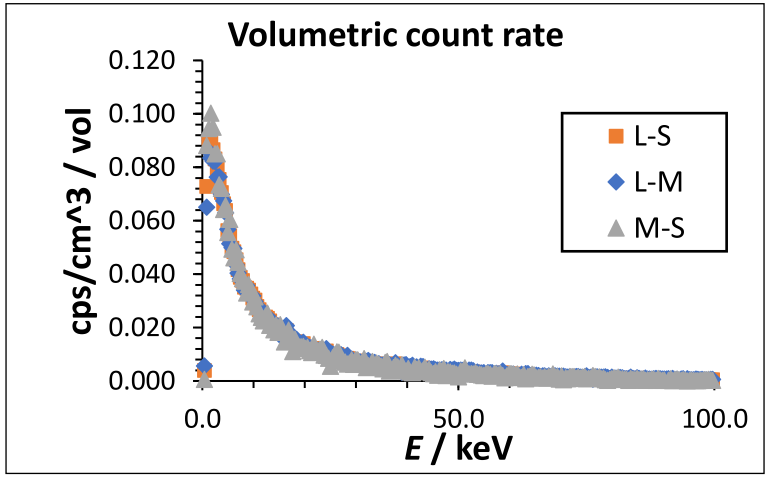


Gas Transfer Procedure



First Kr-85 Results

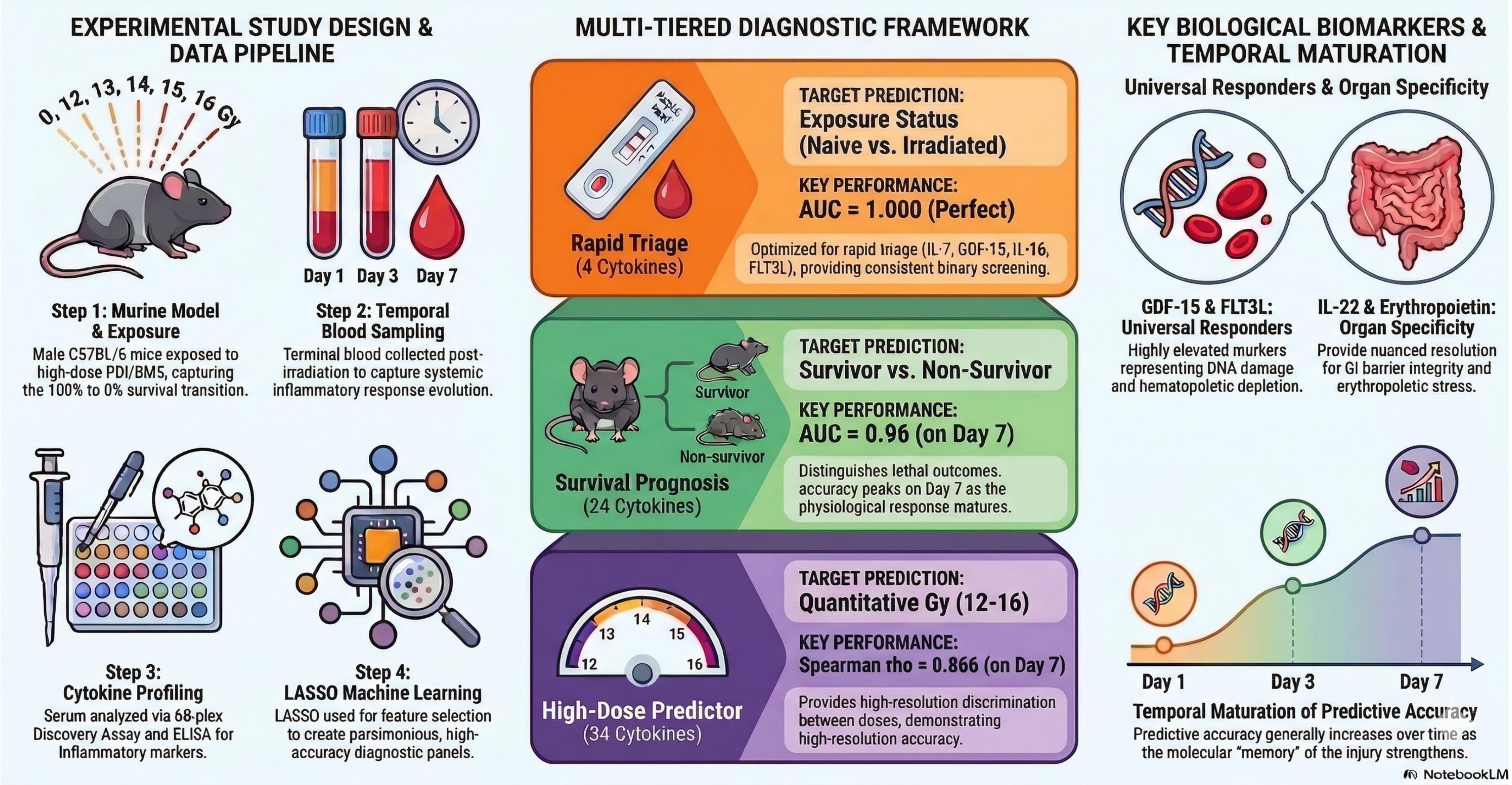




CYTOKINE PROFILING TO PREDICT LETHALITY AND HIGH-DOSE EXPOSURE IN A MURINE PARTIAL-BODY IRRADIATION MODEL

Wanchang Cui, Lisa Hull, Asher Rothstein, Li Wang, Bin Lin, Min Zhai, Alia Weaver, Mang Xiao

Armed Forces Radiobiology Research Institute, Uniformed Services University of the Health Sciences, Bethesda, MD, USA

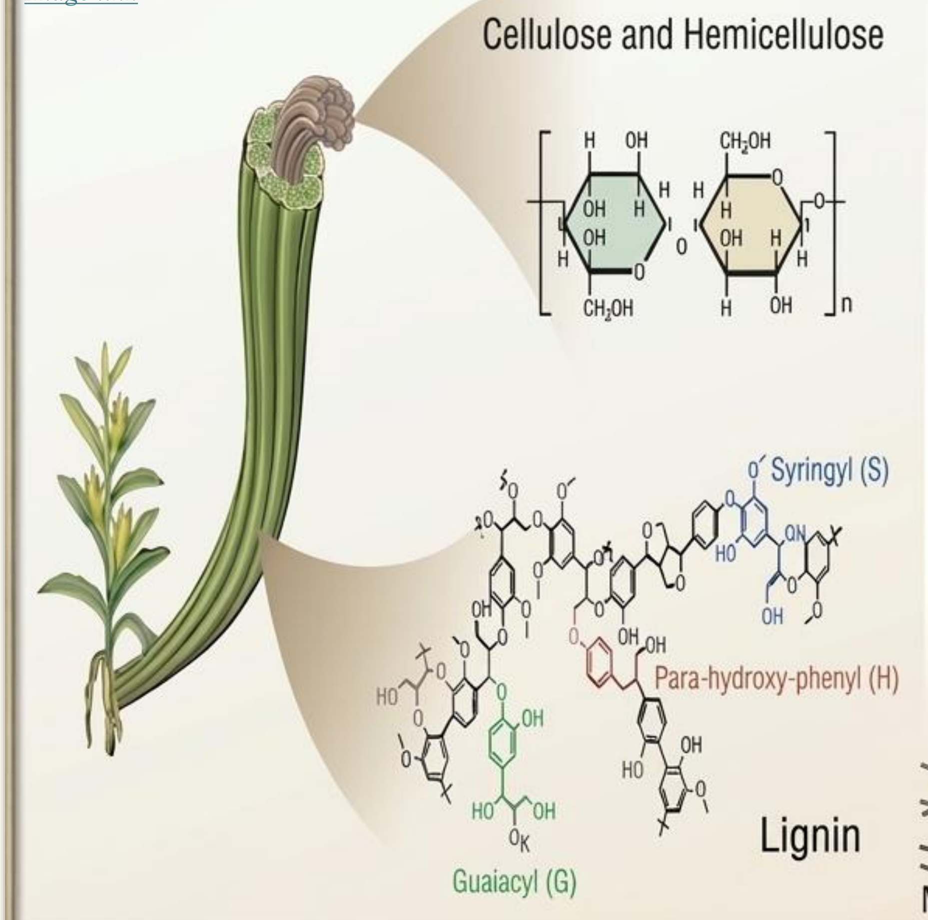


Evaluating the Structural Changes of Irradiated Lignin Following 25–200kGy Electron Beam Exposure

Tau David, Richard List, Mark Driscoll

Department of Chemistry, State University of New York College of Environmental Science and Forestry, Syracuse, NY, 13210

Image link



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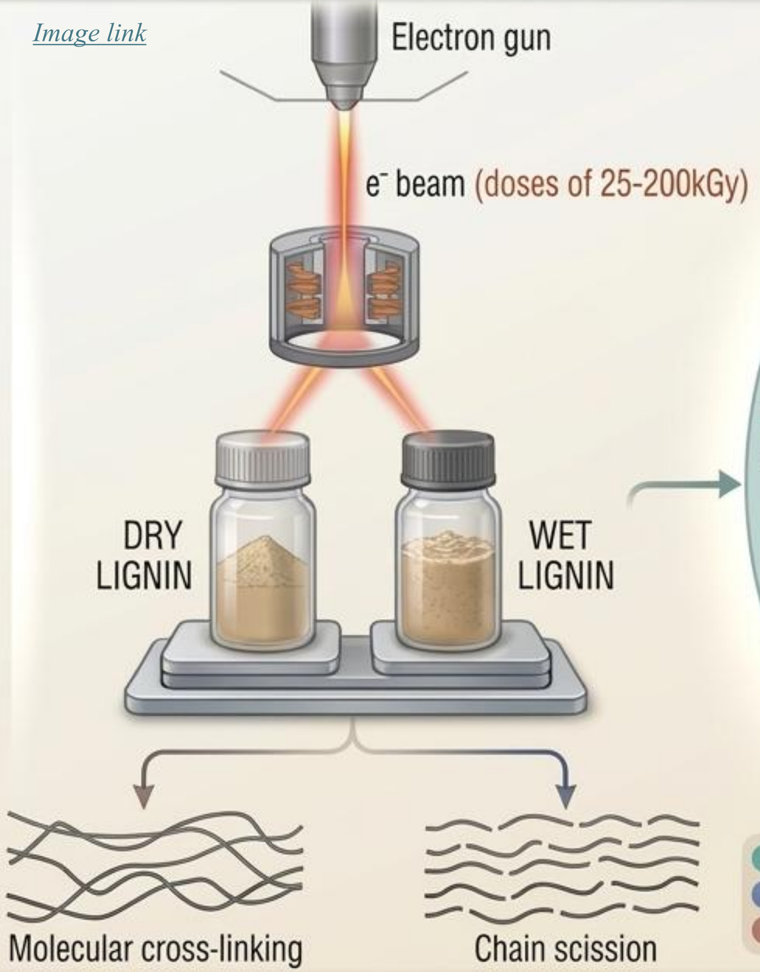

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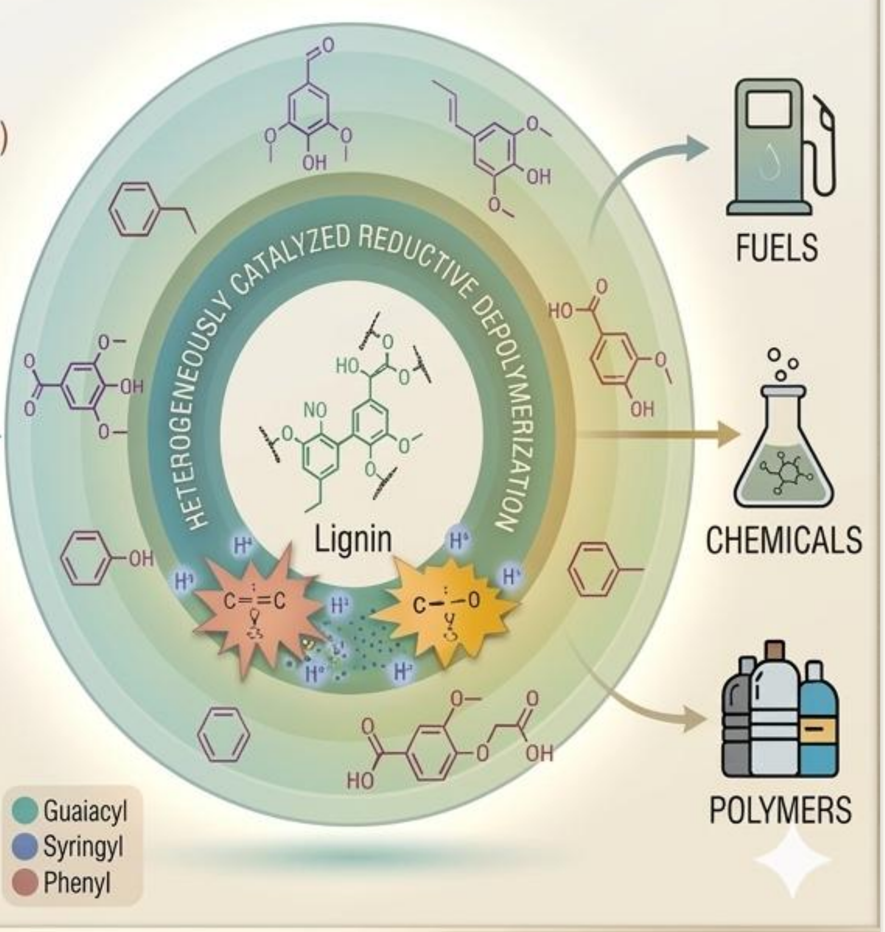

Cellular-Level Dosimetric Characterization of Ionizing Radiation *via* Monte Carlo N-Particle (MCNP6) Simulation

For information about this poster presentation and blitz presentation, please contact the author:

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Measurements of Radiation Transport and Energy Deposition With Fast Neutrons, β's and Compton electron

Noel A. Guardala

Brookhaven Technology Group

- Using both Ga2O3 and GaN scintillators we have measured radiation transport and energy loss with monoenergetic neutrons from 0.289 – 1.5 MeV accelerator produced also with 234Th and 234mPa Compton electron's (from DU) and β's
- In addition with the Compton electrons from 478 keV γ's prompt emission from 7Li, (p,γ) as well as with 60Co and 137Cs
- Initial spectral measurement of all the radiations done with no extra material in front of detector
- Then various absorbers like poly, heavy metals, Si and Kapton are placed in front of the detect and data collected in same fashion as for the initial spectral response measurements
- For some of the "filtered" measurements the thickness of absorber can be changed by thickness alterations on the level of 60 microns. Neutron measurements require much thicker amounts of absorber with no further thickness information
- With thin absorbers like Kapton information about energy depositions on the 5-10 micron level for both β's and Compton electrons
- For neutrons, β's and Compton e-s the spectrum attenuated or not the radiations produce a continuum in the scintillator that would benefit from comparison with various transport codes and also by the use of AI techniques for better data analysis.

Establishment of an *in vivo* dose-response *relationship between* 24Na activity and neutron doses in C57BL/6 mice

Lisa Hull[1,2], Addison Guynn[1], Asher Rothstein[1,2], Min Zhai[1,2], William F. Blakely[1], Mang Xiao[3], and Wanchang Cui[1]

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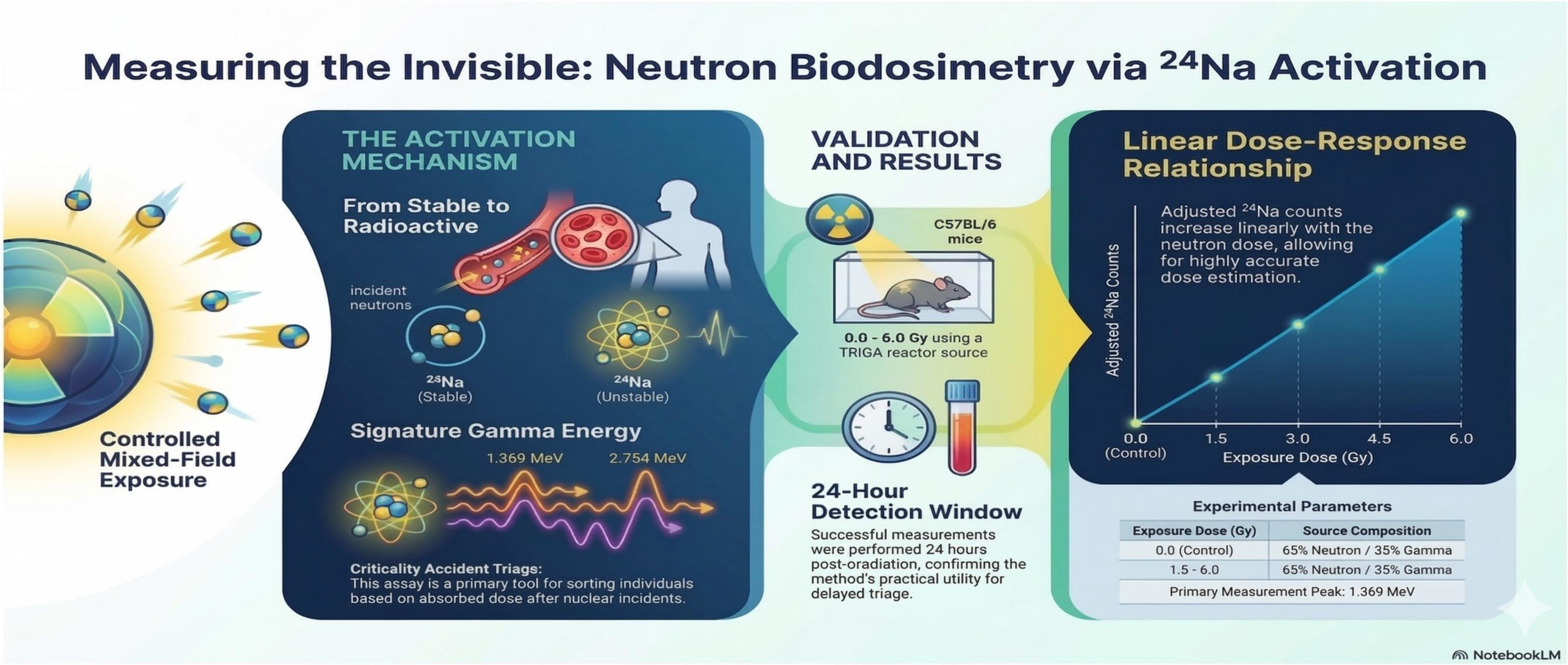
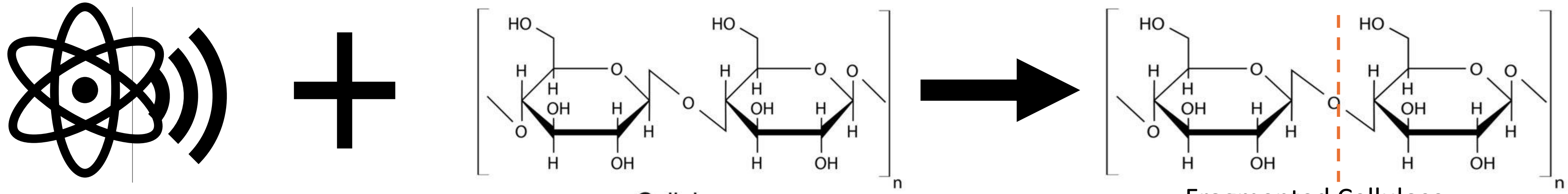
[2]Henry M Jackson Foundation for the Advancement of Military Medicine, Inc., Bethesda, MD 20817, USA

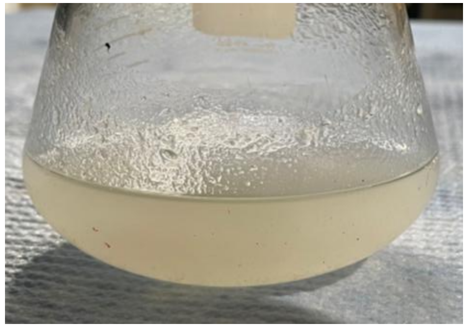


Optimization of Alpha Cellulose and N-Cellulose Solubility in Sodium Hydroxide



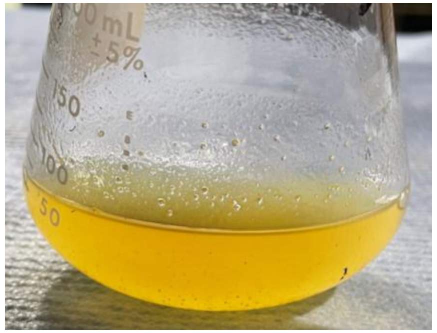
Cellulose

Fragmented Cellulose

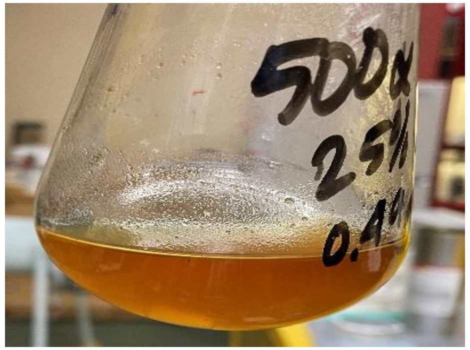


0 kGy alpha cellulose

100 kGy alpha cellulose



250 kGy alpha cellulose



500 kGy alpha cellulose

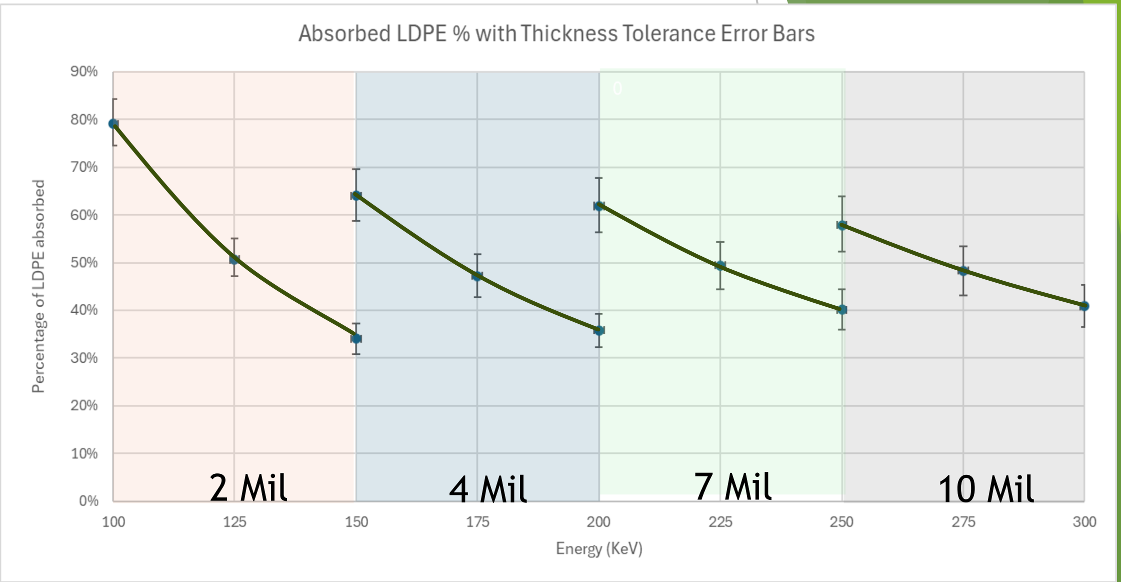
750 kGy alpha cellulose

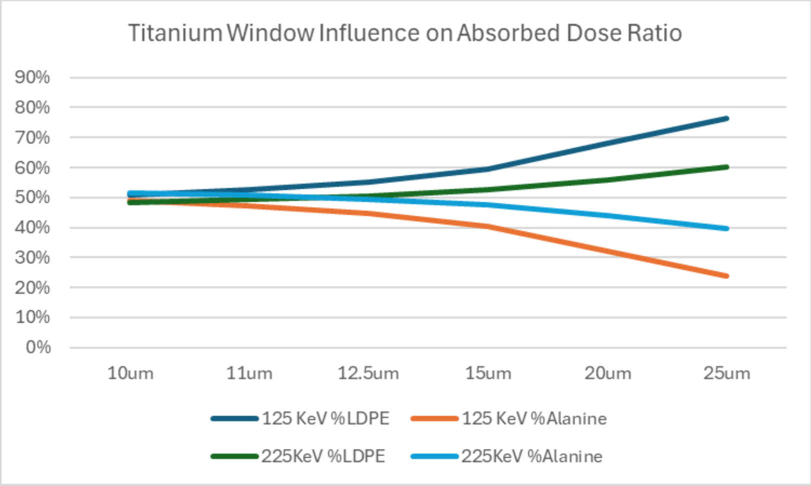
1000 kGy alpha cellulose

Analysis of Electron Beam Calibration Using a Depth-Dose Channel Ratio Model

Using ratio between an absorber layer and dosimeter can deliver an accurate accelerating voltage measurement at low beam energies

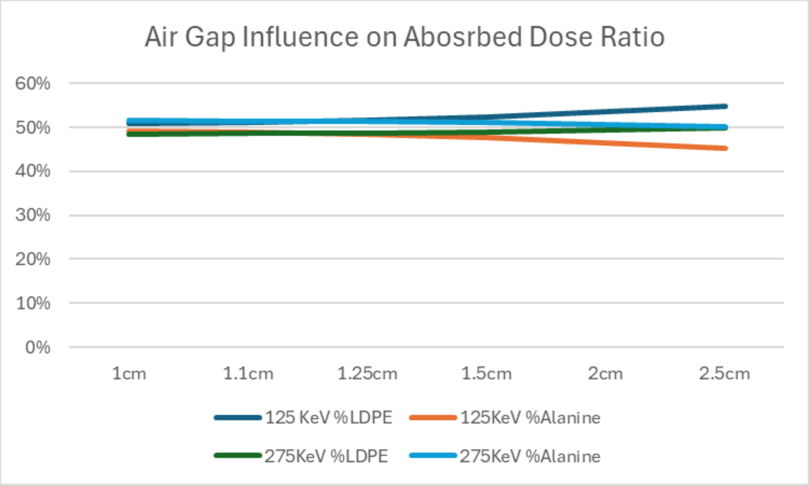
- The PENELOPE Monte Carlo code for radiation transport was used to calculate a channel ratio between the alanine dosimeter and stepped polyethylene absorber layers. 50 KeV increments ranging from 100 KeV to 300 Kev were examined for use as a reference curve during electron beam calibration. The curves at LDPE thickness intervals, which LDPE error bars are depicted to the right.
- For LDPE thickness tolerance consideration: despite large change in LDPE/alanine percent change with +/- 10% thickness variation, an uncertainty reduction method is described in Palm and Driscoll 2025[1].
    - A new comparator tool using ANOVA F-statistic shows promising results to match curves. Comparator tool is still in development.





To keep variation within 1-2% the Titanium window thickness should be kept to +/- 1μm. The AIR gap, despite the prescribed 1cm layer, will maintain accuracy through 2cm of thickness.

Air Gap



[1]Palm, A., & Driscoll, M. (2026). Calculations for electron beam calibration using a depth-dose channel ratio. *Journal of Radioanalytical and Nuclear Chemistry*, 1-8.

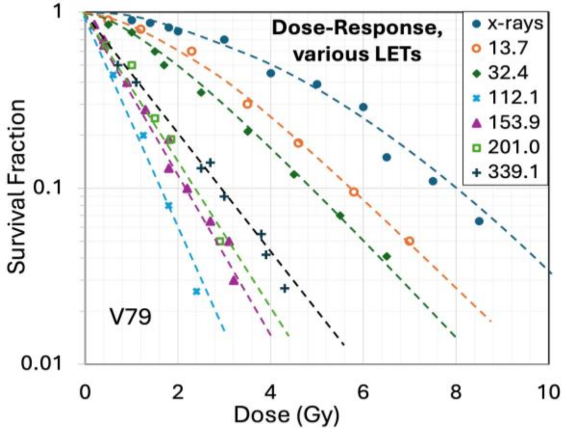
A Novel Biomolecular Dosimetry Metric for Biological Assessment of Particles & Ions

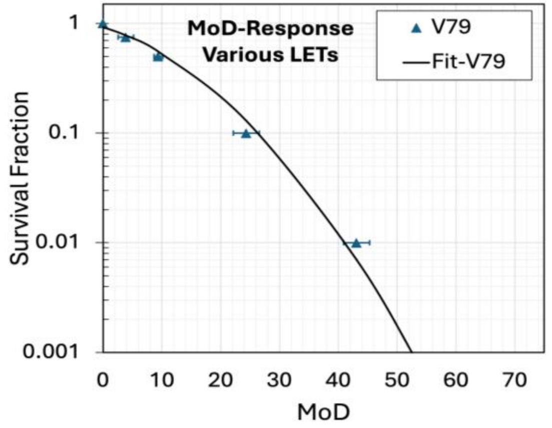
Mohammad Rezaee and John Wong
Radiation Oncology and Molecular Radiation Sciences, Johns Hopkins School of Medicine, Baltimore, MD

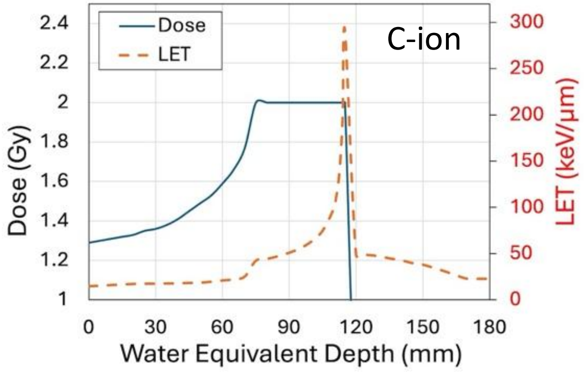
Ionization Dosimetry

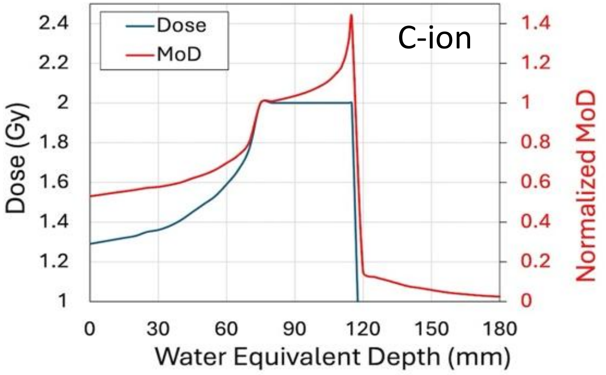
- **Current Standard:** Biological effects assessed by dose in ***Gy***.
- **Limitation:** *Gy* insensitive to *LET* and its biological effects.
- **Applications:** Need empirical factors – **RBE** and **Q-factor**.

Applications: *Gy* vs *MoD*



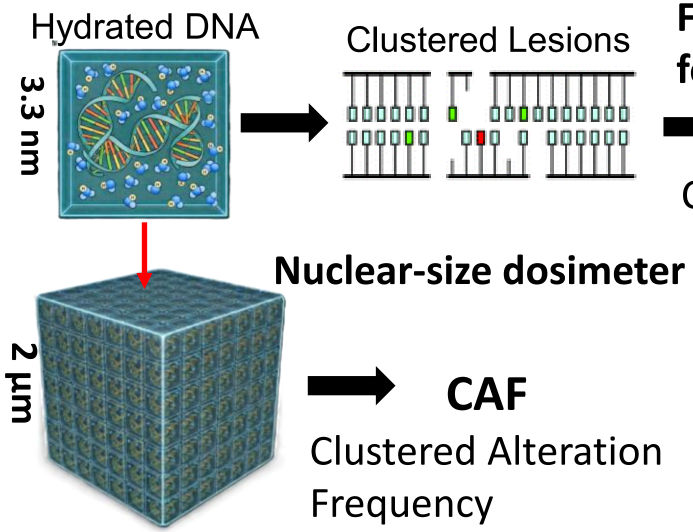






Biomolecular Dosimetry

- <u>Hypothesis</u>: $MoD = f(Molecular\ Alteration)$



Fundamental Parameter for Molecular Dosimetry

→ **CAS**
Clustered Alteration Size

→ **CAF**
Clustered Alteration Frequency

$$MoD = CAS.CAF$$
$$CAS \propto LET$$
$$CAF \propto \varphi$$

Conclusion

- *MoD* captures the effects of *LET* on radiation damage without the need for RBE.
- *MoD* offers a single metric to support clinical practice and decision in particle therapy.
- *MoD* can be used for radiation protection dosimetry.

New Version of PUFFIn Software That Allows Quick Beam Quality and Biological Specimen Dose Distribution Information for Cabinet Irradiators

Randy Schwarz, Mie Azuma, Mark Murphy, Cassidy Zehner, Peter Weil
Pacific Northwest National Laboratory, Richland, WA, 99354 USA

Overview of the Problem

For decades, radiation biology researchers have utilized cesium-137 based irradiators for irradiation of their biological specimens. Due to stricter regulations and increasing costs associated with radionuclide irradiators within the last decade, many institutions are transitioning from these Cs-137 irradiators to X-ray based irradiators. The main complications or issues new users experience with these X-ray irradiators are the differences between their old Cs-137 irradiator and the new X-ray irradiator in terms of 1) The dose distribution within specimens for a given calibrated Gy/min in air, and 2) the difference in biological response for specimens for a given delivered Gy. Many of these researchers are finding that their new X-ray irradiator allows them to perform studies that are very difficult using Cs-137 irradiators.

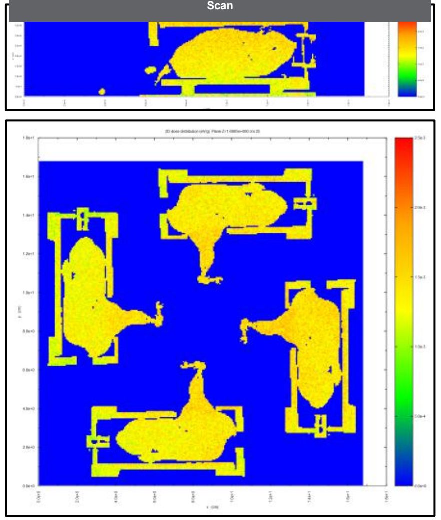
Pacific Northwest National Laboratory (PNNL) has identified that a significant tool gap within the radiation biology research community is a dose distribution software tool that is simple to use, ultra-fast processing times, can be run on a regular laptop, and novices can learn and use with minimal training

What is PUFFIn?

Puffin is a user-friendly fast interface for doing dose mapping of products or specimens irradiated with an electron beam, X-Ray or gamma source:

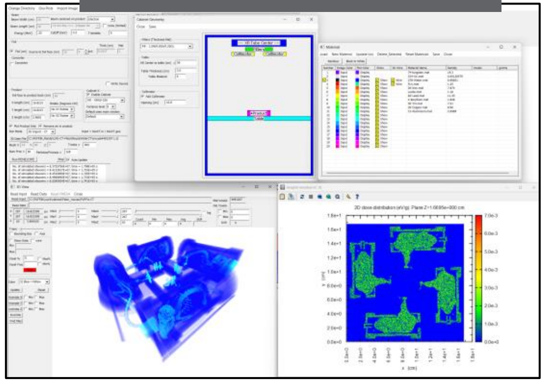
- Source can be electrons, X-rays or a gamma rays
- The geometry can be a simple volume, a voxelized image or a geometry converted form CAD
- The dose can be displayed as line plots, contour plots or 3D data plots
- PUFFIn uses the PENELOPE Monte Carlo code for its calculations
- PUFFIn can create a 3D dose map of a product:
  - Show the minimum and maximum dose locations
  - Help with the placement of dosimeters (Simulation Assisted Dosimetry)
  - Show the differences between electron beam, X-Ray and gamma
  - Show the total dose map for multiple beams
  - Optimize the design of new products
  - Optimize the packaging configuration of a product.
- See Schwarz, et al., *Radiation Physics and Chemistry* 2024. 10.1016/j.radphyschem.2024.111774

Calculation of Dose Distribution in Shielded Mice – From CT Scan

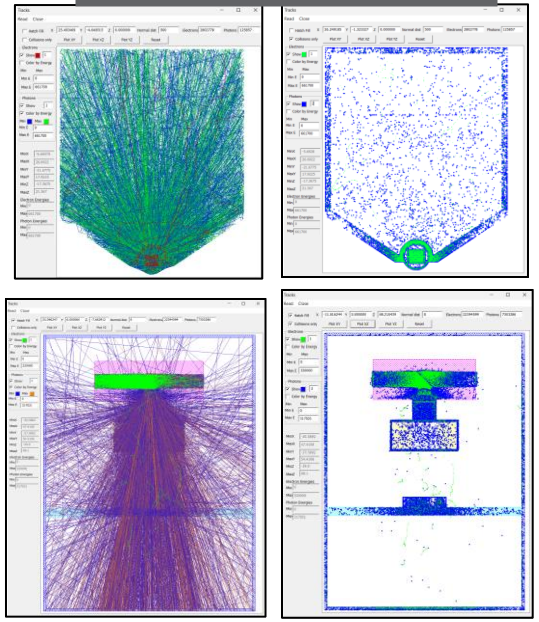


PUFFIn can generate dose contour maps for mouse specimens

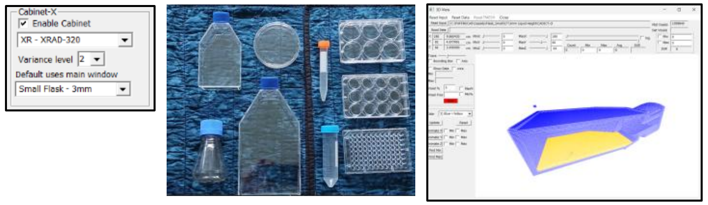
Main User Interface



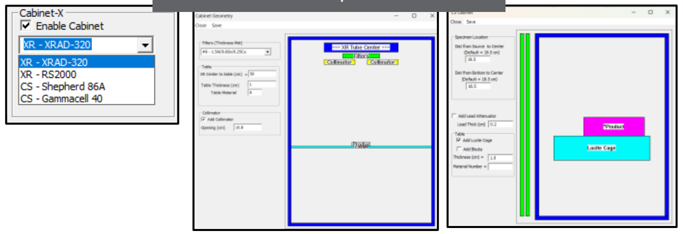
Photon and Electron Tracks Feature



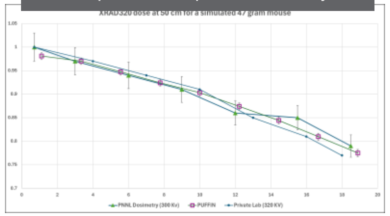
Selection of Cabinet Type and Specimen Type

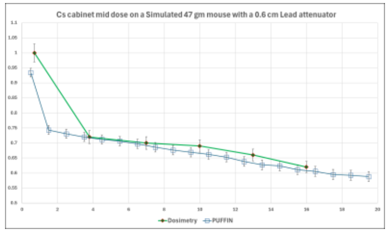


Cabinet Options



Comparison with Experiments/Dosimetry





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NNSA National Nuclear Security Administration

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Pacific Northwest NATIONAL LABORATORY
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Calibrating a Secondary Standard Ionization Chamber for Photon-Emitting Radionuclides in ISO 10R Vials

For information about this poster and blitz presentation, please contact the author directly.

Electron-Induced Degreadation of PTFE

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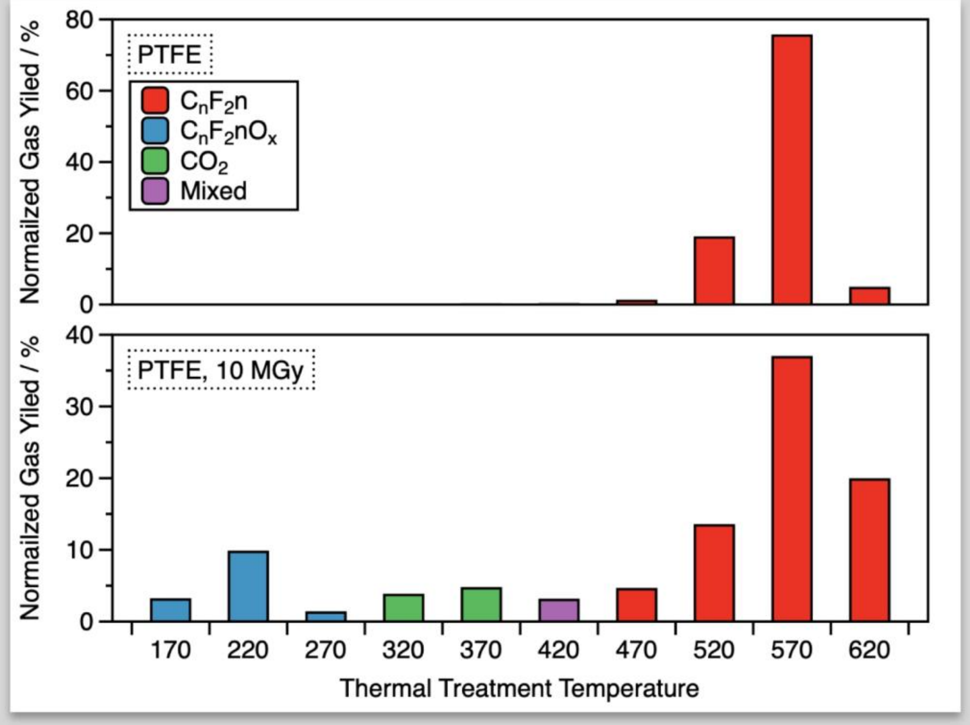
University of Notre Dame, USA;
National Institutes for Quantum Science and Technology, Japan;

Bulk Decomposition

1. High-dose Electron Irradiation

H. Yu et al., Radiat. Phys. Chem., 2024, 216, 111435



High-dose irradiation shifts PTFE decomposition to lower temperatures.

2. High-Temperature Effects

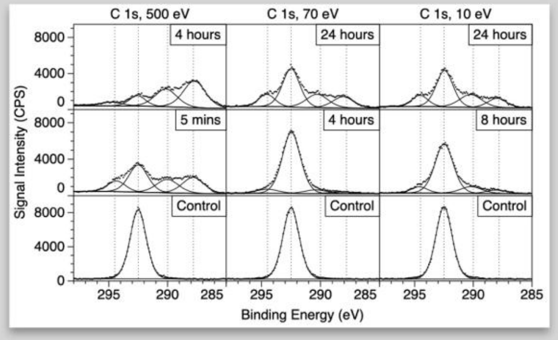
H. Yu et al., Radiat. Phys. Chem., 2025, 237, 113029

3. Ni-Catalyzed Effects

H. Yu et al., ACS Omega, 2025, 10, 28848–28856

Surface Modification

H. Yu et al., Appl. Surf. Sci., 2026, 727, 165988



Electron irradiation induces surface defluorination and reduces the C/F ratio.

Electron irradiation induces bulk decomposition and surface defluorination of PTFE