Biographical Sketch

Dr. McNeil earned a B.S. in Mechanical Engineering with the Nuclear Option and then earned a Ph.D in Nuclear engineering executing research in gamma-ray and neutron sensor design and fabrication. This work included inventing semiconductor device fabrication processes to enhance neutron sensitivity and create the microstructured silicon neutron detector (MSND). From there he worked at the Space and Naval Warfare System Center – Pacific (now Naval Information Warfare Center) developing protypes and limited-rate production systems for search, localization, and identification of radiological threats and hazards for numerous military and government organizations. Systems included scintillator, gas, and semiconductor detection technologies and all were designed for minimal size, weight, and power to maximize portability, meanwhile maximizing sensitivity and detection performance.

Since joining Kansas State University, Dr. McNeil has continued research in mobile detection systems and sensor read-out technologies. His work includes hardware development along with physics modeling and simulation in a diverse portfolio containing electronics, imaging, statistical analysis and algorithms, system design and testing in the lab as well as in the field.

Professional Affiliations

- Associate Editor — Journal of Radiation Physics and Chemistry
- Director — Radiological System Integration Laboratory
- Founder — M2S E&D LLC.
- Member — American Nuclear Society
- Member — SPIE International Society of Optics and Photonic
- Member — International Radiation Physics Society

Some Research Highlights

- CNEC: In the NNSA sponsored Consortium for Nuclear Enabling Capabilities (CNEC) Dr. McNeil was lead of Replacement of Dangerous Radiological Sources (RDRS) thrust area. Here, portable neutron generating fusion devices producing 14 MeV neutrons were investigated as a replacement for Californium-252 radiological sources in oil-well logging. A large-scale materials irradiation facility was created at KSU, called KSUMI, where bulk sedimentary materials and fluids could be placed around a prototype logging tool with gamma-ray and neutron sensors.
- Low Profile Scintillator: A low-profile PMT scintillator readout system was developed for the with two major paths investigating a novel photomultiplier tube (PMT) design along with readout electronics and a spectral detection algorithm implemented with an ultra-low power electronic design. Real-time spectral logging was achieved with less than 19 milliWatts of power consumption. Enabling common scintillator type gamma-ray spectrometers to become an efficient leave-behind sensing node. Feasibility of the novel PMT design was proven through physics-based modeling of electron transport and multiplication within the vacuum tube dynode stages. The modeling method predicted signal time profiles and gain of a commercial PMT to within only a few percent.

- 3D Electronic Circuity: Additive manufacturing methods were developed to fabricate 3-dimension electronic circuity. A PMT high voltage supply was fabricated in an extremely small form-factor using discrete electronic components and 3-dimensional component orientations, micro-extruded conductive epoxy, laser topographical scanning, milling, and pick-and-place features all in one nScrypt printing machine.
- Low Profile Cryogenic Spectrometer: A portable cryogenically-cooled HPGe gamma-ray spectrometer was developed having smaller form-factor than any other commercial system, roughly the size of a large textbook. The high-performance thermal design resulting from complex fluid analysis demonstrated robustness to enable operation in confined spaces, such as a laptop bag with the aid of 3-D printed custom aluminum heat-sinks. The system was commercialized in partnership with PHDS Co. and is now readily available.
- Dirty Bomb Contamination Mapping: Radiological contamination from dirty-bomb detonation tests at Idaho National Laboratory was mapped with precision utilizing ground based collimated sensors and compared to UAV mounted sensors to quantify the accuracy of UAV collected surveys for the purpose of human protection. UAV surveys were collected with automatic flights along with 3D photogrammetry of the surveyed area. This was accomplished with all personnel outside of the controlled radiological area, eliminating the risk of personnel radiological exposure in collecting surveys. A virtual environment of the survey area was created and could be explored in "first person" demonstrating the ability to simulate operations in radiological areas and determine exposure risks in pre-planning. The ground based measurements in this test were used to verify, develop, and calibrate prototype mapping and imaging systems for the NBCRV military CBRN vehicle.
- Dual-Particle Imaging Chip: A silicon chip including the microstructured neutron sensor technology andh the TimePix3 CMOS imaging ASIC was designed and developed to successfully demonstrate the ability to image with thermal neutrons and X-rays simultaneously.
- Explosives Detection: Portable D-D and D-T neutron generators have been investigated with various gamma-ray and neutron sensors to interrogate objects and determine the presence of nitrogen-rich explosive material. This includes pulsed and continuous neutron emission techniques. Minimum detectable mass along with minimal scan durations were quantified for standard configurations of generator, target, and sensor. Tests were executed in field-like environments to aid in the development of a fieldable prototype for the department of defense.

Courses Taught

- ME535 - Measurements and Instrumentation Laboratory, Junior/Senior level course
- ME573 - Fundamentals of Heat Transfer, Senior level course
- NE860 - Radiological Sensor Signal Acquisition and Data Processing (Special Topics, graduate)
- ME699 - Electrical Circuits for MNE Laboratory (Special topics, undergraduate, pilot course)
- NE495 Fundamentals of Nuclear Engineering

Patents, Awards, and Certificates

- No. 8519350: "*Gas-filled neutron detectors having improved detection efficiency*"

- No. 7855372: "*Non-streaming high-efficiency perforated semiconductor neutron detectors, methods of making same and measuring wand and detector modules utilizing same"*
- No. 722030: (Provisional) *"Switchable Passive Neutron Source"*
- "R&D 100 Award": R&D Magazine's top 100 technologically significant inventions of the year, for development of the Lithium Foil Proportional Gas Neutron Detector – 2014
- "R&D 100 Award": R&D Magazine, Micro-structured Semiconductor Detector – 2009
- "R&D 100 Award": R&D Magazine, Insulated Frisch Collar CdZnTe detector. – 2005
- DAWIA Level I Certification – Systems Planning, Research, Development and Engineering, SPRDE Award for "Extraordinary Leadership & Service" presented by the Department head of Mechanical & Nuclear Engineering. - Fall 2004
- Best Presentation, Rad. Shielding section, American Nuclear Society student conference, Berkeley – 2003
- Off-shore survival training including underwater helicopter ditching. – 2001
- Private pilot's license with high performance and complex ratings. - 1998

Funded Research

Radiation Detection HV Switch, *Honeywell Federal Manufacturing & Technologies, LLC*. $110,000.00, 12/3/2021, Co-PI

Radiation Transport Simulations in Support of Active Shielding Measurement Campaign, *KBR Wyle Services*, $45,000.00, 9/30/2021, Co-PI

Radiation Detection HV Switch, *Honeywell Federal Manufacturing & Technologies, LLC*., $24,859.00, 8/31/2021, Co-PI

X-DSMSND: A Dual-Sided Microstructured Semiconductor Neutron Detector with Integrated Pixel Read-Out, *Radiation Detection Technologies, Inc*., $242,715.00, 4/16/2021, Co-PI

Nuclear Engineering Fellowship Program, *NRC - US Nuclear Regulatory Commission*, $400,000.00, 4/6/2021, Co-PI

Radiation Detection HV Switch, *Honeywell Federal Manufacturing & Technologies, LLC*., $144,000.00, 12/18/2020, Co-PI

Discrete 3-D Electronics for Radiation Detection Systems, *Radiation Detection Technologies, Inc*., $640,931.00, 12/1/2020, **PI**

Radiation Transport Simulations in Support of Active Shielding Measurement Campaign, *KBR Wyle Services*, $139,999.00, 10/2/2020, Co-PI

Proposal for a Consortium for Nonproliferation-Enabling Capabilities, *North Carolina State University*, $23,518.00, 10/2/2020, **PI**

Radiological Systems Research for Detection, Localization, and Isotope Identification, *DOD - US Department of Defense*, $74,487.00, 7/21/2020, **PI**

X-DSMSND: A Dual-Sided Microstructured Semiconductor Neutron Detector with Integrated Pixel Read-Out, *Radiation Detection Technologies, Inc*., $252,238.00, 5/27/2020, Co-PI

Proposal for a Consortium for Nonproliferation-Enabling Capabilities, *North Carolina State University*, $35,000.00, 4/8/2020, **PI**

Low-Profile PMT Scintillator Read-Out System, *DOD - Defense Threat Reduction Agency*, $687,881.00, 3/3/2020, **PI**

Radiological Systems Research for Detection, Localization, and Isotope Identification, *DOD - US Department of Defense*, $68,322.00, 2/7/2020, **PI**

Radiation Transport Simulations in Support of Active Shielding Measurement Campaign, *KBR Wyle Services*, $52,461.00, 1/10/2020, Co-PI

Electronics X-Ray Inspection Shielding and Prediction Simulation*, Honeywell Federal Manufacturing & Technologies, LLC*., $178,547.00, 10/30/2019, Co-PI

Additive Manufacture of Sensor Signal Processing Circuitry, *Honeywell Federal Manufacturing & Technologies, LLC*., $66,021.00, 10/28/2019, Co-PI

Electronics X-Ray Inspection Shielding and Prediction Simulation, *Honeywell Federal Manufacturing & Technologies, LLC.*, $21,453.00, 9/26/2019, Co-PI

Discrete 3-D Electronics for Mobile Radiation Detection Systems, *Radiation Detection Technologies, Inc*., $85,390.00, 7/24/2019, **PI**

Radiological Systems Research for Detection, Localization, and Isotope Identification, *DOD - US Department of Defense*, $175,000.00, 5/20/2019, **PI**

X-DSMSND: A Dual-Sided Microstructured Semiconductor Neutron Detector with Integrated Pixel Read-Out, *Radiation Detection Technologies, Inc*., $62,892.00, 3/15/2019, Co-PI

Low-Profile PMT Scintillator Read-Out System, *DOD - Defense Threat Reduction Agency*, $908,182.00, 2/15/2019, **PI**

Electronics Additive Manufacturing PDRD, *Honeywell Federal Manufacturing & Technologies, LLC*., $50,000.00, 11/15/2018, **PI**

PDRD K-State Solid State Dual Neutron-X-Ray Imager, *Honeywell Federal Manufacturing & Technologies*, LLC., $173,812.00, 11/14/2018, Co-PI

Electronics X-ray Inspection Shielding and Prediction Simulation, *Honeywell Federal Manufacturing & Technologies, LLC*., $190,497.00, 11/8/2018, Co-PI

Modular Radiological Survey Imaging System MRSIS, *Radiation Detection Technologies, Inc*., $39,333.00, 9/27/2018, **PI**

A Dedicated Laboratory for Radioactive Sample Handling, *DOE - US Department of Energy*, $167,493.00, 8/24/2018, Co-PI

Low-Profile PMT Scintillator Read-Out System, *DOD - Defense Threat Reduction Agency*, $1,053,767.00, 1/8/2018, **PI**

Kansas State University Nuclear Research Fellowship Program, *NRC - US Nuclear Regulatory Commission*, $393,820.00, 6/30/2017, Co-PI

Radiological Systems Research for Detection, Localization, and Isotope Identification*, DOD - US Department of Defense*, $230,000.00, 5/25/2017, **PI**

Proposal for a Consortium for Nonproliferation-Enabling Capabilities, *North Carolina State University*, $1,430,878.00, 9/24/2014, **PI**

Publications

[1] M. P. Pfeifer, N. Simerl, J. Porter, W. J. McNeil, and A. A. Bahadori, "Comparison of MCCAD and DAGMC for Predictive Capability with BGA Inspection Systems," *Nucl. Sci. Eng.*, 2022.

[2] M. P. Pfeifer *et al.*, "Methods for estimating X-ray machine output through measurement and simulation," *Appl. Radiat. Isot.*, vol. 183, p. 110125, 2022.

[3] E. Giunta *et al.*, "Optimization of a GaN Microstructured Thermal Neutron Detector Geometry using MCNP," 2022.

[4] S. Sharma *et al.*, "Preliminary benchmarks and analysis of boundary conditions in a trenched microstructured silicon radiation detector," *J. Appl. Phys.*, vol. 131, no. 13, p. 134503, 2022.

[5] D. Laramore *et al.*, "Advancements in modeling conformally doped X-MSND radiation imagers," *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, p. 166799, 2022.

[6] D. S. McGregor *et al.*, "Detector development in the Kansas State University SMART laboratory," *Nucl. Sci. Eng.*, 2022.

[7] W. McNeil, A. Bahadori, and D. Laramore, "Neutron emitting devices." 2021.

[8] N. Simerl *et al.*, "Contamination Measurements from Simultaneous Activated Potassium Bromide Radiological Dispersal Devices with a Collimated Vehicular Sensor," *Health Phys.*, vol. 120, no. 6, pp. 618–627, 2021.

[9] S. Sharma, L. Vo, M. P. Pfeifer, W. L. Dunn, W. J. McNeil, and A. A. Bahadori, "Bulk material interrogation experimental results and validation with Geant4 for replacement of dangerous radiological sources in oil-well logging industries," *Appl. Radiat. Isot.*, vol. 170, 2021, doi: 10.1016/j.apradiso.2021.109602.

[10] L. K. Vo, S. Sharma, M. Pinilla, W. L. Dunn, A. A. Bahadori, and W. J. McNeil, "Time dependent signatures: Moisture content interpretation in well logging applications with a DT neutron

generator," *Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms*, vol. 466, pp. 37–41, 2020.

[11] M. I. Pinilla, A. Hellinger, L. K. Vo, W. L. Dunn, W. McNeil, and A. Bahadori, "Design studies using MCNP6® for an oil well logging prototype tool and a test facility," *Radiat. Phys. Chem.*, vol. 167, p. 108393, 2020.

[12] D. Laramore *et al.*, "Simulation of charge drift in surface doped, pixelated micro-structured semiconductor neutron detectors," *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 978, p. 164351, 2020, doi: https://doi.org/10.1016/j.nima.2020.164351.

[13] S. Sharma, D. Laramore, S. Bellinger, W. J. McNeil, and A. A. Bahadori, "Simulation of signal formation and imaging in a dual-sided micro-structured semiconductor neutron detector," in *2019 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, 2019, pp. 1–3, doi: 10.1109/NSS/MIC42101.2019.9059683.

[14] D. Laramore, S. Sharma, S. L. Bellinger, A. A. Bahadori, and W. J. McNeil, "Simulation of charge carrier transport in pixelated micro-structured semiconductor neutron detectors," in *2019 IEEE Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC)*, 2019, pp. 1–3.

[15] S. L. Bellinger and W. McNeil, "Modular Radiological Survey Imaging System (MRSIS)," 2019.

[16] L. Vo, A. Hellinger, M. Pinilla, W. Dunn, A. Bahadori, and W. McNeil, "Development of test facilities for studies relevant to replacing dangerous radiological sources," in *AIP Conference Proceedings*, 2019, vol. 2160, no. 1, p. 50001.

[17] D. Laramore, W. J. McNeil, and A. A. Bahadori, "Design of a micro-nuclear-mechanical system for strain measurement," *Radiat. Phys. Chem.*, vol. 155, pp. 209–212, 2019.

[18] D. S. McGregor, S. L. Bellinger, W. J. McNeil, M. F. Ohmes, and K. A. Nelson, "Gas-filled neutron detectors having improved detection efficiency." Google Patents, 27-Aug-2013.

[19] S. L. Bellinger, R. G. Fronk, W. J. McNeil, T. J. Sobering, and D. S. McGregor, "Improved High Efficiency Stacked Microstructured Neutron Detectors Backfilled With Nanoparticle $^{6} $ LiF," *IEEE Trans. Nucl. Sci.*, vol. 59, no. 1, pp. 167–173, 2011.

[20] S. L. Bellinger, R. G. Fronk, W. J. McNeil, T. J. Sobering, and D. S. McGregor, "Enhanced variant designs and characteristics of the microstructured solid-state neutron detector," *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 652, no. 1, pp. 387–391, 2011.

[21] D. S. McGregor *et al.*, "Non-streaming high-efficiency perforated semiconductor neutron detectors, methods of making same and measuring wand and detector modules utilizing same." Google Patents, 21-Dec-2010.

[22] W. J. McNeil, "Perforated diode neutron sensors," Kansas State University, 2010.

[23] S. L. Bellinger, R. G. Fronk, W. J. McNeil, T. J. Sobering, and D. S. McGregor, “High efficiency dual-integrated stacked microstructured solid-state neutron detectors,” in *IEEE Nuclear Science Symposuim & Medical Imaging Conference*, 2010, pp. 2008–2012.

[24] S. L. Bellinger, R. G. Fronk, W. J. McNeil, J. K. Shultis, T. J. Sobering, and D. S. McGregor, “Characteristics of the stacked microstructured solid state neutron detector,” in *Hard X-Ray, Gamma-Ray, and Neutron Detector Physics XII*, 2010, vol. 7805, p. 78050N.

[25] K. A. Nelson *et al.*, “Investigation of CdZnTe and LiNbO3 as electro-optic neutron detectors,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 620, no. 2–3, pp. 363–367, 2010.

[26] D. S. McGregor *et al.*, “Perforated diode neutron detector modules fabricated from high-purity silicon,” *Radiat. Phys. Chem.*, vol. 78, no. 10, pp. 874–881, 2009.

[27] S. L. Bellinger, W. J. McNeil, and D. S. McGregor, “Improved fabrication technique for microstructured solid-state neutron detectors,” *MRS Online Proc. Libr. Arch.*, vol. 1164, 2009.

[28] S. L. Bellinger, W. J. McNeil, and D. S. McGregor, “Variant designs and characteristics of improved microstructured solid-state neutron detectors,” in *2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC)*, 2009, pp. 986–989.

[29] A. G. Antonacci *et al.*, “PATARA II: A 64-channel solid-state Neutron Detector readout system with integrated analog and digital processing for the SNS,” in *2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC)*, 2009, pp. 68–74.

[30] W. J. McNeil *et al.*, “1-D array of micro-structured neutron detectors,” in *2009 IEEE Nuclear Science Symposium Conference Record (NSS/MIC)*, 2009, pp. 2008–2011.

[31] D. S. McGregor, W. J. McNeil, S. L. Bellinger, T. C. Unruh, and J. K. Shultis, “Microstructured semiconductor neutron detectors,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 608, no. 1, pp. 125–131, 2009.

[32] S. L. Bellinger, W. J. McNeil, T. C. Unruh, and D. S. McGregor, “Characteristics of 3D micro-structured semiconductor high efficiency neutron detectors,” *IEEE Trans. Nucl. Sci.*, vol. 56, no. 3, pp. 742–746, 2009.

[33] W. J. McNeil *et al.*, “1-D array of perforated diode neutron detectors,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 604, no. 1–2, pp. 127–129, 2009.

[34] T. C. Unruh *et al.*, “Design and operation of a 2-D thin-film semiconductor neutron detector array for use as a beamport monitor,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 604, no. 1–2, pp. 150–153, 2009.

[35] D. S. McGregor, T. C. Unruh, and W. J. McNeil, “Thermal neutron detection with pyrolytic boron nitride,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 591, no. 3, pp. 530–533, 2008.

[36] P. Ugorowski *et al.*, “Characterization of the High-Efficiency Neutron Detector Array (HENDA),” in *2008 IEEE Nuclear Science Symposium Conference Record*, 2008, pp. 1901–1903, doi: 10.1109/NSSMIC.2008.4774760.

[37] D. S. McGregor, S. L. Bellinger, W. J. McNeil, and T. C. Unruh, “Micro-structured high-efficiency semiconductor neutron detectors,” in *2008 IEEE Nuclear Science Symposium Conference Record*, 2008, pp. 446–448.

[38] D. S. McGregor *et al.*, “Perforated semiconductor neutron detectors for battery operated portable modules (Invited Paper)[6706-56],” in *PROCEEDINGS-SPIE THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING*, 2007, vol. 6706, p. 6706.

[39] D. S. McGregor *et al.*, “Wireless neutron and gamma ray detector modules for dosimetry and remote monitoring,” in *2007 IEEE Nuclear Science Symposium Conference Record*, 2007, vol. 1, pp. 808–812.

[40] D. S. McGregor *et al.*, “Perforated semiconductor neutron detector modules for detection of spontaneous fission neutrons,” in *2007 IEEE Conference on Technologies for Homeland Security*, 2007, pp. 162–167.

[41] C. J. Solomon, J. K. Shultis, W. J. McNeil, T. C. Unruh, B. B. Rice, and D. S. McGregor, “A hybrid method for coupled neutron--ion transport calculations for 10B and 6LiF coated and perforated detector efficiencies,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 580, no. 1, pp. 326–330, 2007.

[42] D. S. McGregor, S. L. Bellinger, D. Bruno, W. J. McNeil, E. Patterson, and B. B. Rice, “Perforated semiconductor neutron detector modules,” in *Proc. of 32nd Annual GOMACTech Conf.*, 2007.

[43] S. L. Bellinger, W. J. McNeil, T. C. Unruh, and D. S. McGregor, “Angular response of perforated silicon diode high efficiency neutron detectors,” in *2007 IEEE Nuclear Science Symposium Conference Record*, 2007, vol. 3, pp. 1904–1907.

[44] W. J. McNeil *et al.*, “Preliminary tests of a high efficiency 1-D silicon pixel array for small angle neutron scattering,” in *2007 IEEE Nuclear Science Symposium Conference Record*, 2007, vol. 3, pp. 2340–2342.

[45] D. S. McGregor *et al.*, “Perforated semiconductor neutron detectors for battery operated portable modules (Invited Paper)[6706-56],” in *PROCEEDINGS-SPIE THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING*, 2007, vol. 6706, p. 6706.

[46] W. J. McNeil, S. L. Bellinger, T. C. Unruh, E. L. Patterson, J. K. Shultis, and D. S. McGregor, “Perforated diode fabrication for neutron detection,” in *2006 IEEE Nuclear Science Symposium Conference Record*, 2006, vol. 6, pp. 3732–3735.

[47] M. J. Harrison, A. P. Graebner, W. J. McNeil, and D. S. McGregor, “Carbon coating of fused silica ampoules,” *J. Cryst. Growth*, vol. 290, no. 2, pp. 597–601, 2006.

[48] A. Kargar, A. M. Jones, W. J. McNeil, M. J. Harrison, and D. S. McGregor, “CdZnTe Frisch collar detectors for γ-ray spectroscopy,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 558, no. 2, pp. 497–503, 2006.

[49] A. E. Bolotnikov *et al.*, “Performance characteristics of Frisch-ring CdZnTe detectors,” *IEEE Trans. Nucl. Sci.*, vol. 53, no. 2, pp. 607–614, 2006.

[50] A. Kargar, A. M. Jones, W. J. McNeil, M. J. Harrison, and D. S. McGregor, “Angular response of a W-collimated room-temperature-operated CdZnTe Frisch collar spectrometer,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 562, no. 1, pp. 262–271, 2006.

[51] W. J. McNeil, S. L. Bellinger, T. C. Unruh, E. L. Patterson, J. K. Shultis, and D. S. McGregor, “Development of perforated si diodes for neutron detection,” in *IEEE Nucl. Sci. Symp. Conf. Rec.*, 2006.

[52] A. E. Bolotnikov *et al.*, “New results from performance studies of Frisch-grid CdZnTe detectors,” in *Hard X-Ray and Gamma-Ray Detector Physics VI*, 2004, vol. 5540, pp. 33–45.

[53] W. J. McNeil, D. S. McGregor, A. E. Bolotnikov, G. W. Wright, and R. B. James, “Single-charge-carrier-type sensing with an insulated Frisch ring CdZnTe semiconductor radiation detector,” *Appl. Phys. Lett.*, vol. 84, no. 11, pp. 1988–1990, 2004.

[54] N. Simerl, J. Beavers, A. A. Bahadori, and W. McNeil, “Aerial and Collimated Sensor Radiological Mapping Following Dispersal of Activated Potassium Bromide,” *Health Phys.*, pp. 10–1097.