NSREC 2025

IEEE NPSS NUCLEAR & PLASMA SCIENCES SOCIETY

July 14-18, 2025

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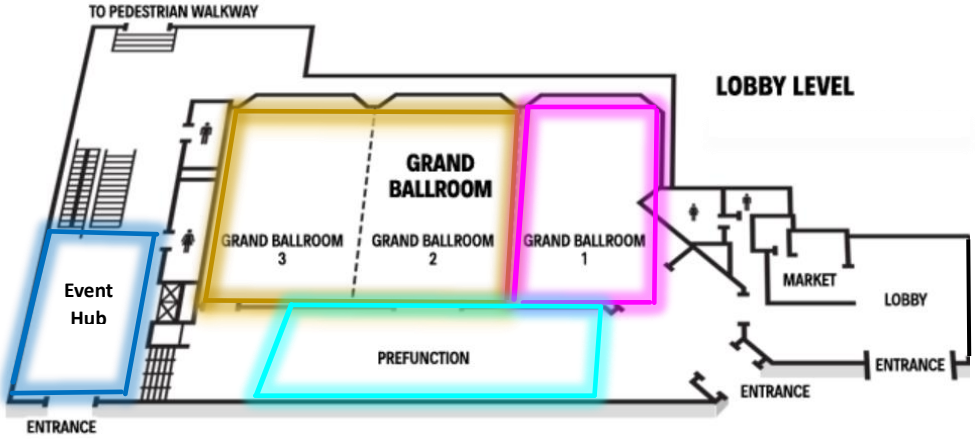

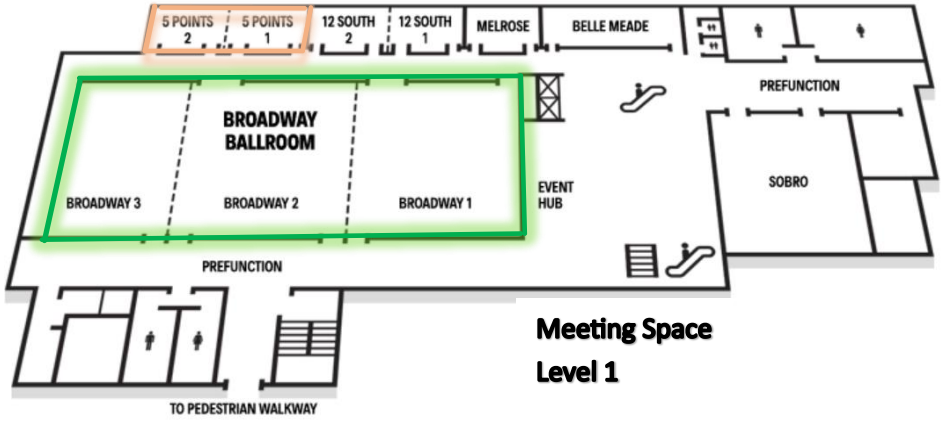

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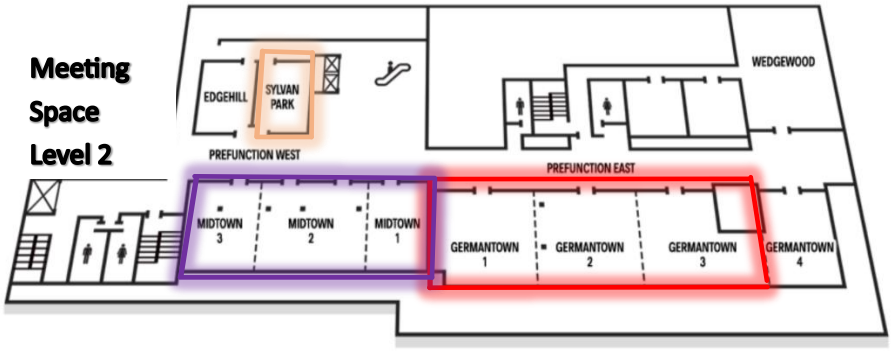
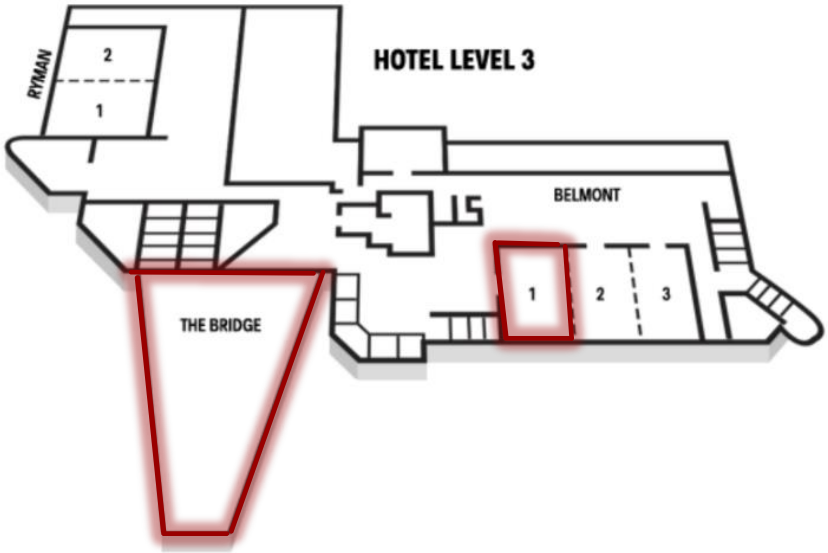




Technical / Exhibit

- On-site Registration – Event Hub Lobby Level
- A/V Preview Room - Edgehill
- Side Meeting 1 – Sylvan Park
- Side Meeting 2 – 5 Points

Monday

Short Course Sessions – Grand Ballroom 2-3

Short Course Exam – Grand Ballroom 2-3

Tuesday

Technical Sessions - Grand Ballroom 2-3

Exhibits - Broadway Ballroom

Wednesday

Technical Sessions - Grand Ballroom 2-3

Exhibits - Broadway Ballroom

Poster Session - Germantown 1-3 (2:50pm – 4:50pm)

Thursday

Technical Sessions - Grand Ballroom 2-3

Exhibits - Broadway Ballroom

Radiation Effects Data Workshop – Midtown (1:30pm-3:30pm)

Open Meeting – Grand Ballroom 2-3 (4:00pm – 5:30pm)

Friday

Technical Sessions - Grand Ballroom 2-3

Dining/Social

Sunday

Welcome Reception – Grand Ballroom 1

Monday

Breakfast – Grand Ballroom 1

Morning/Afternoon Breaks – Grand Ballroom Foyer

Continental Breakfast – Grand Ballroom 1

Young Professional Reception – Belmont 1/Bridge Lounge

Tuesday

Continental Breakfast – Grand Ballroom 1

Women in Engineering Luncheon – Grand Ballroom 1

Exhibits Reception - Broadway Ballroom

Wednesday

Continental Breakfast – Grand Ballroom 1

Morning Break - Broadway Ballroom

Afternoon Break - Germantown 1-3

Thursday

Continental Breakfast – Grand Ballroom 1

Morning Break - Broadway Ballroom

Afternoon Break – Midtown

NPSS New Member – Grand Ballroom 2-3

Friday

Continental Breakfast – Grand Ballroom 1

Morning/Afternoon Breaks – Grand Ballroom Foyer

SCHEDULE

Time	Monday, July 14	Tuesday, July 15	Wednesday, July 16	Thursday, July 17	Friday, July 18
7:00	(7:00) Breakfast – Grand Ballroom 1	(7:00) Breakfast – Grand Ballroom 1			
7:30			(7:30) Breakfast – Grand Ballroom 1	(7:30) Breakfast – Grand Ballroom 1	(7:30) Breakfast – Grand Ballroom 1
8:00	(8:00) **Short Course Introduction**, *Prof. Matthew Marinella* (8:10) **Part I – Cumulative Effects in CMOS**, *Dr. Marc Gaillardin and Prof. Hugh Barnaby* - Grand Ballroom 2-3	(8:00) **RESG Awards** – Grand Ballroom 2-3			
8:30			(8:30) **Invited Speaker** – Grand Ballroom 2-3	(8:30) **Invited Speaker** – Grand Ballroom 2-3	(8:30) **Invited Speaker** – Grand Ballroom 2-3
9:00		(9:00) **Opening Remarks** (9:05) **Session A – Single-Event Effects: Devices and Integrated Circuits**			
9:30	(9:40) Break – Grand Ballroom Foyer		(9:30) **Session D – Radiation Effects in Devices and ICs**	(9:30) **Session F – Basic Mechanisms of Radiation Effects**	(9:30) **Session H – Hardened by Design**
10:00	(10:15) **Part II – Modeling Single Event Effects in CMOS**, *Dr. Scooter Ball and Dr. Jeff Black*	(9:55) Break – Broadway Ballroom	(10:05) Break – Broadway Ballroom		(10:05) Break – Grand Ballroom Foyer
10:30		(10:25) **Session B – Hardness Assurance**	(10:45) **Session D – Radiation Effects in Devices and Integrated Circuits (continued)**	(10:20) Break – Broadway Ballroom	(10:45) **Session I – Power Devices and Wide-Bandgap Semiconductors**
11:00				(11:00) **Session G – Single-Event Effects: Mechanisms and Modeling**	
11:30	(11:45) Lunch – Grand Ballroom 1		(11:30) Lunch – Broadway Ballroom		
12:00		(12:00) Lunch on Own		(12:00) Lunch on Own	(12:05) Closing Remarks
12:30	(12:45) **Part III – Radiation Effects in Nonvolatile Memories**, *Prof. Marta Bagatin and Dr. Patrick Xiao*	***(12:00) Women in Engineering Lunch – Grand Ballroom 1 Ticket Required***			
1:00			(1:00) Exhibitor Drawings – Grand Ballroom 2-3		
1:30			(1:30) **Session E – Environments, Facilities, and Dosimetry**	(1:30) **Radiation Effects Data Workshop - Midtown**	
2:00	(2:15) Break – Grand Ballroom Foyer				
2:30	(2:45) **Part IV – Radiation Effects in Systems**, *Prof. Jeff Goeders and Prof. Fernando Fernandes*	(2:30) **Session C – Photonics Devices and Integrated Circuits**	(2:35) **Poster Session Introduction** – Germantown 1-3		
3:00			(2:50) **Poster Session**	(2:30) Break – Midtown (3:00) Fitness Class	
3:30		(3:50) Break – Broadway Ballroom (4:00) Fitness Class	(3:20) Break – Germantown		
4:00				(4:00) **RESG Open Meeting** – Grand Ballroom 2-3	
4:30	(4:30) CE Exam (for those requesting CEU credit only) (4:30) Fitness Class	(4:45) End of Sessions	(4:30) Fitness Class (4:50) End of Sessions		
5:00					
5:30	(5:30) End of Short Course	(5:30) **Exhibitor Reception** – Broadway Ballroom		(5:30) **New NPSS Member Meeting**	
6:00	(6:00) **IEEE Young Professionals Reception** – Belmont 1 and Bridge Lounge Ticket Required		(5:45) Walk to Social (6:00) **Conference Social** – Country Music Hall of Fame and Museum		
7:00					
8:00					
9:00					
10:00					

CHAIRMAN'S INVITATION

Dolores Black
NSREC 2025 General Chair
Sandia National Laboratories

On behalf of the Institute of Electrical and Electronics Engineers (IEEE) and its Nuclear and Plasma Sciences Society (NPSS), Radiation Effects Steering Committee (RESG) and the 2025 Nuclear and Space Radiation Effects Conference (NSREC) committee, I am pleased to invite you to attend NSREC to be held July 14-18, 2025. The conference will be held the Nashville Renaissance in downtown Nashville adjacent to the famous 5th and Broadway. Nashville, nicknamed, Music City, is the capital of the U.S. state of Tennessee and home to Vanderbilt University. Legendary country music venues include the Grand Ole Opry House, home of the famous "Grand Ole Opry" stage and radio show. The Country Music Hall of Fame and Museum and historic Ryman Auditorium are steps away from the Renaissance.

The conference begins Monday, July 14, with a one-day Short Course titled, "Radiation Effects in Modern and Emerging Technologies." The Short Course is organized by Matthew Marinella (Arizona State University) and features four parts taught by experts from our community. This Short Course will introduce the basic radiation effects on devices and systems, from cumulative effects, transient effects and total dose. In addition, it will offer a valuable perspective of radiation studies and a perspective for future challenges coming from radiation effects in contemporary technologies and devices.

The main technical program is from Tuesday, July 15 to Friday, July 18. Andrew Sternberg, Vanderbilt University, is the conference Technical Program Chair. He, along with his technical committee, have chosen an outstanding set of contributed papers organized into 9 sessions of oral presentation and a poster session encompassing papers from all sessions. In addition to the main technical sessions, the technical committee has also selected outstanding papers for the Radiation Effects Data Workshop. This is an additional poster session describing radiation effects data on electronics and photonic devices and systems and test facilities. Finally, Andrew has invited three speakers to give talks of more general interest to start each morning from Wednesday to Friday.

The Industrial Exhibit, organized by Pierre Maillard, AMD, opens Tuesday morning and concludes Thursday after the morning break. Attendees will be able to visit the booths during scheduled breaks and a lunch on Wednesday. Attendees and guests are invited to attend a cocktail reception in the exhibit hall on Tuesday evening. The exhibit showcases the products and capabilities of the exhibitors in areas such as semiconductors, systems, modeling, and test resources.

I hope that you will enjoy our social program in Nashville organized by Andrew Kelly, BAE Systems. Two companion tours are scheduled, Tuesday going to Imagine Records to sit in a recording session with a recording artist in the daytime, and a Pub Crawl for evening fun. Thursday off to Cheekwood for tours of their amazing gardens and Mansion. On Wednesday evening, we planned a night at the Country Music Hall of Fame, with a live performance to cap off the night. In addition, the conference hotel is well located downtown Nashville, where there are many other fabulous food and museum options.

Your 2025 Conference Committee looks forward to seeing you in Nashville this July.

SHORT COURSE PROGRAM

RADIATION EFFECTS IN MODERN AND EMERGING TECHNOLOGIES

NASHVILLE, TN, USA

GRAND BALLROOM 1

JULY 14, 2025

7:00 AM	**BREAKFAST** (Grand Ballroom 1)
8:00 AM	**SHORT COURSE INTRODUCTION** Prof. Matthew Marinella, *Arizona State University*
8:15 AM	**PART I – CUMULATIVE EFFECTS IN CMOS** Prof. Hugh Barnaby, *Arizona State University* Dr. Marc Gaillardin, *CEA*
9:45 AM	**BREAK** (Grand Ballroom Foyer)
10:15 AM	**PART II – MODELING SINGLE EVENT TRANSIENT EFFECTS IN CMOS** Dr. Dennis (Scooter) Ball, *Vanderbilt University* Dr. Jeff Black, *Sandia National Laboratories*
11:45 AM	**SHORT COURSE LUNCHEON** (Grand Ballroom 1 or Germantown 1-3)
12:45 PM	**PART III – RADIATION EFFECTS IN NONVOLATILE MEMORIES** Prof. Marta Bagatin, *University of Padova* Dr. Patrick Xiao, *Sandia National Laboratories*
2:15 PM	**BREAK** (Grand Ballroom Foyer)
2:45 PM	**PART IV – RADIATION EFFECTS IN MICROELECTRONIC SYSTEMS** Prof. Jeff Goeders, *Brigham Young University* Prof. Fernando Fernandes, *INRIA*
4:15 PM	**WRAP-UP**
4:20 PM	**EXAM (only for students requesting CEU credit)**
5:20 PM	**END OF SHORT COURSE**

The NSREC 2025 Short Course Notebook will be available for download at www.NSREC.com for all registered Short Course Attendees one week before NSREC conference.

SHORT COURSE PROGRAM

COURSE DESCRIPTION

A short course, "*Radiation Effects in Modern and Emerging Technologies*", will be presented at the 2025 IEEE Nuclear and Space Radiation Effects Conference. The radiation effects community is encountering changes in devices, circuits, and systems which will give both existing new opportunities for radiation hardened electronics, but also create new challenges. This course has been designed to provide both the background and fundamentals combined with the recent findings needed to understand this evolving field.

The short course is organized into four sections. Each has two subsections that start with the fundamentals resulting from decades of research, follow up with the application of these principles to radiation effects in modern and emerging technologies. The first two sections cover cumulative and transient effects in CMOS, starting with fundamentals and extending into modern technologies. The third section focuses on nonvolatile memory, covering fundamentals and extending the discussion to modern and emerging memories. Finally, the course concludes with a section on a discussion of radiation effects in systems.

The short course is intended for students, researchers and engineers working in the field of radiation effects and radiation hard electronics. In addition, the short course will be relevant to device, circuit, and system designers and managers involved in implementing these systems. It provides a unique opportunity for IEEE NSREC attendees to benefit from the expertise of excellent instructors, along with a critical review of state-of-the-art knowledge in the field. Electronic copies of detailed course notes will be provided to each participant. Continuing Education Units (CEUs) will be available. For the interested attendees, an exam will be given at the end of the short course. The course is valued at 0.6 CEUs and is endorsed by IEEE and the International Association for Continuing Education and Training (IACET).

CONTINUING EDUCATION UNITS (CEUs)

Continuing Education Units (CEUs) will be available. For the interested attendees, an exam will be given at the end of the short course. The course is valued at 0.6 CEUs, and is endorsed by the IEEE and by the International Association for Continuing Education and Training (IACET).

SHORT COURSE CHAIRMAN

Matthew Marinella
Short Course Chair Arizona State University

Professor Matthew Marinella is an electrical engineer and researcher focused on emerging microelectronic devices and circuits for computing. He is currently Associate Professor in the School of Electrical, Computer and Energy Engineering at ASU since 2022, where he leads a research group focused on emerging technologies for low energy and radiation hard computing.

From 2010 to 2021, he was with Sandia's Microsystems S&T Center, where he was a Distinguished Member of the Technical Staff. At Sandia, Dr. Marinella led projects that sought to develop new methods of efficient computing for government applications and extreme environments. He served as PI of numerous large efforts, including the Secure, Efficient, Extreme Environment Computing (SEEEC) Grand Challenge, the Nonvolatile Memory Technology Development Program, and as the Learning Hardware Task Lead for the Hardware Acceleration of Adaptive Neural Algorithms (HAANA) Project. He served as Lead Scientist for Sandia's Beyond Moore Computing Lab and DOE-Level Initiatives.

Prof. Marinella has published extensively on emerging devices for energy efficient, analog in-memory, neuromorphic, and radiation hard computing (7800 citations, h-index=39), given numerous invited and contributed talks, and presented several short courses on these topics. He has served in technical advising and leadership roles in various Lab- and DOE-level initiatives on next generation computing for government applications and is a member of the SRC Decadal Plan Executive Committee, a member of the Microelectronics and Advanced Packaging Technologies (MAPT) Roadmap, chairs the Emerging Memory Devices Section for the IRDS Roadmap Beyond CMOS Chapter. He serves on various conference committees including NSREC and is a Senior Member of the IEEE. Prior to starting at Sandia in 2010, he was a Device Engineer in Microchip's Technology Development Group. He received his PhD in Electrical Engineering from Arizona State University under advisor Dieter K. Schroder in 2008

Dr. Marc Gaillardin

Marc Gaillardin received is M.S. degree in electronic engineering from Paris Saclay University, France, in 2004 and his PhD in Nanoelectronics from Institut National Polytechnique de Grenoble, France, in 2007. From 2007 to 2019, he was with CEA, DAM, Arpajon where his primary research activities were focused on the radiation effects in innovative technologies including Ultra-thin SOI, FinFET and nanowire devices. Since 2019, he has joined CEA, DAM, Gramat as research engineer on ionizing radiation effects on electronic devices and systems, particularly on power and fast electronic solid-state devices. He now leads the pulsed power and ionizing radiation effects laboratory at CEA, DAM, Gramat. Dr. Marc Gaillardin has authored and co-authored about 100 papers in peer-reviewed international journals. He has served the IEEE and the NSREC and RADECS conferences as a reviewer, session chair and short course speaker

Prof. Hugh Barnaby

Hugh Barnaby is a Professor of Electrical Engineering at Arizona State University. His work focuses on the analysis, modeling, and experimental characterization of extreme environmental effects in semiconductor materials, devices and integrated circuits. He has ongoing research activities in advanced CMOS (bulk PDSOI, FDSOI, multi-gate), CMOS+X, bipolar, HBT, BiCMOS, solar, power device (super junction Si, UWG), and embedded memory technologies, targeted primarily for use in space-based applications. Hugh has been an active researcher in the microelectronics field for over 30 years in both industry and academics, presenting and publishing more than 300 papers during this time. He is an IEEE fellow and has served as IEEE journal Associate Editor (IEEE Transactions on Nuclear Science), and on numerous IEEE conference Technical and General program committees.

PART I – CUMULATIVE EFFECTS IN CMOS

Prof. Hugh Barnaby, *University of Saint-Etienne*
Dr. Marc Gaillardin, C*NES*

The history of cumulative radiation effects on MOSFET and CMOS technologies traces back to the early days of semiconductor devices and their deployment in space and military applications. As CMOS technologies gained prominence in the 1960s and 1970s, researchers observed that ionizing radiation exposure could degrade the performance of these majority carrier devices. This discovery led to an increased focus on understanding the mechanisms of total ionizing dose (TID) radiation-induced damage, typically characterized by trapped charge accumulation in the dielectric and trap buildup at dielectric-semiconductor interface. By the 1980s, as CMOS integrated circuits became more complex, the effects of TID radiation on MOSFETs became a critical area of study, especially for space missions and other high-radiation environments. Early studies of TID effects concentrated on traditional bulk and silicon-on-insulator (SOI) technologies with an emphasis on ionization damage to the relatively thick gate oxides and even thicker buried oxides (used in SOI). As CMOS technologies scaled, the threats posed by ionizing radiation to ever thinner gates oxides began to diminish, leading to greater concentration on sidewall isolating dielectrics, particularly for bulk processes. In the first section of the short course, Dr. Marc Gaillardin of CEA will present the history of TID effects in these older technologies, with a review of the fundamental concepts associated with charge generation, recombination, carrier transport, defect creation and annealing, which are still important today.

The second part of the course given by Prof. Hugh Barnaby will focus on cumulative radiation effects on modern/emerging CMOS, which have made or will make their way into mainstream integrated circuits. These advanced MOSFETs include ultra-thin body SOI (UTBSOI) devices (e.g., partially and fully depleted SOI); Fin-based Field Effect Transistors (FinFETs), and Gate All Around (GAA) Transistors. Recent investigations have shown some recognizable effects but also novel response characteristics that are unique to the very complex structural features, chemistry and material systems used in these advanced process nodes. The course will also review some of the less studied but important concerns encountered in MOSFETs and beyond CMOS transistors that are exposed to cumulative radiation dose such as displacement damage and enhanced low dose rate sensitivity.

A top-level outline of the presentation is as follows:

Part A – Basic Mechanisms of Total Ionizing Dose (Gaillardin)

- Fundamental Processes of Damage
  - Interactions and Energy Deposition
  - Yield, Transport, Reactions
  - Bias Dependence
  - Annealing
- Defects
  - Precursors
  - Fixed trapped charge, Border traps
  - Interface traps
- Dependence on Dielectric Material
  - Gate vs. Isolation Oxides
  - Impact of Material Type
- Test and Analysis Techniques
  - Characterization
  - Modeling
  - Dosimeters
- Current and Future Challenges

Part B – Total Ionizing Dose in Advanced CMOS (Barnaby)

- Advanced CMOS Technologies
  - Planar SOI
  - MUGFET
- Overview of TID Response
  - Ionizing effects
  - Displacement Damage Effects

Dr. Scooter Ball

Dennis (Scooter) Ball is a Principal Research Engineer at the Institute for Space and Defense Electronics. He earned his Ph.D in Electrical Engineering from Vanderbilt University in 2020, and an MBA from Vanderbilt University in 2009. Dennis is an expert on TCAD modeling and simulation of semiconductor devices. His expertise covers a range of technology nodes, ranging from 0.25 um CMOS to sub-100 nm CMOS, such as 14 nm SOI FinFETs and thin-film FDSOI. He has also had extensive experience modeling wide-bandgap power devices, such as silicon carbide power MOSFETs and diodes and GaN HEMTs, along with gallium oxide materials. His skillset includes modeling and simulating the effects of total ionizing dose, single event effects, and dose rate environments in semiconductor devices. As the lead TCAD engineer at ISDE, Dennis supports DoD and industrial agencies by providing device radiation response simulation data points in the absence of test data, for example, looking at extremely high angle single events which naturally occur in space environments, but are challenging to reproduce in a laboratory. In addition, he is adept at interpreting radiation test data and simulating the device structure to reproduce the test results and explore new and unique mechanisms that are otherwise obscured at the circuit or system level.

Dr. Jeffrey Black

Jeffrey Black currently works for Sandia National Laboratories in the Radiation and Electrical Sciences Center. His areas of specialty and interest are in transient radiation effects – modeling and simulation, circuit mitigation approaches, and experiment execution. Prior to joining Sandia, Jeffrey worked for the United States Air Force, Mission Research Corporation, and Vanderbilt University. He received his education from the United States Air Force Academy (BSEE, 1988), University of New Mexico (MSEE, 1991), and Vanderbilt University (Ph.D., 2008). His 37 years of experience have covered nuclear survivability, satellite communications, fault tolerant computing, and radiation hardening of microelectronics

PART II – MODELING SINGLE EVENT EFFECTS IN CMOS

Dr. Scooter Ball, *Institute for Space and Defense Electronics, Vanderbilt*
Dr. Jeffrey Black, *Sandia National Laboratories*

Dr. Dennis (Scooter) Ball of Vanderbilt University, and Dr. Jeffrey Black of Sandia National Laboratories, will give a presentation on the multi-tooled approaches to modeling and simulation of single event transients in CMOS technologies. The course will cover the modeling tools being used: Technology Computer Aided Design (TCAD), radiation transport, circuit simulation, and fault injection/emulation. An example will be presented demonstrating how each of the tools are used to reproduce ground-based accelerator experimental data and then used to predict environmental rates. Further examples will be provided showing how single event modeling is done in emerging technologies like FinFETs and Gate All Around (GAA) FETs and what we have learned from modeling results.

A top-level outline of the presentation is as follows:

Part A – Single Event Effect Modeling Overview and TCAD (Ball)

- Introduction
  - Goal - design a system to operate in a radiation environment
  - Radiation response is a design variable
  - Single event effects testing
  - Single event effects mechanisms
    - How radiation particles create carriers in the semiconductor materials
    - How carriers create charge on circuit nodes
- Technology Computer Aided Design (TCAD)
  - What it is and what it does
  - 2D vs. 3D simulation
  - Case study – Thorlabs FDS010 Photodiode
  - Case study – Bulk vs. FinFET D Flip-Flop

Part B – Circuit Simulation, GEANT4, and Modeling a Heavy Ion Experiment (Black)

- Circuit simulation
  - TCAD to circuit simulation
  - Double exponential current source
    - Single event upset simulation
    - Parameter sensitivity analysis
    - Case study – Feedback resistance hardening of memory cell
  - Single event effect stimuli improvements
    - Case study – Feedback resistance hardening of memory cell
    - Case study – single event transient generation
- GEANT4 radiation transport
  - Setting the size of the simulated world
  - Semiconductor materials in the simulation
  - Rare event weighting
  - Number of particles to be simulated
- Modeling a heavy ion experiment
  - TCAD to GEANT4 sensitive volumes
  - GEANT4 and circuit simulation case study - Ions with critical charge threshold pre-characterized
  - GEANT4 and circuit simulation case study - Ions generating charge to inject in circuit simulation
  - Making a rate prediction
- Challenging case study - Simulating multiple node charge collection

Part C – System Level Modeling and Conclusion (Ball)

- System-level modeling – Bayesian network
- Conclusion

Prof. Marta Bagatin

Marta Bagatin graduated cum laude in Electronic Engineering in 2006 and received her PhD in Information Science and Technology in 2010 from the University of Padova. Since September 2022, she has been Associate Professor of Electronics at the University of Padova. Her research interests include experimental study and modeling of radiation effects and reliability aspects on electronic devices for space, nuclear and terrestrial applications, with particular attention to semiconductor non-volatile memories. Marta is the author or co-author of 4 book chapters, about 150 peer-reviewed articles and presentations at international conferences, and editor of a book. Her work has been recognized with 10 awards at NSREC and RADECS conferences. She has presented invited seminars and lectures on her research at universities, research centers, space agencies and companies in Europe, USA, Brazil, China, and Australia.

Dr. Patrick Xiao

T. Patrick Xiao is a Principal Member of Technical Staff at Sandia National Laboratories. He received his B.A. degree in Physics in 2014 and his Ph.D. in Electrical Engineering and Computer Sciences in 2019, both from the University of California, Berkeley. He joined Sandia in 2019, where he is developing reliable and energy-efficient analog processors that can enable next-generation processing capabilities for space and other edge applications. His research interests include physics-based or analog computing; non-volatile memory technologies including flash, spintronics, and memristors; radiation effects in memory devices and in-memory computing systems; and modeling and co-design of emerging computing systems from devices and circuits to algorithms.

PART III – RADIATION EFFECTS IN NONVOLATILE MEMORIES

Prof. Marta Bagatin, *University of Padova*
Dr. Patrick Xiao, *Sandia National Laboratories*

Flash memories are ubiquitous in all digital systems today and are also attractive as non-volatile storage in space, because their capacity is unmatched by any rad-hard memory. In the first part of the short course, Prof. Marta Bagatin of the University of Padova will cover the effects of ionizing radiation in Flash memories. After reviewing the operation principles of these devices, total ionizing dose and single event effects will be illustrated. Possible short- and long-term phenomena following radiation exposure both in the memory cells and in the peripheral circuitry will be covered. The course will be supported by experimental data, analysis, and simulations, highlighting the impact of the technological evolution in a journey from traditional, planar devices to the most novel 3D integrated architectures.

In the second half of this short course, Dr. T. Patrick Xiao of Sandia National Labs will review the current understanding of the effects of ionizing radiation and displacement damage on emerging non-volatile memories such as magnetic memory, resistive memory, ferroelectric memory, and electrochemical memory. The physics of radiation effects in emerging memories is often fundamentally distinct from effects on commercial NAND flash and other CMOS electronics. For non-charge-based memories, this leads to very high intrinsic radiation tolerance, making them attractive for space applications. Furthermore, as the end of Moore's law has slowed progress in computer processors, there has been significant research momentum to repurpose these emerging memories as low-power analog computational devices. However, using a traditionally binary memory as an analog memory can greatly increase radiation sensitivity. This course will review the operation and design principles of analog in-memory computing systems and how the accuracy of analog computing is affected by radiation effects.

A top-level outline of the presentation is as follows:

Part A – Radiation Effects in Flash Memories

- Introduction to NV and Flash memories (planar and 3D)
- Radiation effects in planar Flash memories (floating gate and charge trap
  - TID in memory cells
  - SEE in memory cells
  - Effects in the peripheral circuitry
- Radiation effects in 3D NAND Flash memories
  - TID in memory cells
  - SEE in memory cells
  - Scaling trends

Part B – Total Ionizing Dose in Advanced CMOS

- Radiation effects in emerging NVMs
  - ReRAM
  - MRAM
  - ECRAM
- Radiation effects in emerging analog computing systems
  - Introduction to analog computing and AI applications
  - Overview of the sources of accuracy loss in analog computing
  - Accuracy impact of TID effects in NVMs
  - Case study: SONOS Charge trapping flash
  - Accuracy impact of SEEs in NVMs
  - Case study: SONOS Charge trapping flash
  - Accuracy effects due to peripheral circuit radiation effects
  - Potential mitigation

Prof. Jeff Goeders

Jeff Goeders is an Associate Professor in the Department of Electrical and Computer Engineering at BYU in Provo, Utah. He received his BASc degree in Computer Engineering from the University of Toronto, Canada, and MASc and PhD degrees in Computer Engineering from The University of British Columbia, Canada. His research focuses on reconfigurable computing and embedded systems, with an emphasis on security and reliability.

Prof. Mike Wirthlin information on next page.

Prof. Fernando Fernandes

Fernando Fernandes dos Santos is a tenured researcher on the TARAN Team at INRIA Rennes, France. He specializes in the reliability of high-performance computing, the design of efficient hardening methods, processing-in-memory architectures, and radiation effects on deep neural network accelerators. He obtained his Ph.D. from the Federal University of Rio Grande do Sul, Brazil, in 2021. He was then a postdoc in the Co-funded BIENVENUE Marie Skłodowska-Curie Actions Programme from 2022 to 2023 at INRIA Rennes.

Prof. Paolo Rech information on next page

PART IV – RADIATION EFFECTS IN SYSTEMS

Profs. Jeff Goeders and Mike Wirthlin, *Brigham Young University*
Prof. Fernando Fernandes, *INRIA* and Dr. Paolo Rech*, Università di Trento*

In the first part of this course, co-authored by Prof. Mike Wirthlin and Prof. Jeff Goeders, both of BYU will discuss radiation effects in modern, complex systems, with a focus on FPGAs, GPUs, and SoCs. Prof. Goeders will present the material. These types of commercial off-the-shelf (COTS) devices are increasingly being used in space and other radiation environments due to their high performance, low cost, and rich features. However, these devices are subject to various single-event effects (SEEs) and total ionizing dose (TID) effects, which can manifest as silent data corruption, system crashes and hangs, and permanent damage. The complexity of these devices makes it difficult to model and predict their radiation response, as the devices typically contain substantial internal state and complex interactions between components. Radiation testing of such systems requires substantial effort, time and expertise in developing appropriate test frameworks. This course will discuss both the radiation effects in these systems, as well as different strategies and lessons learned in how to effectively test and characterize these devices.

In the second half of this course, co-authored by Prof. Fernando Fernandes from INRIA, and Prof. Paolo Rech from the University of Trento. Prof. Fernandes will discuss the reliability challenges of adopting emerging post-Von Neumann architectures in safety-critical applications and space missions. While existing hardware architectures offer high computational performance, the memory bottleneck remains a limiting factor for energy efficiency and scalability since, in most applications, including AI, most of the power is wasted on data movement. New technologies such as processing in-memory and neuromorphic computing are emerging as alternatives to existing ones. Unfortunately, characterizing radiation effects and fault models on emerging hardware is challenging as conventional evaluation methods are not suitable for the task. The challenges include not only fault identification and correction but also designing radiation tests and qualification methodologies for emerging architectures.

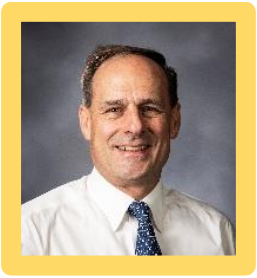
A top-level outline of the presentation is as follows:

Part A – Radiation Effects in Modern Systems

- Motivations & Modern Devices
- Radiation Effects on Microelectronic Devices
  - Memories
  - Processors
  - FPGAs
  - Other Specialized Hardware
- Radiation Effects on Complex Heterogeneous Devices
  - SEUs in complex devices
  - Describing and cataloging failure modes
  - Examples of capturing failure modes
- Radiation Testing of Complex Heterogeneous Devices
  - Major Challenges
  - Exercising Device Components
  - Data Extraction Methods
  - Case Studies & Results

Part B – Emerging Architectures

- Introduction
  - Current and future AI applications
  - New tools, old problems
- Deep learning systems complexity
  - The data
  - The algorithms
  - The hardware
- Modern AI Systems Reliability
  - Radiation effects on AI accelerators
  - Modern accelerators radiation testing
  - Efficient protection methods
  - Conclusions



Mike Wirthlin, Brigham Young University

Dr. Mike Wirthlin is currently a Professor and associate chair in the Department of Electrical and Computer Engineering at BYU in Provo, Utah. He is the director of the BYU site of the Center for Space, High-Performance, and Resilient Computing (SHREC). His research interests include reliable FPGA design, fault tolerant computing, mitigation techniques for single-event effects, and Configurable Computing Systems. He has led the development of several tools and techniques for improving the reliability of FPGA designs and SoC systems.

Paolo Rech, Università di Trento

Dr. Paolo Rech received his master and Ph.D. degrees from Padova University, Padova, Italy, in 2006 and 2009, respectively. He was then a Post Doc at LIRMM in Montpellier, France. Since 2022 Paolo is an associate professor at Università di Trento, in Italy and since 2012 he is an associate professor at UFRGS in Brazil. He is the 2019 Rosen Scholar Fellow at the Los Alamos National Laboratory, he received the 2024 Italy-Canada innovation award, the 2020 impact in society award from the Rutherford Appleton Laboratory, UK and the Marie Curie Fellowship at Politecnico di Torino, in Italy. His main research interests include the evaluation and mitigation of radiation-induced effects in autonomous vehicles for automotive applications and space exploration, in large-scale HPC centers, and quantum computers.

TECHNICAL PROGRAM

TECHNICAL INFORMATION

"On behalf of the Technical Program Committee, I invite you to attend the 2025 NSREC Technical Sessions in Nashville, Tennessee. The session chairs, poster chair, and data workshop chair have assembled an outstanding program highlighting the latest results in nuclear and space radiation effects on materials, device, and systems. The broad set of topics presented will benefit individuals in industry, government, and academia from around the globe. I look forward to working to all those who contribute to making this a successful program."

Andrew Sternberg
Vanderbilt University
Technical Program Chair

The NSREC Technical Program consists of contributed oral and poster papers, a data workshop, and invited talks. The oral presentations will be 12 minutes in duration with an additional three minutes for questions. The technical sessions and their chairpersons are:

- **Single-Event Effects: Devices and Integrated Circuits**
  Chair: Sapan Agarwal, Sandia National Laboratories
- **Hardness Assurance**
  Chair: Rebekah Austin, NASA Goddard
- **Photonic Devices and Integrated Circuits**
  Chair: Damien Lambert, CEA
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Aymeric Privat, On Semiconductor
- **Environments, Facilities, and Dosimetry**
  Chair: Matthieu Beaumel, Sodern
- **Basic Mechanisms of Radiation Effects**
  Chair: Giulio Borghello, CERN
- **Single-Event Effects: Mechanisms and Modeling**
  Chair: Ashok Raman, CFD Research Corporation
- **Hardening By Design**
  Chair: Enxia Zhang, University of Central Florida
- **Power Devices and Wide Bandgap Semiconductors**
  Chair: Art Witulski, Vanderbilt University
- **Poster Session**
  Chair: Enxia Zhang, University of Central Florida
- **Radiation Effects Data Workshop**
  Chair: Matt Von Thun, Frontgrade

Poster Session Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session. Posters can be viewed during the week, and authors will be available during the Poster Session (Wednesday, July 16th, 2:50 PM – 4:50 PM). The Poster Session is chaired by Enxia Zhang from University of Central Florida.

Data Workshop Workshop papers provide piece part radiation response data and radiation test facilities technical information. Workshop papers can be viewed during the week, and authors will be available during the Workshop Session (Thursday, July 17th, 1:30 PM - 3:30 PM). The Data Workshop is chaired by Matt Von Thun from *Frontgrade.*

LATE NEWS A limited number of late-news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The submission window for these newsworthy papers is open through May 9, 2025. Detailed instructions for submitting late-news summary are available on the NSREC website at www.nsrec.com.

SESSION CHAIRS

Sapan Agarwal
Sandia National Laboratories
Single-Event Effects: Devices and ICs

Rebekah Austin
NASA Goddard Space Flight Center
Hardness Assurance

Damien Lambert
CEA
Photonic Devices and ICs

Aymeric Privat
ON Semiconductor
Radiation Effects in Devices and ICs

Matthieu Beaumel
Sodern
Environments, Facilities, and Dosimetry

Giulio Borghello
CERN
Basic Mechanisms of Radiation Effects

Ashok Raman
CFDRC
Single-Event Effects: Mechanisms and Modeling

Enxia Zhang
University of Central Florida
Hardening by Design

Art Witulski
Vanderbilt University
Power Devices and Wide Bandgap Semiconductors

Enxia Zhang
University of Central Florida
Poster Session

Matt Von Thun
Frontgrade
Radiation Effects Data Workshop

TECHNICAL PROGRAM TUESDAY

GRAND BALLROOM

8:00 AM **OPENING REMARKS**
Dolores Black, Sandia National Laboratories, General Chair

8:05 AM **AWARDS PRESENTATION**
Kay Chesnut, RTX, Radiation Effects Steering Group, Executive Chair

9:00 AM **TECHNICAL SESSION OPENING REMARKS**
Andrew Sternberg, Vanderbilt University, Technical Program Chair

SESSION A **SINGLE-EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS**

9:05 AM

SESSION INTRODUCTION
Chair: Sapan Agarwal (Sandia National Laboratories)

A-1 **Key Variables in the Reliability of ML Models Exposed to Neutrons, Protons, and Heavy**
9:10 AM **Ions**
B. Coelho[1], M. Saveriano[1], M. Tali[2], C. Frost[3], M. Donetti[4], M. Pullia[4], E. Verroi[5], F. Tommasino[1], S. Bounasser[6], C. Poivey[2], P. Rech[1]
1. *University of Trento, Italy*
2. *ESA, Netherlands*
3. *ISIS Neutron and Muon Facility, United Kingdom*
4. *CNAO, Italy*
5. *TIFPA, Italy*
6. *ESA, France*

We test large machine learning models on TPUs at 5 different radiation facilities to identify particle, software, and hardware-dependent reliability behaviors and reduce the variable space to qualify the reliability of neural networks.

A-2 **Assessing System-Level SET Response in Analog PLLs from Component-Level Response**
9:25 AM
D. Sam[1], J. Teng[2], B. Ringel[1], P. Francis[1], J. Moody[1], J. Shin[1], Z. Brumbach[1], A. Ildefonso[3], A. Khachatrian[4], T. Crane[5], D. McMorrow[4], J. Cressler[1]
1. *Georgia Institute of Technology, USA*
2. *The Aerospace Corporation, USA*
3. *Indiana University Bloomington, USA*
4. *U.S. Naval Research Laboratory, USA*
5. *Jacobs, Inc. and U.S. Naval Research Laboratory, USA*

The SETs of standalone circuits of a fully analog SiGe PLL are used to understand system-level SET responses and determine the circuit whose SET response is the most impactful to the output of the PLL.

A-3 **One-Fin Versus Two-Fin Single Event Upset Vulnerability at the 3-nm Bulk FinFET**
9:40 AM **Technology**
S. Tolson[1], J. Kronenberg[1], N. Pieper[1], Y. Xiong[1], D. Ball[1], B. Bhuva[1]
1. *Vanderbilt University, USA*

Single-event upset cross-sections are investigated as a function of the number of fins in a transistor at the 3-nm node. Results show that one-fin D-FF designs are less vulnerable than similar two-fin D-FF designs under identical conditions.

POSTER PAPERS

PA-1 **The Research on 22 nm UTBB-FDSOI SRAM MCUs with Staggered Well Under Back-Bias of 0 V**

L. Tongde[1], Z. Yuanfu[2], Z. Yong-Qin[1], Y. Jing-Shuang[1], A. Paccagnella[3], W. Liang[1]
1. Beijing Microelectronics Technology Institute, China
2. China Academy of Aerospace Electronics Technology, China
3. University of Padua, Italy

This paper investigated the MCU characteristics of nano-scale FDSOI SRAM under different incident directions and angles. According to the experimental and numerical simulation results, the charge collection mechanisms were discussed.

PA-2 **Neutron-Induced Single Event Effects in 3D Managed NAND Memories**

D. Peyronel[1], G. Lama[1], M. Valla[1], M. Kastriotou[2], C. Cazzaniga[2], M. Bagatin[3], S. Gerardin[4]
1. Micron Semiconductor Italia Srl, Italy
2. STFC, United Kingdom
3. University of Padova, Italy
4. DEI - Padova University, Italy

The sensitivity of 3D managed NAND Flash memories to atmospheric spectrum neutrons has been investigated, with a focus on the functional elements that lead to single event functional interrupts and user data corruption.

PA-3 **Versal ACAP AI Engine Heavy Ion Testing with Spill Synchronization**

C. Price[1], G. Smith[1], M. Wirthlin[1]
1. Brigham Young University, USA

This work presents the heavy ion of the AI/ML engines within the Versal Core and Edge series devices. This approach tests the hundreds of AI engines within these devices simultaneously and synchronously with beam spills.

PA-4 **The Effect of Heavy Ions on Inference Accuracy on the IBM NorthPole**

F. Viramontes[1], V. Vergara[2], A. Romero[1], M. Spear[3], W. Slater[3], H. Quinn[3]
1. UNM COSMIAC, USA
2. Blue Halo, USA
3. Air Force Research Laboratory, USA

This abstract covers a heavy-ion test that was recently performed on the IBM NorthPole. SEFI and SEU cross sections of the device are discussed, as well as the effect of heavy-ions on AI/ML inference accuracy.

PA-5 **Input and Clock State Dependence of D-FF SEU Vulnerability at 3-nm Bulk FinFET Node**

J. Kronenberg[1], N. Pieper[1], Y. Xiong[1], D. Ball[1], B. Bhuva[1]
1. Vanderbilt University, USA

SERs for D-FFs in a 3-nm technology show differences based on stored data, indicating state-dependent Qcrit values. Simulations show differences in charge collection by n- & p-hits, and design asymmetry are primary factors determining state-dependent SERs.

PA-6 **Charge Generation Correlation in Silicon PN Diodes for Heavy Ions vs. Two-Photon Absorption**

R. Rodriguez-Davila[1], A. Carillo-Osuna[1], T. Moise[1], B. Gnade[1], R. Baumann[1], M. Quevedo-Lopez[1]
1. The University of Texas at Dallas, USA

Bessel-focusing two-photon absorption (TPA) in silicon diodes accurately simulates the effects of heavy ion radiation, offering a cheaper and more accessible alternative for evaluating single event effects in semiconductor devices.

9:55 AM – 10:25 AM
BROADWAY BALLROOM **BREAK**

SESSION B **HARDNESS ASSURANCE**

10:25 AM **SESSION INTRODUCTION**
Chair: Rebekah Austin (NASA Goddard Space Flight Center)

B-1 **A Survey of Depth-Parameter Selection in Upset-Rate Calculations**
10:30 AM

D. Hansen[1], B. Kimbrell[1], T. Manich[1], C. Pownell[1], I. Zavatkay[1]
1. L3 Harris, USA

This paper reviews guidelines for depth parameter selection in rate calculation and compares them to published on-orbit data. Current guidelines result in underestimates for some modern devices.

B-2 **Dynamic Time Warping for ASET Cluster Analysis**
10:45 AM

J. Carpenter[1], D. Loveless[1], A. Ildefonso[1], J. Hales[2], D. McMorrow[2], T. Peyton[1], S. Westfall[1], J. Lazenby[1]
1. Indiana University, USA
2. U.S. Naval Research Laboratory, USA

Dynamic time warping (DTW) is used to analyze ASETs, enabling discrimination based on radiation source, LET, and strike location. Heavy-ion and laser-QBB data show that DTW enables cross-source correlation while enhancing insight into circuit behavior.

B-3 **Scaling Factors for Single Event Upsets With High Error Counts**
11:00 AM

P. Oldiges[1], N. Domme[1], R. Zedric[1]
1. Sandia National Laboratories, USA

We perform an analysis of multiple single events in individual bits of memory during SEU testing. Large numbers of multiple strikes can be accounted for, even with asymmetry in the logic state upset cross-section.

B-4 **PEARCE: Pulsed Electrons for Alternative Radiation Effects Characterization of Electronics**
11:15 AM

G. Tzintzarov[1], J. Teng[1], A. Kulkarni[2], A. Bushmaker[1], P. Musumeci[2], M. Looper[1], D. Daniel[1], M. Voegtle[1], R. Berry[3], S. Milton[4], G. Allen[5]
1. The Aerospace Corporation, USA
2. UCLA, USA
3. RadiaBeam, USA
4. Tau Systems, USA
5. NASA JPL, USA

Development of SEE testing using pulsed electrons is discussed. The Thorlabs FDS010 photodiode is used as a vehicle to compare electron tests, heavy-ion tests, and simulation. Results support the future use of such beams.

B-5
11:30 AM

SEU Cross-Section Predictions in 3nm FinFET Using an Advanced Charge Transport Model

S. El Hajji[1], G. Gasiot[1], T. Thery[1], V. Correas[1], N. Pieper[2], Y. Xiong[2], J. Kronenberg[2], J. Autran[3], B. Bhuva[2], D. Pandini[4], V. Malherbe[1], P. Roche[1]

1. STMicroelectronics, France
2. Vanderbilt University, USA
3. Univ Rennes, CNRS, IPR (Institut de Physique de Rennes) - UMR 6251, France
4. STMicroelectronics, Italy

A fast 3D Poisson equation solver optimized for FinFET architectures has been integrated into the TIARA simulation platform. SEU predictions of a 3nm FinFET flip-flop exposed to heavy ions are made and compared with experiments.

B-6
11:45 AM

Implications of Ion Fragmentation for High-Energy Heavy Ion Single-Event Effects Testing

R. Garcia Alia[1], M. Sacristan Barbero[2], D. Lucsanyi[2], A. Waets[1], K. Bilko[1], M. Cecchetto[1], M. Delrieux[1], N. Emriskova[3], D. Prelipcean[1], I. Slipukhin[1], D. Soderstrom[1], F. Ravotti[1], L. Esposito[1], F. Cerutti[1], S. Gilardoni[1], M. Sivertz[4], S. Kodaira[5], F. Saigné[6]

1. CERN, Switzerland
2. Univ. Montpellier, CERN, Switzerland
3. CERN, Univ. Montpellier, Switzerland
4. NSRL-BNL, USA
5. National Institutes for Quantum Science and Technology (QST), Japan
6. Université de Montpellier, France

We extend the fragmented SEE benchmark to include additional ions (beyond lead) and effects (beyond SEU) and apply the same simulation framework to estimate the beam contaminant impact on ground-based high-energy SEE measurements.

POSTER PAPERS

PB-1

Novel Statistical Method for Quantifying the Uncertainty on the Measurement of Single Event Effects

N. Rostand[1], A. Losquin[1], T. Jarrin[1], O. Duhamel[1], J. Rebourg[1]

1. CEA, France

We develop a novel statistical method providing guarantee on the uncertainty on the number of Single Event Effects measured during experiments. Comparison with the literature is exposed through SEU/SET experimental data on elementary electronic cells.

PB-2

Bounding SEL Rates for Null Results and Other Limited Test Data

R. Ladbury[1], M. Joplin[1], J. Lauenstein[1]

1. NASA Goddard Space Flight Center, USA

We exploit trends observed in historical archives of SEL test data to develop methods for bounding SEL rates based on null heavy-ion test results and other minimally constraining test data.

PB-3 **Principles for Selecting Pulsed-Laser Operating Parameters to Predict Heavy-Ion SEE Response**

A. Ildefonso[1], J. Hales[2], D. McMorrow[2]
1. Indiana University, Bloomington, USA
2. U.S. Naval Research Laboratory, USA

This work establishes quantitative principles for determining when a pulsed-laser test configuration can predict ion-induced single-event effects. Validated experimentally, these principles provide a systematic framework for assessing the ability of any surrogate test approach to be predictive.

PB-4 **Error Pattern Analysis of Commercial Ferroelectric RAM under Total Ionizing Dose Effects**

M. Ahmed[1], J. Bell[1], A. Brandl[1], B. Ray[1]
1. Colorado State University, USA

Commercial FeRAM exhibits data corruption from 50 krad(Si), with an overall error rate (~0.01%) at 500 krad(Si). Errors are asymmetric, with stored ones experiencing significantly more bit-flips than stored zeros.

12:00 PM – 2:30 PM **LUNCH and WOMEN IN ENGINEERING (WIE) LUNCHEON**

SESSION C **PHOTONICS DEVICES AND INTEGRATED CIRCUITS**

2:30 PM **SESSION INTRODUCTION**
Chair: Damien Lambert (CEA)

C-1
2:35 PM **Very Low to High Dose Rate Irradiation Response of a Single-Mode Optical Fiber at Telecom Wavelengths**

M. Roche[1], H. Boiron[2], T. Maraine[3], E. Marin[4], A. Meyer[5], D. Lambert[6], P. Paillet[6], J. Boch[3], F. Saigné[3], A. Morana[4], Y. Ouerdane[7], A. Boukenter[4], S. Girard[7]
1. Laboratoire Hubert Curien - CEA DAM, France
2. Exail, France
3. Université de Montpellier, France
4. Laboratoire Hubert Curien, France
5. Université Jean Monnet, France
6. CEA, France
7. Université de Saint Etienne, France

We investigate the growth kinetics of the radiation induced attenuation of 25-km long commercial Ge-doped optical fiber coils during a long-term gamma irradiation at different very low dose rates.

C-2
2:50 PM

Analysis of Optical and Electrical Single-Event Transients in Integrated Silicon Photonic Micro-Ring Modulators

B. Ringel[1], P. Francis[1], J. Teng[2], M. Hosseinzadeh[1], D. Sam[1], Z. Brumbach[1], J. Shin[1], A. Ildefonso[3], A. Khachatrian[4], D. McMorrow[4], J. Hales[5], T. Crane[5], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. The Aerospace Corporation, USA
3. Department of Intelligent Systems Engineering, Indiana University, USA
4. U.S. Naval Research Laboratory, USA
5. Jacobs, Inc. and U.S. Naval Research Laboratory, USA

The SET response of MRMs is evaluated following carrier injection by laser pulses. Optical signals experience transient phenomena plausibly due to carrier and temperature changes. MRMs exhibit SET sensitivity potentially relevant for harsh environment operation.

C-3
3:05 PM

Characterization of Single-Event Effects in Integrated Electronic-Photonic Optical Transceivers for Space-based Communications

M. Hosseinzadeh[1], J. Teng[2], B. Ringel[1], Y. Mensah[1], D. Sam[1], Z. Brumbach[1], A. Ildefonso[3], T. Crane[4], A. Khachatrian[5], D. McMorrow[5], J. Cressler[1]

1. Georgia Institute of Technology, USA
2. The Aerospace Corporation, USA
3. Indiana University Bloomington, USA
4. Jacobs, Inc., USA
5. U.S. Naval Research Laboratory, USA

An integrated optical transceiver in a silicon ePIC platform is exposed to pulsed-laser-induced TPA. SEE sensitivity of subsystems and the full-system is investigated, with a numerical model comparing link sensitivity to different propagating SET types.

C-4
3:20 PM

Low Temperature Proton Irradiation and Annealing Effects on Accumulation CCDs

A. Plocina[1], V. Goiffon[1], O. Marcelot[1], S. Rizzolo[2], D. Marchais[2], O. Saint-Pe[2], J. Pratlong[3]

1. ISAE-SUPAERO, France
2. Airbus Defence and Space S.A.S., France
3. Teledyne e2v, United Kingdom

This study reveals the impact of low temperature on-ground irradiation and annealing on pixel dark currents, activation energies and RTS pixels in silicon detectors, and compares these data to room temperature irradiation test results.

C-5
3:35 PM

Proton-Induced Displacement Damage in AlGaInAs on InP Multi-Quantum-Well Continuous Wave Laser Diodes

C. Bryant[1], D. Huang[2], K. Arnold[1], H. Dattilo[1], D. Fleetwood[1], R. Schrimpf[1], E. Zhang[2], P. Harris[1], J. Trippe[1], M. Alles[1], D. Ball[1], S. Weiss[1], P. Delfyett[2], R. Reed[1]

1. Vanderbilt University, USA
2. University of Central Florida, USA

The threshold current and the emission wavelength of AlGaInAs-InP lasers change significantly with increasing proton fluence. The observed emission wavelength shift is attributed to defects located in the bandgap, rather than increases in series resistance.

POSTER PAPERS

PC-1 **Total Ionizing Dose Effects on a PbS-QD-Based CMOS Direct-Conversion X-ray Image Sensor**

C. Zhang[1], V. Goossens[2], A. Neyret[3], R. Quaglia[1], V. Goiffon[3], A. Shulga[2], P. Rüedi[1]

1. CSEM SA, Switzerland
2. QDI Systems, Netherlands
3. ISAE-SUPAERO, France

This work presents the first observation of ionizing radiation effects on the first PbS-QD-coated CMOS X-ray image sensor from the evolution of dark current, X-ray sensitivity, spatial resolution, and X-ray imaging capability under X-ray irradiation.

PC-2 **Dark Current and Random Telegraph Signal Degradation Induced by Proton Radiation in a Long-Wave HgCdTe Infrared Sensor**

T. Friess[1], E. de Borniol[2], A. Antonsanti[3], N. Baier[2], A. Rouvie[4], A. Le Roch[4], V. Goiffon[3], S. Rizzolo[5], O. Gravrand[2]

1. CNES / CEA Leti / ISAE Supaero / Airbus DS, France
2. CEA Leti, France
3. ISAE-SUPAERO, France
4. CNES, France
5. Airbus Defence and Space S.A.S., France

Dark current and Random Telegraph Signal degradations were analyzed in an HgCdTe Long-Wave InfraRed (LWIR) sensor after proton irradiation. The evolution of those mechanisms was evaluated after different annealing temperatures.

PC-3 **Bias and Geometry Dependent Ionization Effects on Waveguide-Integrated Germanium-Silicon Vertical p-i-n Photodiodes**

A. Veluri[1], K. Arnold[1], S. Musibau[2], A. Tsiara[2], K. Croes[2], D. Linten[2], J. Vancampenhout[2], S. Kosier[1], R. Schrimpf[1], D. Fleetwood[1], R. Reed[1], S. Weiss[1]

1. Vanderbilt University, USA
2. imec, Belgium

We investigated ionization effects on Ge-Si VPIN photodiodes under 10-keV X-ray irradiation. Localized P+ doping shows 75% higher dark current sensitivity, while smaller Ge width shows stronger bias-dependent increase. Fast room-temperature recovery confirms space-based viability.

PC-4 **Fundamental Mechanisms of Total-Ionizing-Dose Response in Waveguide-Coupled Ge-on-Si PIN Photodiodes**

S. Musibau[1], K. Arnold[2], A. Veluri[2], A. Tsiara[3], J. Franco[3], K. Croes[3], D. Linten[3], J. Van campenhout[3], S. Weiss[2], R. Schrimpf[2], D. Fleetwood[2], S. Kosier[2], I. De Wolf[1], R. Reed[2]

1. imec and KU Leuven, Belgium
2. Vanderbilt University, USA
3. imec, Belgium

Calibrated TCAD simulations of total-ionizing-dose effects in vertical Ge-on-Si photodiodes reveal dominant charge trapping at top-corner Ge/SiO2 interfaces, enhancing local electric fields, Shockley-Read-Hall generation/recombination rates and trap-assisted tunneling currents.

PC-5 **Radiation Reliability of the White LEDs of the MMX mission on Phobos**

L. Weninger[1], G. Ciachera[1], M. Darnon[1], A. Morana[1], F. Fricano[1], V. Lalucaa[2], J. Belloir[2], C. Durnez[2], C. Virmontois[2], N. Kerboub[2], J. Mekki[2], Y. Morilla[3], P. Martin Holgado[3], A. Romero Maestre[3], M. Gaillardin[4], O. Duhamel[4], P. Paillet[4], S. Girard[5]

1. Laboratoire Hubert Curien - UJM, France
2. CNES, France
3. Centro Nacional de Aceleradores (CNA), Spain
4. CEA, France
5. Université de Saint Etienne, France

This work presents the results on the external quantum efficiency degradation under various ionizing radiations of the white LEDs selected for the illumination system of the cameras of the MMX mission rover on Phobos.

PC-6L **Photonics in Space: Single-Event Radiation Effects on Silicon Photonic Digital Optical Receiver**

M. Hoff[1], K. Arnold[2], A. Sternberg[2], J. Slaby[3], R. Stevens[1], S. Weiss[2], R. Reed[2], S. Ralph[3]

1. Lockheed Martin Advanced Technology Labs, USA
2. Vanderbilt University, USA
3. Georgia Institute of Technology, USA

This paper investigates the radiation tolerance of digital optical links, focusing on the receiver performance in the presence of pulsed-laser-induced single-event transients. Device measurements are presented, together with in-situ measurements of the bit error ratio.

3:50 PM – 4:45 PM **BREAK**
BROADWAY BALLROOM

5:30 PM – 7:00 PM **EXHIBITOR RECEPTION**
BROADWAY BALLROOM

TECHNICAL PROGRAM WEDNESDAY

GRAND BALLROOM

8:30 AM **TBA**
INVITED SPEAKER

SESSION D **RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS**

9:30 AM **SESSION INTRODUCTION**
Chair: Aymeric Privat (On Semiconductor)

D-1 **Ultra-Fast Recovery of TID-Induced Degradation in MOS Transistors via Electrical Rapid**
9:35 AM **Annealing**
A. Vidana[1], C. Mckay[1], N. Dodds[1], T. Wallace[1], J. D'Amico[1], J. Joffrion[1], N. Nowlin[1], P. Oldiges[1], K. Sapkota[1], H. Barnaby[2], D. Hughart[1]
1. Sandia National Laboratories, USA
2. Arizona State University, USA

We present a room temperature, ultra-fast electrical rapid annealing (ERA) method that achieves near-complete recovery of TID-induced degradation in at least two FinFET technologies. Work is ongoing to understand the recovery mechanism and reliability impacts.

D-2 **Effects of Total Ionizing Dose on Specific Emitter Identification and Authentication of**
9:50 AM **Software-Defined Radios**
R. Baltazar Felipe[1], J. Ermi[1], H. Hunnicutt[2], J. Tyler[2], I. Hudson[1], B. Himebaugh[1], D. Reising[2], D. Loveless[1]
1. Indiana University Center for Reliable and Trusted Electronics, USA
2. University of Tennessee at Chattanooga, USA

Total-ionizing dose effects on specific emitter identification and authentication of wireless transmitters are investigated. Co-60 experiments reveal degradation in the ability to classify software-defined-radio transmitters post-irradiation and suggest likely failure mechanisms within the local oscillator.

10:05 AM – 10:45 AM **BREAK**

BROADWAY BALLROOM

D-3 **SEE and TID Resilient Vanadium Dioxide Phase Transition Material Millimeter-Wave**
10:45 AM **Switches**
Z. Brumbach[1], D. West[1], D. Sam[1], J. Shin[1], S. Dasari[1], G. Ashley[1], B. Ringel[1], J. Teng[2], P. Harris[3], M. McCurdy[3], R. Reed[3], G. Allen[4], N. Ghalichechian[1], J. Cressler[1]
1. Georgia Institute of Technology, USA
2. The Aerospace Corporation, USA
3. Vanderbilt University, USA
4. JPL, USA

The effects of TID and SEE on vanadium dioxide (VO2) millimeter-wave switches were measured and analyzed. No evidence of the high-speed, low-loss VO2 switches changing states, or degrading was observed.

D-4
11:00 AM

Recovery of JunoCam by Annealing in the Jovian Radiation Environment

J. Schaffner[1], M. Caplinger[1], M. Ravine[1], L. Lipkaman Vittling[1], D. Krysak[1], C. Hansen[2], S. Madsen[3], A. Berkun[3], B. Rax[3], M. Johnson[3], E. Sturm[3], J. Delavan[4], H. Yonter[4], S. Bolton[5]

1. Malin Space Science Systems, USA
2. Planetary Science Institute, USA
3. Jet Propulsion Laboratory, California Institute of Technology, USA
4. Lockheed Martin Space, USA
5. Southwest Research Institute, USA

After eight years in the Jovian radiation environment, well past its design life, JunoCam suffered a series of anomalies due to radiation dose. Annealing, by heating, has recovered the instrument and extended its useful life.

D-5
11:15 AM

Total Ionizing Dose Response of Novel n-Type Vertical Nanosheet FETs with C-Shaped-Channel

M. Chen[1], Y. Huang[1], Y. Wu[1], F. Liu[1], B. Li[1]

1. Key Laboratory of Science and Technology on Silicon Devices, Institute of Microelectronics of the Chinese Academy of Sciences, China

The total ionizing dose response of n-type vertical C-shaped-channel nanosheet FETs (n-VCNFETs) are investigated. First experimental study reveals n-VCNFETs exhibit ≥ 500 krad(Si) radiation tolerance through self-healing or layout optimization, enabling LEO satellite applications.

POSTER PAPERS

PD-1

TID-Induced Degradation in 3-nm FinFET SRAM Cell Retention

N. Pieper[1], J. Kronenberg[1], Y. Xiong[1], J. Pasternak[2], D. Ball[1], B. Bhuva[1]

1. Vanderbilt University, USA
2. Synopsys, Inc., USA

TID-induced degradation in SRAM cell stability is measured in a commercial 3-nm bulk FinFET node. TID-induced increases in data retention voltages for 3-nm cells are observed to be greater than that for 5-nm SRAM cells.

PD-2

Evidence for Single-Particle Displacement Damage in 14-nm FinFET SRAMs

Y. Xiong[1], J. Kronenberg[1], J. Xiong[2], J. D'amico[2], A. Vidana[2], N. Pieper[1], G. Vizkelethy[2], N. Dodds[2], N. Nowlin[2], B. Bhuva[1]

1. Vanderbilt University, USA
2. Sandia National Laboratories, USA

Experiments on 14-nm FinFET SRAMs reveal that single-ion-induced displacement damage causes stuck memory bits in 1-fin bitcell designs, but not in 2-fin bitcell designs. Failure mechanisms are identified and discussed using experimental results and simulations.

PD-3

Strategic Input Selection For Deep Neural Networks Reliability Evaluation

L. Roquet[1], F. Fernandes dos Santos[1], M. Kastriotou[2], A. Kritikakou[1]

1. IRISA/Inria Rennes, France
2. ISIS Neutron and Muon Source, United Kingdom

We present a robust methodology for selecting inputs for DNNs in radiation experiments. Using our approach, we obtained a 12.19× higher DNN misclassification rate on average compared to the commonly used random input selection.

PD-4 **Degradation of Charge Transport in Irradiated FDSOI Devices at Cryogenic Temperatures**

F. Mamun[1], M. Spear[2], J. Solano[3], J. Neuendank[1], M. Turowski[4], H. Barnaby[1], I. Esqueda[1]

1. Arizona State University, USA
2. Airforce Research Lab, USA
3. MOOG Space and Defense, USA
4. Alphacore Inc, USA

This work establishes the impact of radiation on the transport properties of FDSOI devices at cryogenic temperatures. A quasi-ballistic transport model reveals bias-dependent degradation in mobility attributed to charge buildup in the buried oxide.

PD-5 **To Explore the Future of Quantum ICs for Space applications: A Study on Cryogenic Behavior of X-ray Irradiated 22nm FD-SOI MOSFETs**

J. Zhao[1], Y. Qing[1], Z. Li[2], M. Gorbunov[2], Q. Ma[1], L. Marien[1], M. Zhang[1], T. Maraine[3], F. Saigné[3], J. Prinzie[1], P. Leroux[1]

1. KU Leuven, Belgium
2. IMEC, Belgium
3. Université de Montpellier, France

This study explores 22-nm FD-SOI MOSFETs under X-ray irradiation at 20 K. NMOSFETs recover, but PFETs show increased Vth. A transimpedance amplifier analysis highlights radiation challenges for quantum ICs in space applications.

PD-6 **Investigation of the Degradation Mechanism of LDMOS Under Electromagnetic Pulse**

S. Guan[1], Y. Wu[2], L. Shu[2], F. Liu[2], H. Zhang[1], X. Wei[1]

1. Beijing University of Posts and Telecommunications, China
2. Institute of Microelectronics of China Academy of Sciences, China

This work investigates Electromagnetic Pulse (EMP) damage mechanisms in LDMOS transistors for varying conditions. Neural networks and electromagnetic leakage signal have been used to achieve damage classification of LDMOS with EMP.

PD-7 **Ionizing Dose Effects on DNA Data Storage Nanoplatforms**

L. Sala[1], K. Cardos[1], V. Olšanský[2], D. Chvátil[2], F. Chevalier[3], V. Vizcaino[3], A. Méry[3], J. Kočišek[1]

1. J. Heyrovsky Institute of Physical Chemistry of the CAS, Czech Republic
2. Nuclear Physics Institute of the CAS, Czech Republic
3. Normandie Univ, ENSICAEN, UNICAEN, CEA, CNRS, CIMAP, France

DNA origami nanoplatforms for data storage were exposed to ionizing radiation to identify structural vulnerabilities. This analysis contributes to optimizing these nanoplatforms and advancing methods to enhance data integrity and long-term preservation.

PD-8L **A Comparative Study of Single-Bit Upset Cross Sections Between Single-Photon Absorption Laser and Heavy Ion Testing**

S. Toguchi[1], N. Rezzak[1], J. McCollum[1]

1. Microchip Technology Inc., USA

This study compares SBU XS from SPA laser and heavy-ion tests for 28 nm Planar and 12 nm FinFET SRAMs, finding good agreement at high LET and underestimation at low LET.

TECHNICAL PROGRAM WEDNESDAY

11:30 AM – 1:00 PM **LUNCH with the Exhibitors**

BROADWAY BALLROOM

1:00 **EXHIBITOR DRAWINGS**
Chair: Pierre Maillard (AMD)

GRAND BALLROOM

SESSION E **ENVIRONMENTS, FACILITIES, AND DOSIMETRY**

1:30 PM **SESSION INTRODUCTION**
Chair: Matthieu Beaumel (Sodern)

E-1
1:35 PM **Analysis of High-Energy Heavy-Ion SEE Results Through Standard-Energy Ion SEE Data**

M. Sacristan Barbero[1], R. Garcia[2], I. Slipukhin[2], D. Soderstrom[2], K. Bilko[3], N. Emriskova[2], A. Waets[2], D. Prelipcean[2]

1. CIEMAT - CERN, Switzerland
2. CERN, Switzerland
3. Université Jean Monnet, France

This summary presents the results of several SEE measurements performed in two Single Event Effect testing facilities, such as CERN and NSRL. Besides, the results are compared to those obtained in another standard SEE facility like RADEF.

E-2
1:50 PM **P-I-N diodes for Displacement Damage Monitoring in a Heavy ion Space Radiation Environment**

D. Bennett[1], V. Pan[1], J. Vohradsky[1], L. Tran[1], D. Bolst[1], K. Aoki[2], T. Nakaji[2], H. Mizuno[2], H. Takei[2], T. Inaniwa[2], I. Anokhin[3], M. Lerch[1], M. Petasecca[1], A. Rosenfeld[1]

1. University of Wollongong, Australia
2. Quantum Science Technology, Japan
3. Institute for Nuclear Research, Ukraine

We've demonstrated that a newly developed p-i-n diode's response is proportional to displacement damage dose, is energy and ion type independent and can be used as a damage monitor in a mixed space radiation environment.

E-3
2:05 PM **Advancing Radiation Hardness Assurance at CERN: Improved HEH Sensors for Enhanced Radiation Monitoring and Reliability System Study**

A. Zimmaro[1], R. Ferraro[1], S. Fiore[1], A. Masi[2], S. Danzeca[2]

1. CERN, France
2. CERN, Switzerland

This paper presents a study of a new radiation sensor embedded in the new wireless IoT radiation monitoring system for electronics. Its advantages in terms of measurement uncertainty and radiation tolerance are presented.

E-4 2:20 PM **Enhancing Performance of Optical Fiber-Based Sensor for Proton Dosimetry Through Pre-Irradiation Treatment**

F. Fricano[1], A. Morana[1], C. Hoehr[2], C. Campanella[1], C. Bélanger-Champagne[2], M. Trinczek[2], G. Melin[3], T. Robin[4], D. Lambert[5], A. Boukenter[1], E. Marin[1], Y. Ouerdane[1], P. Paillet[5], S. Girard[6]

1. Laboratoire Hubert Curien, France
2. TRIUMF, Canada
3. iXblue, France
4. EXAIL, France
5. CEA, France
6. Université de Saint Etienne, France

We compare the performances of nitrogen doped silica-based optical fibers, one pristine and one pre-irradiated to monitor proton beams. Pre-irradiation results in sensitivity enhancement and improvements in Bragg peak reproduction, limiting quenching effect.

POSTER PAPERS

PE-1 **Space Weather Launch Commit Criteria Study for Heavy Ion Susceptible Avionics**

A. Destefano[1], J. Martin[2]

1. NASA, USA
2. Amentum, USA

In this work, we study the effectiveness of a space weather launch commit criteria based on proton fluxes on mitigating risk due to avionics that are susceptible to heavy ions.

PE-2 **Comparison of Active and Passive Adjustment of the Entrance Energy of Synchrotron Ions for Single Event Effect Testing**

M. Eizinger[1], W. Treberer-Treberspurg[2], P. Schieder[2], A. Hirtl[3], B. Seifert[1]

1. Fotec Forschungs- und Technologietransfer GmbH, Austria
2. University of Applied Sciences Wiener Neustadt, Austria
3. Atominstitut, TU Wien, Austria

We compare two methods for varying the Bragg peak depth of carbon ions in silicon. Inserting passive degraders achieves finer resolution compared to variation of the initial energy, at the cost of stronger parasitic effects.

PE-3 **Quenching Corrections for Proton-Irradiated Scintillators Using Geant4 Simulations of LET**

E. Auden[1], J. George[1], A. Hoover[1], C. Delzer[1], G. Riley[1], F. Liang[1], T. Espinoza[1]

1. Los Alamos National Laboratory, USA

Proton quenching effects in scintillators reduce light output similar to charge collection effects for high density particle tracks in silicon devices. We compare experimental and Monte Carlo quenching results in YSO and discuss quenching parameterization.

PE-4 **Radiation Detection Based on Transient Non-equilibrium Body Potential under SOI-SBFETs Configuration**

T. Zhang[1], F. Liu[1], L. Shu[1], S. Chen[1], Y. Huang[1], Y. Wu[1], J. Wan[2], Y. Xu[3], Y. Ding[4], B. Li[1], Z. Han[1], T. Ye[1]

1. The Institute of Microelectronics of the Chinese Academy of Sciences, Beijing 100029, China, China
2. School of Microelectronics, Fudan University, China
3. School of Microelectronics, Nanjing University of Posts and Telecommunications, China
4. China Institute of Atomic Energy, China

A new transient method has been adapted to detect γ-ray. This method relies on non-equilibrium body potential, which shows advantages in fast testing, low process cost, and simple data processing.

PE-5 **A Method for Low-Cost Cold Total Ionizing Dose Dosimetry and Irradiation**

S. Katz[1]

1. Johns Hopkins University Applied Physics Laboratory, USA

Irradiating samples on dry ice in an insulated box reduces the complexity, expense of, and space required for cold radiation testing of electronics. Polyethylene simulant allows dosimetry at room temperature prior to irradiation.

PE-6L **Effect of Partial Volume Irradiation in p-i-n Sensors for NIEL Monitoring**

D. Bennett[1], V. Pan[1], J. Vohadsky[1], L. Tran[1], Z. Pastuovic[2], S. Peracchi[2], R. Drury[2], A. Perevertaylo[3], I. Anokhin[4], A. Rosenfeld[1]

1. University of Wollongong, Australia
2. Australian Nuclear Science and Technology Organisation, Australia
3. SPA-BIT, Ukraine
4. Institute for Nuclear Research, Kyiv, Ukraine

We demonstrated the effect of partial volume irradiation on long base p-i-n diodes response in terms of DDD monitoring and possible error in DDD determination associated with this effect.

POSTER SESSION

2:35 PM **SESSION INTRODUCTION**
Chair: Enxia Zhang (UCF)

2:50 PM – 4:50 PM **POSTER SESSION**

GERMANTOWN

GRAND BALLROOM

8:30 AM **TBA**

INVITED SPEAKER

SESSION F **BASIC MECHANISMS OF RADIATION EFFECTS**

9:30 AM **SESSION INTRODUCTION**
Chair: Giulio Borghello (CERN)

F-1
9:35 AM **Gamma Ray Induced Displacement Damage in Silicon Microvolumes: Single Defect Generation Rate and Random Telegraph Signal**

V. Goiffon[1], C. Durnez[2], A. Antonsanti[1], A. Jouni[3], V. Lalucaa[2], A. Jay[4], D. Lambert[5], T. Jarrin[5], R. Monflier[4], N. Richard[5], P. Paillet[5], C. Virmontois[2]

1. ISAE-SUPAERO, France
2. CNES, France
3. Sodern, France
4. LAAS, CNRS, France
5. CEA, France

The expression of single displacement damage defects induced by ^{60}Co gamma-rays is revealed in silicon microvolumes using a state-of-the-art CMOS pixel array. The creation of gamma induced bulk random telegraph signal is also evidenced.

F-2
9:50 AM **Differences in TID Response When Irradiating Highly-Scaled MOSFETs with 10 keV X-rays Versus 1 MeV Gammas**

J. Kauppila[1], G. Poe[1], T. Haeffner[1], J. Laporte[1], M. Siath[1], S. Vibbert[1], C. Moyers[1], M. Evans[1], D. Vibbert[1], C. Conte[1], A. Vidana[2], N. Dodds[2], N. Nowlin[2], P. Oldiges[2], K. Sapkota[2], J. Joffrion[2], T. Wallace[3], H. Barnaby[3], L. Massengill[1]

1. Reliable MicroSystems, LLC, USA
2. Sandia National Laboratories, USA
3. Arizona State University, USA

Experiments on three highly-scaled technologies show that 10-keV X-rays cause far more TID degradation than 1-MeV gammas, even when irradiating to the same dose. The underlying mechanism is being identified to inform hardness assurance guidelines.

F-3
10:05 AM **SQUID GAME: Gamma, Atmospheric, and Mono-Energetic Neutron Effects on a Quantum Device**

G. Casagranda[1], C. Cazzaniga[2], M. Kastriotou[2], C. Frost[3], F. Vella[1], P. Rech[1]

1. University of Trento, Italy
2. STFC, United Kingdom
3. ISIS Neutron and Muon Facility, United Kingdom

We present data from 14MeV and atmospheric-like neutron experiments on a SQUID. We characterize the radiation impact on the quantum device and find that neutrons and background gammas can generate peak or burst I-V perturbations.

POSTER PAPERS

PF-1 **TID Degradation Mechanisms in Gate-All-Around Silicon Nanowire FETs**

C. Champagne[1], D. Ball[1], J. Trippe[1], R. Ritzenthaler[2], J. Mitard[2], D. Linten[2], L. Massengill[1], S. Kosier[1], R. Reed[1], E. Zhang[3], M. Alles[1], S. Bonaldo[4], D. Fleetwood[1], B. Sierawski[1]

1. Vanderbilt University, USA
2. imec, Belgium
3. University of Central Florida, USA
4. University of Padova, Italy

TCAD analysis of the contributions of gate and spacer oxides to the measured TID response of nanowire FETs indicates that the gate oxide is a significant degradation driver. Results are compared with previous technology nodes.

PF-2 **An Implicit Radiation-Aware Surface Potential Model for FDSOI CMOS Technologies**

I. Livingston[1], I. Esqueda[1], H. Barnaby[1], M. Spear[1], J. Solano[1], T. Wallace[1]

1. Arizona State University, USA

An implicit defect-based surface potential model is presented for fully-depleted silicon-on-insulator MOSFETs. The accuracy of this model is compared to experimental data on devices from a commercial 22nm FDSOI process after total ionizing dose exposure.

PF-3L **Total-Ionizing-Dose Effects and Low-Frequency Noise in 90 nm Bulk CMOS Devices**

J. Neuendank[1], T. Kirby[1], H. Barnaby[1], D. Fleetwood[2], S. Bonaldo[3], D. Loveless[4], S. Westfall[4], P. Muscat[1], M. Nour[5], M. Chambers[5]

1. Arizona State University, USA
2. Vanderbilt University, USA
3. University of Padova, Italy
4. Indiana University, USA
5. Skywater Technology, USA

The impact of ^{60}Co gamma rays on the total ionizing dose DC response and random telegraph noise in bulk MOSFETs at 300 Kelvin is reported. Results show behavior is consistent with radiation-induced switching border/interface traps.

PF-4L **Si Thinning as a Hardening Technique Against SEU for 28-nm Bulk CMOS 6T SRAMs**

S. Yazigi-Richoux[1], H. Barnaby[1], P. Kerber[2], C. Saltonstall[2], L. Andrus[2], M. Marinella[1], J. Neuendank[1]

1. School of Electrical, Computer and Energy Engineering, Arizona State University, USA
2. Sandia National Laboratories, USA

This work investigates how Si substrate thinning affects SEU sensitivity for 28nm process 6T SRAM cells. Both laser raster-scan data and TCAD simulation results are in qualitative agreement that thinning decreases the LET upset threshold.

10:20 AM – 11:00 AM **BREAK**

BROADWAY BALLROOM

SESSION G **SINGLE-EVENT EFFECTS: MECHANISMS AND MODELING**

11:00 AM **SESSION INTRODUCTION**

Chair: Ashok Raman (CFD Research)

G-1 11:05 **Impact of CnRX Structure on SEU Sensitivity Increasement by Using Stacked Transistors at 22-nm FD SOI Node and Improvement Method**

L. Tongde[1], Z. Yuanfu[2], Z. Yong-Qin[1], Y. Jing-Shuang[1], Y. Chun-Qing[1], W. Liang[1]

1. Beijing Microelectronics Technology Institute, China

2. China Academy of Aerospace Electronics Technology, China

SE-Hardening efficiency by using stacked devices is reduced due to process-dependent CnRX structure with virtual transistors at nodes protected by stacked structure. An insertion structure is designed to decouple connection relationships and achieve full hardening.

G-2 11:20 **Atomic-Scale Molecular-Dynamics Framework for Single-Event Displacement Damage in Silicon**

G. Mayberry[1], J. Trippe[1], D. Ball[1], R. Reed[1], D. Fleetwood[1], R. Schrimpf[1], S. Pantelides[1]

1. Vanderbilt University, USA

A two-stage, atomic-scale molecular-dynamics framework is employed to describe vacancy-count distributions for single-event displacement damage (SEDD) in advanced CMOS. Broad distribution variances, corroborated by experimental data, suggest a role in future hardness assurance against SEDD.

G-3 11:35 **Design of Experiments Applied to the Single-Event Upset-Rate Equation**

D. Hansen[1], B. Kimbrell[1], T. Manich[1], C. Pownell[1], I. Zavatkay[1]

1. L3 Harris, USA

This paper takes a design of experiments approach to rate calculations using different expressions for the cross-section, flux, and transport operator. The best methods are identified based on comparison to on-orbit data.

POSTER PAPERS

PG-1 **Impact of Hot-Carrier Diffusivity on Single-Event Upsets in Highly Scaled FinFETs**

J. Vielmette[1], D. Ball[1], J. Trippe[1], G. Walker[1], M. Fischetti[2], D. Nielsen[2], M. Alles[1], K. Nagamatsu[3], R. Schrimpf[1]

1. Vanderbilt University, USA

2. University of Texas at Dallas, USA

3. Northrop Grumman Systems Corporation, USA

Sensitivity of charge collection in scaled finFET devices to the assumed thermalization rate of radiation-induced hot carriers is demonstrated. Full-band Monte Carlo simulations validate current approaches to simulating single-event effects using drift-diffusion tools.

PG-2 **Evaluation of Single-Event Effects on Sub-20nm FinFET Based AI Chips**

F. Shuanglin[1], L. Bin[1], W. Xun[1], C. Yaqing[1], C. Jianjun[1], L. Deng[1], Y. Guofang[1]

1. College of Computer Science and Technology, National University of Defense Technology, China

Through results of heavy-ion and laser pulse testing, the Single-Event Effect (SEE) performance of neural network algorithms on sub-20nm AI chips was summarized, and the characteristics of SEE were revealed.

11:50 AM **RADIATION EFFECTS DATA WORKSHOP INTRODUCTION**
Chair: Matt Von Thun (Frontgrade)

12:00 PM – 1:30 PM **LUNCH**

1:30 PM – 3:30 PM **RADIATION EFFECTS DATA WORKSHOP**

MIDTOWN

DW-1 **The Aerospace Corporation's Compendium of Recent Radiation Testing Results**

S. Davis[1], R. Koga[1], K. Lee[1], J. Taggart[1], G. Tzintzarov[1], A. Wright[1]
1. The Aerospace Corporation, USA

Radiation testing was performed on several commercial components to determine the response of these components to the space radiation environment. Testing was mostly focused on SEE from protons and heavy ions.

DW-2 **CHALICE: Calculator for Highly Accurate Laser-Induced Carrier Excitation**

A. Ildefonso[1], J. Hales[2], T. Crane[2], D. McMorrow[2]
1. Indiana University Bloomington, USA
2. U.S. Naval Research Laboratory, USA

We present details on the operation of CHALICE, which is a freely available online tool that calculates fundamental quantities related to pulsed-laser SEE testing including laser-equivalent LET and deposited charge.

DW-3 **Single-Event Latch-up Data from Heavy-Ion Irradiation of COTS Components with Inter-Lot Variability Study**

D. Soderstrom[1], I. Slipukhin[1], M. Sacristan Barbero[2], M. Poizat[3], T. Borel[3], H. Kettunen[4], M. Sivertz[5], N. Emriskova[1], A. Waets[1], K. Bilko[1], M. Delrieux[1], R. Garcia[1]
1. CERN, Switzerland
2. CIEMAT - CERN, Switzerland
3. ESA, Netherlands
4. RADEF, Finland
5. NSRL-BNL, USA

Multiple samples of five different references of COTS components have been irradiated at various heavy-ion facilities, and measured single-event latch-up cross sections are reported. Part-to-part variations of latch-ups sensitivities are investigated.

DW-4 **Radiation Evaluation of the TPS7H6101-SEP Radiation-Tolerant 200V, 12A GaN Half Bridge Power Stage**

T. Lew[1], A. Marinelarena[1], M. Trevino[1]
1. Texas Instruments, USA

Single Events Effect (SEE) characterization and total ionizing dose (TID) results for the TPS7H6101-SEP eGaN power stage are summarized, showing very robust SEE performance up to LET_{EFF}=43 MeV-cm^2/mg and excellent TID behavior to 50 krad(Si).

DW-5 **Compendium of NASA Goddard Space Flight Center's Current Radiation Effects Test Results**

M. O'Bryan[1], L. Ryder[2], J. Lauenstein[2], E. Wilcox[3], K. Ryder[2], T. Carstens[2], S. Roffe[2], A. Wood[2], M. Campola[2], J. Osheroff[3], M. Joplin[3]

1. SSAI, Inc., USA
2. NASA GSFC, USA
3. NASA, USA

We present results and analysis investigating the effects of radiation on a variety of candidate spacecraft electronics to heavy ion and proton induced single-event effects (SEE), proton-induced displacement damage dose, and total ionizing dose (TID).

DW-6 **Soft Error Evaluation of 12nm FinFET Technology Based on COTS GPU Neutron Testing**

L. Artola[1], A. Urena-Acuna[1], E. Christopher[2], C. Li[2], G. Hubert[1]

1. ONERA - University of Toulouse, France
2. University of Saskatchewan, Canada

This work presents the experimental SEE evaluation of TU104 COTS-GPU designed in 12nm FinFET technology under neutron irradiations. SEU and SEFI events are discussed and compared with SEU modeling to consolidate the technology susceptibility acknowledge.

DW-7 **Neutron Radiation Results of Fault-Tolerant Soft RISC-V Linux SoCs on SRAM-based FPGAs**

A. Wilson[1], G. Baker[1], M. Wirthlin[1]

1. Brigham Young University, USA

This work presents a fault-tolerant RISC-V Linux SoC employing TMR, ECC, and SEU-aware placement on Kintex 7 and KU060 FPGAs. The neutron radiation results demonstrate improved cross-section up to 43 times for the mitigation methods.

DW-8 **Total Ionizing Dose Effects on Clock Systems and Peripheral Modules of the MSP430FR6989**

I. Hudson[1], J. Carpenter[1], T. Peyton[1], J. Kim[1], R. Baltazar Felipe[1], J. Ermi[1], D. Loveless[1]

1. IU CREATE, USA

TID testing of the MSP430FR6989 microcontroller was conducted to evaluate bias dependence and variation in peripheral module degradation. Three peripherals were tested at two low-power modes and over 30 configurations, showing variability in TID response.

DW-9 **Threshold Shifts Caused by TID Depending on Memory Cell States in Charge Trap Flash Memories**

T. Ozawa[1], F. Jun[2], K. Kobayashi[1]

1. Kyoto Institute of Technology, Japan
2. Okayama Prefectural University, Japan

Total Ionizing Dose effect on Triple Level Cell NAND flash was studied. Threshold shifts and retention degradation varied by programmed state and electric field direction. Errors are from both charge loss and peripheral circuit degradation.

DW-10 **Radiation Evaluation of the TPS7H502X-SP Radiation-Hardness-Assured (RHA) Single-Ended PWM Controller with Integrated Silicon (Si) and Gallium Nitride (GaN) Field Effect Transistor (FET) Gate Driver**

T. Lew[1], A. Marinelarena[1], E. Johnson[1]
1. Texas Instruments, USA

Single Events Effect (SEE) characterization and total ionizing dose (TID) results for the TPS7H502X-SP single-ended PWM controller with integrated gate driver are summarized, showing robust SEE performance up to LET_{EFF}=75 MeV-cm^2/mg and excellent TID behavior.

DW-11 **Characterization of Several RF Devices Sensitivity to Total Ionizing Dose**

J. Diot[1], G. Assaillit[1], D. Poujols[1], M. Gaillardin[1]
1. CEA, France

Radio-Frequency (RF) components are increasingly used. It is therefore essential to be able to characterize their sensitivity to ionizing radiation. The aim of this study is to determine the susceptibility of five RF components.

DW-12 **Single-Event Effects in Commercial Photonic Transceivers**

G. Tzintzarov[1], J. Ocheltree[1], G. Allen[2], C. Boone[1], A. Bozovich[2]
1. The Aerospace Corporation, USA
2. NASA JPL, USA

The Aerospace Corporation is beginning to build a database of heavy ion data for COTS small form-factor pluggable transceivers. A small collection of transceivers were exposed to heavy ions and SEFI cross sections are shown.

DW-13 **2025 CERN Compendium of Radiation Effects in Candidate Electronics for High-Energy Particle Accelerator Systems**

R. Ferraro[1], A. Zimmaro[1], A. Scialdone[1], G. Foucard[1], E. Vasileiadi[1], S. Georgakakis[1], V. Pirc[1], S. Danzeca[1], A. Masi[1]
1. CERN, Switzerland

The sensitivity of a variety of components for particle accelerator electronics has been analyzed against Single Event Effects, Total Ionizing Dose and Displacement Damage. The tested parts include analog, linear, digital, and mixed devices.

DW-14 **System-Level Single Event Effects Testing of the PIRT 1280MVCam InGaAs Infrared Camera**

L. Ryder[1], J. Lauenstein[1], M. Campola[1], M. Kowalewski[1]
1. NASA GSFC, USA

System-level SEE testing was conducted on a commercial-off-the-shelf InGaAs camera to examine the impacts of SEFIs originating within the constitutive electronics. SEFI signatures and the complexities of testing tightly packaged commercial imaging systems are discussed.

DW-15 **SEE and Total Dose Results of the ISL74324Mxx 500MHz-6.5GHz RF Amplifier**

W. Newman[1], M. Campanella[1], D. Thornberry[1], M. Bailly[1], E. Thomson[1]
1. Renesas Electronics America, USA

We report the single event performance and low dose rate TID results of the radiation-hardened ISL74324Mxx 500MHz-6.5GHz Broadband RF Amplifier.

DW-16 **The Radiation Performance and Production Flows of Renesas's Radiation Tolerant and Radiation Hardened Space Plastic Parts**

W. Newman[1], M. Campanella[1], J. Brewster[1], E. Thomson[1]
1. Renesas Electronics America, USA

We describe the production flows of Renesas's ISL71xxxM/SLHM families of radiation-tolerant and radiation-hardened plastic-package integrated circuits and report some example single event and TID results.

DW-17 **Total Dose and SEE Testing of the ISL74420M Radiation Tolerant Quad Clock Fanout IC**

N. van Vonno[1], W. Newman[1], L. Pearce[1], E. Thomson[1], M. Campanella[1]
1. Renesas Electronics America, USA

We report results of total ionizing dose and single-event effects testing on the radiation tolerant ISL74420M Quad Clock Fanout IC. The part provides four synchronized clocks and is particularly useful in multiphase power converters.

DW-18 **Compendium of Single-Event Effects Test Results for Candidate Electronics at NASA Johnson Space Center from 2024**

R. Rinderknecht[1], S. Martinez[2], K. Nguyen[1], E. Agarwal[3], J. Pritts[1], B. Reddell[1], R. Gaza[1]
1. NASA Johnson Space Center, USA
2. NASA, USA
3. NASA Johnson Space Center, EV5 Electronic Design and Manufacturing Branch, USA

We present single-event effect (SEE) test results and analysis produced by NASA JSC in 2024 for candidate electronic components and devices. Devices tested include commercial memories, integrated circuits, and a prototype flight unit.

DW-19 **Total Dose and Single-Event Effects Testing of the ISL75054 Ultra-Low Noise LDO**

M. Campanella[1], W. Newman[1], N. van Vonno[1], D. Wackley[1], P. Larry[1], E. Thomson[1], C. Thomson[1]
1. Renesas Electronics America, USA

We report the single event effects and total ionizing dose test results for the ISL75054 ultra-low noise low-dropout regulator.

DW-20 **Total Ionizing Dose Response of COTS Operational Amplifiers**

D. Feist[1], D. Hiemstra[2], A. Noguera Cundar[1], J. Cardenas Chavez[1], L. Chen[1]
1. University of Saskatchewan, Canada
2. MDA, Canada

This study evaluated the Total Ionizing Dose response of four different COTS operational amplifiers using low dose rate ^{60}Co irradiation. Results revealed all amplifiers remained functional up to 30 krad(Si).

DW-21 **TID and SEE Response of the AMC1350EVM Isolation Amplifier**

A. Noguera Cundar[1], D. Hiemstra[2], J. Cardenas Chavez[1], L. Chen[1]
1. University of Saskatchewan, Canada
2. MDA, Canada

TID and SEE effects on the AMC1350 isolation amplifier were studied using low dose rate ^{60}Co irradiation and high-energy protons respectively. The isolation amplifier showed high robustness against radiation.

DW-22 **Radiation Evaluation of the TPS7H4104-SP Radiation-Hardness-Assured (RHA) 3V to 7V Input, 3A/Channel Quad-Channel Synchronous Step-Down Converter**

A. Marinelarena[1], T. Lew[1], J. Cruz-Colon[1]
1. Texas Instruments, USA

Single Events Effects characterization and Total Ionizing Dose results for the TPS7H4104-SP 3V to 7V Input, Step-Down Converter is summarized, showing very robust SEE performance up to LET_{EFF}=75MeV-cm^2/mg and excellent TID performance up to 100 krad(Si).

DW-23 **Investigating the suitability of High-Performance Linux-based System-on-Modules for Lunar Applications**

L. Coïc[1], G. Giuffrida[2], E. Le Goulven[1], S. Yjjou[1], A. Marino[2], P. Garcia[1], L. Turchi[3], G. Magistrati[4], A. Cowley[4]
1. TRAD, France
2. IngeniArs, Italy
3. SPACECLICK, Italy
4. European Space Agency, Netherlands

Characterization campaigns conducted on two System-on-Modules destined for lunar surface applications are presented. Their TID and SEE sensitivities were investigated under irradiation. Outgassing, Offgassing and Lifetest campaigns were also performed in this ESA project.

DW-24 **Development of a Double Scattering System for Radiation Effects**

C. Corbridge[1]
1. ProNova Solutions, USA

A double scattering system has been developed at ProNova Solutions for radiation effects testing. This system utilizes protons more efficiently, resulting in a more uniform 40 cm diameter beam.

DW-25 **Functional Failure Induced by TID at Low-Dose Rate and High Energy Proton SEE Response of Commercial-off-the-Shelf Electronics**

B. Torres-Kulik[1], M. Mahmud[1], D. Hiemstra[1]
1. MDA Space, Canada

Commercial-off-the-shelf electronic components were subjected to gamma (^{60}CO) irradiation at low-dose rate and 105 MeV protons to characterize their susceptibility to total ionizing dose and proton induced single event effects respectively.

DW-26 **Total Ionizing Dose Characterization of Microchip Retriggerable Latching Current Limiting Power Switch**

S. Russell[1], D. Johnson[1], E. Colmet-Daage[1]
1. Microchip Technology, USA

The 100 krad total ionizing dose characterization results of Microchip Technology's radiation-hardened quad retriggerable latching current limiter (RLCL) power switch IC, the LX7714, are presented.

DW-27 **SEE Evaluation of a Serverless Computing Architecture under 14-MeV Neutrons**

D. Pacios[1], M. Rezaei[1], J. Vázquez-Poletti[1], S. Ignacio-Cerrato[1], J. Clemente[1]
1. Universidad Complutense de Madrid (UCM), Spain

This paper presents the effects of 14-MeV neutrons on a NVIDIA Jetson Nano running a serverless computing architecture. SDCs and DUEs were observed in its CPU and GPU when executing a serverless-based FFT function.

DW-28 **Heavy Ion Induced Single Event Effects on the Agilex Commercial Off-the-Shelf CMOS Field Programmable Gate Array (FPGA)**

R. Koga[1], S. Davis[1], J. Shanney[1], K. Pham[1], C. Cao[1], K. Pham[1], J. Dixon[1]
1. Aerospace, USA

Agilex field programmable gate array (FPGA) was tested for single event effects with heavy ions. SEEs such as SEU and SEFI were detected. No destructive SELs were observed.

DW-29 **Neutron-Induced Upsets and Stuck Bits on COTS Pseudo-Static RAMs**

M. Rezaei[1], F. Franco Peláez[1], A. Colangeli[2], J. Clemente[1]
1. Universidad Complutense de Madrid (UCM), Spain
2. ENEA Frascati Research Center, Italy

This paper presents an experimental study on the SEE radiation effects of several pseudo-static RAMs (PSRAMs) under 14-MeV neutrons. SEFIs and stuck-at faults were observed while performing static and dynamic tests.

DW-30 **Guide to the 2024 IEEE Radiation Effects Data Workshop Record**

D. Hiemstra[1]
1. MDA Space, Canada

The 2024 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

DW-31 **Single Event Upset Characterization of the Versal® Adaptive SoC Using Proton Irradiation**

D. Hiemstra[1], N. Hu[1]
1. MDA Space, Canada

Proton induced SEU cross-sections of the SRAM which stores the logic configuration and certain functional blocks of the Versal® Adaptive SoC Processing System and Programmable Logic are presented. Upset rate in the space radiation environment is estimated.

DW-32 **Single-Event Latchup Analysis and Mitigation Techniques on I/O Standard Cells in a 12nm Bulk FinFET Technology Node**

M. Evans[1], G. Poe[1], J. Laporte[1], S. Vibbert[1], T. Haeffner[1], J. Kauppila[1], L. Massengill[1]
1. Reliable MicroSystems, LLC, USA

Guard ring design variations are explored to mitigate single-event latch-up for Input/Output cell design. Data is presented for 12nm bulk FinFET I/O standard cells and custom structures to explore device spacing and guard ring effectiveness.

DW-33 **Single Event Latch-up Performance of the INA240 with Mitigation Technique & Proton vs. Heavy Ion Rate Prediction**

A. Dyer[1], M. Brozak[1], S. Kulkarni[1], A. Hof[1]
1. Mynaric, Germany

The SEE response of the TI-INA240 Bidirectional Current Sense Amplifier has been tested with high energy protons and heavy ions to evaluate on orbit upset rates. A successful SEL mitigation and its effectiveness is presented.

DW-34 **System-level Avionics Single Event Effects Testing for Extreme Space Weather Conditions**

A. Hands[1], E. Benton[2], C. Bélanger-Champagne[1], B. Gersey[3], M. Trinczek[1], E. Blackmore[1]
1. TRIUMF, Canada
2. Oklahoma State University, USA
3. Founders Classical Academy, USA

We present new dosimetry measurements for the development of a space weather test facility at TRIUMF, which is capable of recreating the extreme neutron fluxes that would be experienced by avionics during a 1-in-1000-year event.

DW-35 **General Purpose RISC-V Processor and SOC SEE Test Results**

S. Guertin[1]
1. NASA JPL, USA

We report SEE performance of RISC-V processors from StarFive (JH7110) and SiFive (U740). L2 Cache bit errors and crashes of a Linux OS provide upset sensitivity and system impact.

DW-36 **Reliability Impacts of Non-Destructive Single-Event Latch-ups in Commercial Electronics**

S. Martinez[1], R. Gaza[1], R. Ladbury[2], L. Ochs[2], G. Allen[3], A. Topper[4], T. Mondy[2], R. Hodson[5]
1. NASA Johnson Space Center, USA
2. NASA Goddard Space Flight Center, USA
3. NASA JPL, USA
4. SSAI, USA
5. Langley Research Center, USA

This paper presents the results of reliability life testing performed on commercial electronic devices that experienced non-destructive single-event latch-up (SEL) during heavy-ion testing. Lifetime degradations and their implications for space applications are discussed.

DW-37 **TID Induced Parametric Degradation of Commercial-off-the-Shelf Electronics and their SEE responses**

M. Mahmud[1], B. Torreskulik[1], D. Hiemstra[1]
1. MDA Space, Canada

To characterize the radiation susceptibility, commercial-off-the-shelf electronic components were tested to gamma (Co-60) irradiation for total ionizing dose and to 105 MeV proton irradiation for single event effects.

DW-38 **Multi-Angle Single Event Effects Characterization of 100V GaN-on-Si Power Transistor**

J. Brandt[1], R. Strittmatter[2]
1. EPC SPACE, USA
2. EPC Corp, USA

We report on Single Event (SEE) characterization of latest generation radiation hardened 100V GaN-on-Si transistors. Testing was conducted at NSRL using 147MeV/n Bi ion with nominal LET of ~83MeV/mg*cm^2(in Si) over multiple angles.

DW-39 **Total Ionizing Dose Effects on 28nm Microchip RT PolarFire® FPGA SRAM Physical Unclonable Functions**

M. Urias[1], A. Cai[1], N. Rezzak[1], R. Newell[1], R. Chipana-Quispe[1], K. Dave[1]
1. Microchip Technology, Inc., USA

This paper provides Total Ionizing Dose (TID) results and experimental evidence of the 28nm PolarFire® FPGA SRAM physical unclonable functions (PUF) maintaining operational reliability exceeding 100 krad(SiO_2), demonstrating potential suitability for space application security.

DW-40 **Complexities of Ionizing Radiation Testing of State-of-the-Art Single Board Computers**

C. Billie[1], R. Pinson[2], B. Rutherford[1], M. Spear[2], W. Slater[2], H. Quinn[2]
1. University of New Mexico COSMIAC, USA
2. Air Force Research Laboratory, USA

Evaluating complex computing systems presents challenges due to the radiation testing requirements. This work investigates ionizing radiation effects in Nvidia SBCs and power systems and components to better understand testing schemes to increase testing efficiency.

DW-41 **In-Situ Measurement of TID Performance of Alphacore's 22-nm SOI RO-PLL**

R. Chandru[1], K. Balantrapu[1], A. Benedetto[1], H. Choudhary[1], M. Turowski[1], P. Bikkina[1], E. Mikkola[1], A. Levy[1]
1. Alphacore Inc, USA

Alphacore's RO-PLL is irradiated in Co-60 chamber up to 300 krad and we observe degradation of jitter (6x from 290fs), duty cycle distortion (6x from 0.2%) and voltage amplitude (up to 100mV from 260mV).

DW-42 **Neutron Radiation Testing of Multiple System-on-Chip Devices Using an Open Test Framework**

J. Goeders[1], W. Smith[1], J. Bertrand[1], E. Hunter[1], M. Wirthlin[1]
1. Brigham Young University, USA

This work presents an open-source framework for neutron testing of various system-on-chip (SoC) devices. The framework is demonstrated through a neutron test with four different types of SoC boards and 16 boards in total.

DW-43 **Radiation-Induced Single-Event Effects on Gemini APU In-Memory Processors**

D. Wildenstein[1], M. Gruber[2], G. Williams[3], N. Sampson[3], A. George[1]
1. University of Pittsburgh, USA
2. Troxel Aerospace, USA
3. GSI Technology, USA

Processing-in-memory architectures exhibit many characteristics beneficial for spaceflight, including fast performance and low power consumption. This research documents the first heavy ion radiation test of the Gemini-I APU processing-in-memory architecture for single-event effects.

DW-44 **Impact of Single-Event Upsets on an SPI-Controlled Ka-Band Radiation-Hardened Beamformer Core Chip for Space Applications**

N. Pelagalli[1], F. Pergolesi[2], F. Vargas[1], A. Franzese[3], A. Malignaggi[1], C. Carta[1]
1. Leibniz Institute for High Performance Microelectronics, Germany
2. Paradigma Technologies, Slovenia
3. Qualcomm Technologies Inc., USA

This paper presents high-energy radiation tests on a 28-GHz SPI-controlled beamformer chip for satellite communications in 130nm SiGe BiCMOS rad-hard technology. Results show robust RF performance and mixed-signal functionality despite increased SEU sensitivity.

DW-45 **High-Speed In-situ TID Testing of QSFP Transceivers**

R. Chandru[1], D. Ramaswami[1], K. Balantrapu[1], E. Mikkola[1], S. Moazeni[2]
1. Alphacore Inc, USA
2. Univ of Washington Seattle, USA

We describe a lightweight test setup irradiating QSFPs in Co-60 chamber and observe 100% reduction of the eye-opening at 12.5Gbps for DUTs with link loss and an increase in BER of up to 1000x.

DW-46L **2025 Compendium of Recent Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory's Radiation Effects Group**

G. Allen[1], S. Vartanian[1], F. Irom[1], A. Daniel[1], S. Guertin[1], A. Bozovich[1]
1. NASA JPL, USA

This paper reports heavy ion induced SEE results for a variety of microelectronic for possible use on NASA missoins. The compendium covers devices tested between 2020-2025. It is formatted as an update to the SEE compendia.

DW-47L **SEE and beam characterization with high energy heavy ions at HIMAC**

M. Cecchetto[1], K. Bilko[2], R. Garcia[1], S. Kodaira[3], J. Autran[4]
1. CERN, Switzerland
2. Université Jean Monnet, France
3. National Institutes for Quantum Science and Technology (QST), Japan
4. Institut de Physique de Rennes (IPR), France

Single event effect cross sections and energy deposition events in a silicon diode were measured with high energy heavy ions at HIMAC, in Japan, by varying LETs through PMMA degraders.

DW-48L **Radiation Characterization of Radiation Hardened by Design 12 nm FinFET Memories**

R. Lawrence[1], J. Ross[1], M. Casey[1]
1. BAE Systems, USA

Total Dose and Single Event Effect test results are discussed on Radiation Hardened by Design (RHBD) 12 nm FinFET memory devices.

DW-49L **Radiation Effects Characterization of TI ADC168M102R-SP Analog to Digital Converter (ADC)**

V. Narayanan[1], T. Senter[1], R. Rao[1]
1. Texas Instruments Inc., USA

Radiation study of ADC168M102R-SP 8-channel, 16-bit analog-to-digital converter released for space applications. Device passed 100 krad total dose and is latch-up immune up to 75 MeV-cm^2/mg at 125C. SET was characterized up to 48 MeV-cm^2/mg.

DW-50L **Radiation Effects Characterization of TI ADC3683-SP 18bit Analog to Digital Converter (ADC)**

V. Narayanan[1], E. Rives[1], A. Arounpradith[1], R. Rajagopalan[1]
1. Texas Instruments Inc, USA

Radiation study of ADC3683-SP 2-channel, 18-bit analog-to-digital converter released for space applications. Device passed 300 krad total dose and is latch-up immune up to 75 MeV-cm^2/mg at 125C. SET was characterized up to 78 MeV-cm^2/mg.

DW-51L **SEE and TID test results of Microchip's M6™ Power MOSFET Technology**

O. Mansilla[1]
1. Microchip, USA

Microchip's M6™ technology has been developed to provide reliability and radiation hardness on power MOSFETs for space applications. This paper focuses on the test results, total ionizing dose (TID) and destructive single event effects (SEE).

DW-52L **Heavy ions single event latchup test results for the NA2200 analog front-end**

T. Rajkowski[1], G. Szaciłowski[1], A. Dziedzic[1]
1. National Centre for Nuclear Research, Poland

Heavy ions SEL test results of the NA2200 analog front-end are presented. The component might be considered for use in some space applications, although further radiation characterization (including soft SEEs and TID effects) is required.

DW-53L **SEE Results of a Custome Power Management Integrated Circuit (PMIC) Using Global Foundries 130 nm Technology**

M. Byers[1], A. Omprakash[1], R. Young[1], B. Liu[1], R. Ng[1], A. Lara[1], A. Huynh[1], J. Steffan[1], A. Soto[1], M. Herrera[1], D. Kachuche[1], E. Normandy[1], B. Do[1], R. De Jesus[1], R. Lyons[1]

1. Raytheon, USA

SEE test results for a custom PMIC are presented for heavy ion and proton environments. While no destructive events were observed, latchup was observed in the heavy ion environment. SEFIs were observed in both environments.

DW-54L **Heavy Ion-Induced Single-Event Effects in eGaN HEMTs**

A. Billa[1], P. Maloney[1], G. Mayberry[2], T. Liu[2], B. Bolton[1], H. Parra[1], F. Ahmed[1], J. Debnath[1], D. Fleetwood[2], E. Zhang[1]

1. University of Central Florida, USA

2. Vanderbilt University, USA

Angular and electric-field dependences of SELC and SEB were investigated in EPC2037 and EPC2038 eGaN HEMTs using 16- and 20-MeV ions. SELC and SEB sensitivity are found under Xe irradiation at high drain bias.

4:00 PM – 5:30 PM **RESG OPEN MEETING**

GRAND BALLROOM

5:30 PM – 6:00 PM **New NPSS Member Reception**

GRAND BALLROOM

TECHNICAL PROGRAM FRIDAY

GRAND BALLROOM

8:30 AM **TBA**
INVITED SPEAKER

SESSION H **HARDENED BY DESIGN**

9:30 AM **SESSION INTRODUCTION**
Chair: Enxia Zhang (UCF)

H-1 **Radiation-Hardened-by-Design Techniques to Mitigate Inductor-Originated Single-Event**
9:35 AM **Frequency Transients in CMOS LC-Tank Oscillators**

G. Adom-Bamfi[1], S. Biereigel[2], E. Tackx[1], P. Leroux[1], J. Prinzie[1]
1. KU Leuven, Belgium
2. CERN, Switzerland

This work investigates RHBD techniques to mitigate SEFT in CMOS oscillators caused by single-event sensitivity in on-chip inductors. Heavy-ion microbeam tests on DCO circuits show that incorporating N+ islands and N-well layers reduces SEFT sensitivity.

H-2 **Design and Testing of a 32-Bit Radiation-Tolerant RISC-V Microcontroller Fabricated at**
9:50 AM **the 22-nm FDSOI Node**

C. Elash[1], Z. Li[1], J. Xing[1], P. Pour Momen[1], D. Ramaswami[1], D. Lambert[1], J. Cardenas[1], R. Fung[2], S. Wen[2], G. Martin[3], L. Chen[1]
1. University of Saskatchewan, Canada
2. Cisco, USA
3. QuickLogic Corporation, USA

A 32-bit RISC-V microcontroller is designed and fabricated at a 22-nm FDSOI node using Radiation Hardening by Design Techniques. Testing of the device shows remarkable tolerance to single event effects from protons and heavy ions.

POSTER PAPERS

PH-1 **System-Level SEU Hardening of Wireless Receivers through Modulation Scheme Selection**

J. Shin[1], J. Teng[2], Z. Brumbach[1], B. Ringel[1], D. Sam[1], A. Ildefonso[3], T. Crane[4], A. Khachatrian[5], D. McMorrow[5], J. Cressler[1]
1. Georgia Institute of Technology, USA
2. The Aerospace Corporation, USA
3. Indiana University, Bloomington, USA
4. Jacobs, Inc., USA
5. U.S. Naval Research Laboratory, USA

Pulsed-laser SEE testing is utilized to evaluate SEU-hardening of a SiGe wireless receiver through modulation scheme selection. Results demonstrate that intentionally selecting modulation schemes based on known component sensitivity can reduce system-level SEU rates.

PH-2 **Total Dose Hardening Using a Sensitive Circuit Identification Methodology in a DC-DC Converter**

M. Murillo[1], R. Milner[2], B. Dean[1], J. D'Amico[1], T. Tengberg[2], A. Witulski[1], M. Alles[1], S. Kosier[1], J. Trippe[1], T. Holman[1], D. Ball[1], M. Hu[1], A. Fayed[2], L. Massengill[1]

1. Vanderbilt University, USA

2. The Ohio State University, USA

Data-calibrated models of TID effects were used to simulate radiation effects in a DF-SIMO buck converter. Through this, a method of "sensitive circuit" identification was developed to efficiently simulate TID effects mitigation.

PH-3 **Optimized Dynamic Back-Biasing Strategy to Improve TID Tolerance in Conventional-Well 22nm FDSOI Transistors**

B. Dean[1], M. Hu[1], T. Haeffner[2], J. Kauppila[2], M. Alles[1], J. Trippe[1], D. Ball[1], B. Sierawski[1], T. Holman[1], S. Kosier[1], L. Massengill[1]

1. Vanderbilt University, USA

2. Reliable MicroSystems, USA

An optimizable back-biasing strategy for TID mitigation is presented based on 22nm FDSOI transistor data obtained with in situ back-bias variation, resulting in a calculated maximum survivable dose increase of over 35%.

10:05 AM – 10:45 AM **BREAK**

GRAND FOYER

SESSION I **POWER DEVICES AND WIDE-BANDGAP SEMICONDUCTORS**

10:45 AM **SESSION INTRODUCTION**

Chair: Art Witulski (Vanderbilt)

I-1
10:50 AM **Temperature Effect of Single Event Burnout and Leakage Current in SiC Power MOSFETs**

K. Niskanen[1], A. Javanainen[1], C. Martinella[2], A. Witulski[3], H. Kettunen[1]

1. University of Jyväskylä, Finland

2. APS Laboratory - ETH Zurich, Switzerland

3. Vanderbilt University, USA

The effect of temperature on the heavy ion response of SiC power MOSFETs was investigated. The single event burnout (SEB) threshold increased and the ion-induced leakage current decreased with increasing temperature.

I-2
11:05 AM **Physical Model for Epitaxial Doping Dependence of Single-Event Leakage Current in SiC Power Devices**

A. Sengupta[1], S. Kosier[1], D. Ball[1], S. Islam[1], A. Sternberg[1], J. Hutson[2], J. Osheroff[3], R. Schrimpf[1], K. Galloway[1], A. Witulski[1]

1. Vanderbilt University, USA

2. Lipscomb University, USA

3. NASA Goddard Space Flight Center, USA

Epitaxial doping plays a dominant role in determining the single-event leakage current degradation thresholds in silicon carbide devices. This is established using the experimental measurements of heavy-ion responses for 1200, 1800, and 4500 V devices.

I-3 11:20 AM **Laser-Induced Single-Event Burnout in GaN Devices**

A. Khachatrian[1], A. Koehler[1], S. Buchner[2], J. Hales[2], D. McMorrow[1]

1. U.S. Naval Research Laboratory, USA

2. Jacobs, Inc., USA

Single-event effects in GaN devices are studied using ultrafast laser pulses. Defects in the GaN material lead to an increased sensitivity to SEB, suggesting that the pulsed laser can be used to screen devices.

I-4 11:35 AM **Investigations on TID Effects-Induced Parasitic Transistors in GaN Cascode Power Transistors.**

H. Couillaud[1], M. Gaillardin[1], L. Artola[2], G. Hubert[2]

1. CEA, DAM, CEA-Gramat, France

2. ONERA/DPHY, France

TID effects are studied for two commercial GaN Cascode power technologies. TID triggers unexpected parasitic transistors which are investigated using both experiments and TCAD simulations.

I-5 11:50 AM **Failure Mechanism Analysis, Modeling, and Simulation with TCAD for Wide Area SEB in 4H-SiC Power Device caused by Proton and Neutron Irradiation**

H. Lee[1]

1. QRT Inc, Republic of Korea

The failure phenomenon in a wide area was analyzed, and this was explained with physical analysis and TCAD based proposed trap-assist tunneling current model for SEB during irradiation in SiC power diode.

POSTER PAPERS

PI-1 **Single Ion-Induced Damage in Gallium Nitride High Electron Mobility Transistors**

J. Gray[1], A. Sternberg[1], J. Kauppila[2], D. Ball[1], J. Trippe[1], S. Kosier[1], A. Witulski[1], M. Alles[1], J. Davidson[1], R. Schrimpf[1], L. Massengill[1]

1. Vanderbilt University, USA

2. Reliable MicroSystems, LLC, USA

Ion-induced damage leading to increased leakage current and hard failures in gallium nitride transistors are reported. Leakage current paths are identified using failure analysis and TCAD simulations.

PI-2 **Estimating SELC and SEB Thresholds in SiC Power Devices Using Standard Benchtop Switching Energy Measurements**

D. Ball[1], S. Kosier[1], K. Galloway[1], A. Witulski[1], A. Sternberg[1], S. Islam[1], A. Sengupta[1], M. Alles[1], J. Hutson[2], R. Reed[1], J. Osheroff[3], R. Schrimpf[1]

1. Vanderbilt University, USA

2. Lipscomb University, USA

3. NASA Goddard Space Flight Center, USA

Switching energy measurements are used to estimate ion-induced leakage and burnout thresholds in SiC power devices, while the non-linear, ion-induced carrier mobility degradation is shown to explain SELC/SEB threshold trends seen in measured data.

PI-3 **Impact of Proton Energy on Displacement Damage and Total Ionizing Dose in SiC Vertical Power MOSFETs**

C. Martinella[1], S. Bonaldo[2], M. Belanche[1], R. Kupper[1], G. Andreetta[2], M. Bagatin[2], S. Gerardin[3], A. Paccagnella[2], U. Grossner[4]

1. APS Laboratory - ETH Zurich, Switzerland
2. University of Padova, Italy
3. DEI - Padova University, Italy
4. APS - ETH Zurich, Switzerland

DD and TID have been studied in SiC power MOSFETs with 1 and 3 MeV protons. Deep-level transient spectroscopy (DLTS) has been used to investigate the generation of defects in 4H-SiC wafers.

PI-4 **Neutron SEE Test Considering Actual EV Operating and Environment for Commercial 1200V SiC MOSFET**

M. Jo[1]

1. QRT Inc., Republic of Korea

We performed neutron SEE tests with reflecting conditions driving distance and driving environment for EVs.

PI-5L **Influence of Ion LET and Epitaxial Thickness on Single-Event Effects in Homojunction GaN Vertical Diodes**

A. Senarath[1], S. Islam[1], A. Sengupta[1], O. Meilander[1], J. Osheroff[2], T. Anderson[3], A. Jacob[4], R. Kaplar[5], S. Kosier[1], M. Ebrish[1], D. Fleetwood[1], J. Caldwell[1], R. Schrimpf[1]

1. Vanderbilt University, USA
2. NASA Goddard Space Flight Center, USA
3. University of Florida, USA
4. U.S. Naval Research Laboratory, USA
5. Sandia National Laboratories, USA

Higher-LET ions and thinner epitaxial layers lead to lower SEB thresholds in homojunction GaN PIN diodes. Higher-LET ions enhance degradation through a positive feedback loop mechanism involving Joule heating and nitrogen vacancy formation.

12:05 PM **CLOSING REMARKS**

RESG NEWS

The purposes of the Radiation Effects Committee (REC) of the IEEE Nuclear and Plasma Sciences Society are to advance the theory and application of radiation effects and its allied sciences, to disseminate information pertaining to those fields, and to maintain high scientific and technical standards among its members.

Kay Chesnut, RTX
Executive Chair

The Committee aids in promoting close cooperation and the exchange of technical information among its members. This goal is met by running conferences for the presentation and discussion of original contributions, assisting in the publication of technical papers on radiation effects in the *IEEE Transactions on Nuclear Science (TNS)*, coordinating development of radiation effects measurement definitions and standards within IEEE and other standards organizations, providing a sounding board for radiation effects specialists, providing for the continued professional development and needs of its members, and providing liaisons between IEEE and other technical organizations in the areas of radiation effects.

Each year, the REC provides a forum for the technical exchange of information by holding the Nuclear and Space Radiation Effects Conference (NSREC). NSREC is an international forum for presentation of research papers on radiation effects, including effects on electronic and photonic materials, devices, circuits, sensors, systems, semiconductor processing technology, and design techniques for producing radiation-tolerant (hardened) devices and integrated circuits. Papers presented at the NSREC are submitted for possible publication in the Spring issue of the *IEEE TNS*.

Heather Quinn,
Air Force Research Laboratory
Executive Vice-Chair

NSREC 2025 will be held in Nashville, TN, July 14-18, at the Renaissance Nashville. Dr. Dolores Black, Sandia National Laboratories, is the Conference Chair. The 2025 NSREC supporters are Aerospace Corporation, EPC Space, Frontgrade, Northrop Grumman, Renesas, Southwest Research Institute, and Western Digital. We appreciate our supporters for their significant commitment to the conference. The supporters' ongoing commitment to NSREC allows us to keep conference registration rates affordable. We welcome other organizations to consider supporting NSREC 2026 in San Juan, Puerto Rico.

Our upcoming NSREC chairs include Philippe Paillet, CEA, France, for 2026, Jonathan Pellish, IEEE, for 2027, and Pascale Gouker, MIT Lincoln Laboratories, for 2028.
Papers presented at the 2025 NSREC are eligible for publication in a Spring 2026 issue of the IEEE TNS. Authors must upload their papers prior to the conference for consideration for publication in the TNS Special Issue. Detailed instructions can be found at www.nsrec.com.

Keep visiting our web site for author information, paper submission details, exhibitor links, on-line registration, and the latest NSREC information.

Dan Fleetwood
Vice-Chair of Publications

All papers accepted for oral or poster presentation in the 2025 technical program will be eligible for publication in a special Spring 2026 issue of the *IEEE Transactions on Nuclear Science (TNS)*, based on separate submission of a complete paper. Each *IEEE TNS* submitted paper will be subject to the standard full peer review. All papers must be submitted through the IEEE Author Portal. While this is a different site than used for submissions in previous years, the process is similar. Instructions for submitting and reviewing papers can be found under the Publications tab at the Conference website ***www.nsrec.com.*** The deadline for submission of *TNS* papers is July 11, 2025. Data Workshop papers are published in a Workshop Record and are not candidates for publication in the *IEEE TNS.* The process for the Workshop Record is managed by the Workshop Chair.

The review process for papers submitted to the *TNS* is managed by a team of editors. To provide consistent review of papers, this editorial team manages the review process for all radiation effects papers submitted to the *TNS* throughout the year. The editorial team consists of a senior editor and associate editors who are technically knowledgeable in one or more specializations and are experienced in the publication process. If you would like to serve as a reviewer for the NSREC or RADECS special issues of the *TNS*, and/or for radiation effects papers submitted throughout the year, please contact one of the editors. The editors for the 2025 NSREC are:

Dan Fleetwood, Senior Editor, Vanderbilt University
Email: dan.fleetwood@vanderbilt.edu

Heather Quinn, Associate Editor, Air Force Research Laboratory
Email: heather.quinn.2@spaceforce.mil

Steven Moss, Associate Editor, The Aerospace Corporation, retired
Email: scmosshb@aol.com

Vincent Goiffon, Associate Editor, ISAE-SUPAERO
Email: vincent.goiffon@isae.fr

Philippe Paillet, Associate Editor, CEA
Email: philippe.paillet@cea.fr

Lili Ding, Associate Editor, NINT, China
Email: lili03_ding@126.com

Daniel Loveless, Associate Editor, Indiana University
Email: dlovele@iu.edu

Jeffrey Black, Associate Editor, Sandia National Laboratories
Email: jefblac@sandia.gov

Federico Faccio, Associate Editor, CERN
Email: Federico.Faccio@cern.ch

Janet Barth, Associate Editor, NASA, retired
E-mail: jbarth@ieee.org

Cui Meng, Associate Editor, Zhejiang University
Email: mengcui@zju.edu.cn

Enxia Zhang, Associate Editor, University of Central Florida
Email: enxia.zhang@ucf.edu

RESG NEWS

ARE YOU A MEMBER OF IEEE?

Now is the time to join the Institute of Electrical and Electronics Engineers (IEEE) and the Nuclear Plasma Sciences Society (NPSS). Why? First of all, you'll become a member of the largest professional engineering society in the world. About 60% of NSREC attendees are IEEE members. The cost of membership in the IEEE depends on your country and your career phase. IEEE members receive access to a broad range of benefits, including a terrific insurance program, on-line access to IEEE publications and reduced rates at all IEEE-sponsored conferences, including, of course, NSREC and the Short Course!

NPSS membership is $35 annually. NPSS members receive a free subscription to NPSS News, and a free on-line electronic access via IEEE Xplore to the *IEEE Transactions on Nuclear Science* (*TNS*) and the NSREC Data Workshop Records. Members can search and view digital copies of the entire IEEE TNS paper archive from current issues to the first IEEE NSREC in 1964. NPSS members get to vote in our elections, including the election for Junior Member At-Large that is held at the annual open meeting during the conference.

Apply for membership at ***http://ieee-npss.org/why-join-npss-and-ieee/*** or visit the IEEE registration desk at the conference.

NSREC PUBLICATIONS

NSREC has two publications each year:

- ***IEEE Transactions on Nuclear Science.*** This IEEE journal is the official archive of research papers presented at NSREC. Papers presented at the conference undergo an additional submission and peer review before they are accepted for the 2026 special issue.
- ***IEEE Radiation Effects Data Workshop Record.*** Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components.

A complimentary copy of the 2025 *IEEE Radiation Effects Data Workshop Record* and the 2026 special NSREC issue of the *IEEE TNS* is mailed to each NSREC technical session attendee if one has opted into inclusion on the attendee list.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 17, 4:00 pm – 5:30 pm. All conference attendees are encouraged to attend, including attendees that are not IEEE NPSS members. A welcome reception for new NPSS members will follow the open meeting.

THURSDAY, JULY 17
4:00 PM – 5:30 PM

During the open REC meeting we will discuss the current and future conferences. Nominations for the 2025 Junior Member-at-Large to the Radiation Effects Steering Group are accepted at the meeting. Voting instructions for IEEE NPSS members will be provided. Join IEEE NPSS and you can vote!

AWARDS

2024 OUTSTANDING PAPER AWARD

Effectiveness of NIEL as a Predictor of Single Event Displacement Damage Effects in CMOS Circuits

J. M. Trippe, B. D. Sierawski, G. Mayberry, H. M. Dattilo, S. T. Pantelides, D. M. Fleetwood, R. D. Schrimpf, L. W. Massengill, and R. A. Reed

2024 OUTSTANDING STUDENT PAPER AWARD

SEU Cross-Section Trends for Threshold Voltage Options from 16-nm to 3-nm Bulk FinFet Nodes

Y. Xiong, N. J. Pieper, J. B. Kronenberg, M. Delaney, C. N. N. Sanchez, D. R. Ball, M. Casey, R. Fung, S.-J. Wen, and B. L. Bhuva

2024 OUTSTANDING DATA WORKSHOP PRESENTATION AWARDS

Compendium of NASA Goddard Space Flight Center's Recent Radiation Effects Test Results

M. O'Bryan, S. Roffe, E. Wilcox, M. Campola, J. Osheroff, M. Casey, M. Joplin, T. Carstens, J. Barth, L. Ryder, K. Ryder, J. Lauenstein, W. Adia, and P. Majewicz

2025 RADIATION EFFECTS AWARDS

The winners of the 2025 Radiation Effects and 2025 Radiation Effects Early Achievement Awards will be announced Tuesday, July 15, at the conference opening. The purpose of the Radiation Effects Award is to recognize individuals who have had a sustained history of outstanding and innovative technical and/or leadership contributions to the radiation effects community. The purpose of the Radiation Effects Early Achievement Award is to recognize an individual within the first ten years of beginning his or her career whose technical contributions and leadership have had a significant impact on the field of radiation effects.

2026 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2026 IEEE Nuclear and Plasma Sciences Society (NPSS) Radiation Effects Award. The basis of the award is for individuals who have: (1) a substantial, long-term history of technical contributions that have had major impact on the radiation effects community. Examples include benchmark work that initiated major research and development activities or a major body of work that provided a solution to a widely recognized problem in radiation effects; and/or (2) a demonstrated long-term history of outstanding and innovative leadership contributions in support of the radiation effects community. Examples include initiation or development of innovative approaches for promoting cooperation and exchange of technical information or outstanding leadership in support of the professional development of the members of the radiation effects community.

Nominations are currently being accepted for the 2026 Radiation Effects Early Achievement Award. The basis of the award is for individuals whose technical contributions and leadership during the first ten years of the recipient's career that have had a major impact on the Radiation Effects Community. Examples include work that provides a solution to important technical problems in radiation effects or work that identifies significant new issues in the field. Other factors are cumulative research contributions over the first part of the career, internationally recognized leadership, and mentorship. It is the intent of the RESG to give special consideration for this award to members of the community who are IEEE/NPSS members.

Monetary awards and plaques will be presented at the NSREC in San Juan, Puerto Rico, in July 2026. Nomination forms are available electronically in PDF Format or in Microsoft Word format at ***http://ieee-npss.org/technical-committees/radiationeffects/***. Forms should be sent to Laurent Artola, Member-at-Large, ONERA at ***laurent.artola@onera.fr***

CONFERENCE INFORMATION

CONFERENCE LOCATION

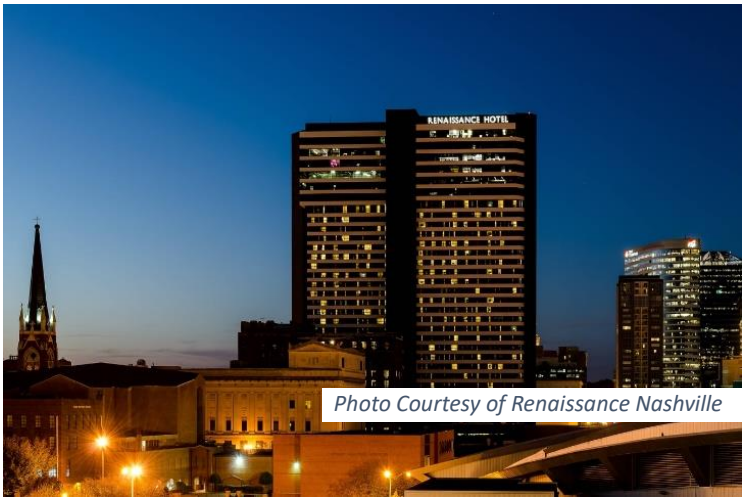


Photo Courtesy of Renaissance Nashville

The Renaissance Nashville Hotel with the adjoining Conference Center is the location for NSREC 2025. Nashville is the capital of the U.S. state of Tennessee and home to Vanderbilt University. Legendary country music venues include the Grand Ole Opry House, home of the famous “Grand Ole Opry” stage and radio show. The Country Music Hall of Fame and Museum and historic Ryman Auditorium are Downtown, as is the District, featuring honky-tonks with live music and the Johnny Cash Museum, celebrating the singer's life.

The NSREC 2025 is at the Nashville Renaissance in downtown Nashville adjacent to the famous 5th and Broadway. Nashville, nicknamed Music City, is the capital of the U.S. state of Tennessee and home to Vanderbilt University. Legendary country music venues include the Grand Ole Opry House, home of the famous “Grand Ole Opry” stage and radio show. The Country Music Hall of Fame and Museum and historic Ryman Auditorium are steps away from the Renaissance.

Music is the universal language and there is no better place to experience music than in Nashville, a city of storytellers and dreamers. It is a city where all are welcome with an authentic, friendly, creative spirit. It’s a city for you to discover all it has to offer and you can write your own Music City story. Nashville is the culinary destination of today, with chef-driven restaurants and classic dining spots serving up hot chicken, barbecue, and of course, meat and three. With nearly 200 new restaurants opening in the past two years, a one-of-a-kind culinary adventure awaits.

Beyond the music, food and drink, there is never a shortage of inspiring things to do. From the museums, the arts, sports and shopping, there is an “only in Nashville” experience waiting for you.


Photo Courtesy of Renaissance Nashville

This is Nashville, Tennessee’s capital. Please join us for NSREC 2025 and experience it for yourself.

The location for NSREC 2025 will be the Renaissance Nashville and the adjoining Conference Center in Nashville, TN.

Renaissance Nashville Hotel,
611 Commerce Street,
Nashville, TN, USA, 37203

Website: https://www.marriott.co m/en-us/hotels/bnash-renaissance-nashville-hotel/overview/

CONFERENCE INFORMATION

BREAKFASTS, LUNCHES, AND BREAKS

The 2025 IEEE NSREC will provide breakfast and refreshments at breaks during the NSREC Short Course and Technical Sessions. Additionally, lunch will be included on Monday for the Short Course attendees. These meals and refreshments are for ***registered conference attendees only***. Please see the schedule for times and locations.

The exhibitors will host a lunch on Wednesday, July 16th in the Broadway Ballroom. This lunch is for ***registered conference attendees and Exhibit Booth Staffers only.***

BUSINESS CENTER

The Renaissance Nashville Hotel has a FedEx on the 4th floor. Designed to accommodate those traveling on business, this self-service facility allows guests to fax, copy, and print documents and surf the web. Take advantage of black and white printers as well as reliable parcel service.

ROOMS FOR SIDE MEETINGS

A few "side meeting rooms" are available for use by any registered conference attendee at the Renaissance Nashville Hotel Conference Center on a first-come, first-served basis. *NSREC encourages side meetings to be scheduled at times other than during technical sessions.* Send an e-mail **to j.teehan@ieee.org** to make side meeting reservations before the conference. To make a side meeting room reservation during the conference, see the NSREC Registration staff.

Notes: You must register for the conference before a side meeting room can be reserved! All audio/visual equipment and refreshments must be coordinated directly with the Hotel and are the responsibility of the attendee hosting the meeting.

For more details on how to request additional accommodations for the side meeting rooms, please contact j.teehan@ieee.org.

HEALTH AND WELLNESS PROTOCOLS/COVID-19 PREPAREDNESS

IEEE NSREC will implement health and wellness protocols appropriate to the public health recommendations existing at the time of the conference. Compliance with the protocols adopted by IEEE NSREC may be mandatory for in-person attendance and participation at the conference. We will communicate any additional information regarding the specific health and safety measures, and any necessary consents by you, to attendees and exhibitors before the conference.

REGISTRATION AND TRAVEL

CONFERENCE REGISTRATION

John Teehan IEEE Registration Services

NSREC encourages Pre-Registration and offers a lower registration rate, "Early Registration," if the payment is received no later than Friday, June 20. After that date, the "Late Registration" rates apply.

Registrations can be submitted using the NSREC website link: www.nsrec.com. All Registrations must be completed online using the Registration Portal. Telephone registrations will not be accepted.

A Hospitality desk will be available for "On-site" Registration (Late Fees) next to the Registration Desk for those that may not have access to the online registration.

There are three acceptable forms of payment for registration and activity fees: 1) check made payable to "IEEE NSREC" in U.S. dollars and drawn on a U.S. bank, 2) Wire Transfer, or 3) MasterCard, VISA, Discover, and American Express credit card.

REGISTRATION LOCATION & TIMES IN Nashville

Event Hub on the Lobby Level of the Conference Center

Registration hours are:

Sunday, July 13	**5:00 PM – 8:00 PM**
Monday, July 14	**7:30 AM – 5:00 PM**
Tuesday, July 15	**7:30 AM – 5:00 PM**
Wednesday, July 16	**7:30 AM – 3:00 PM**
Thursday, July 17	**7:30 AM – 3:00 PM**
Friday, July 18	**7:30 AM – 10:00 AM**

CONFERENCE CANCELLATION POLICY

A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 30, 2025, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify NSREC at NSRECreg@ieee.org.

ON-SITE HOSPITALITY LOCATION & TIMES

Event Hub on the Lobby Level of the Conference Center next to will provide ***ON-SITE*** assistance for ***REGISTRATION***, directions to the different events, and answer any questions.

Hospitality hours are:

Sunday, July 13	**5:00 PM – 8:00 PM**
Monday, July 14	**7:30 AM – 5:00 PM**
Tuesday, July 15	**7:30 AM – 5:00 PM**
Wednesday, July 16	**7:30 AM – 3:00 PM**
Thursday, July 17	**7:30 AM – 3:00 PM**
Friday, July 18	**7:30 AM – 10:00 AM**

HOTEL RESERVATIONS

The preferred method to make reservations is by using the following weblinks:

Renaissance Nashville room rates for a standard king or two queen are:
NEGOTIATED GROUP RATE:
$269.00 USD single/double per night
https://book.passkey.com/event/50994782/owner/684/home?mobile=true&dw=390

Room taxes currently at 15.25% + $2.50 will be added to all rates listed above.
In any case, enter your arrival and departure dates and follow the prompts.
Room reservations require a credit card as a guarantee. The cut-off for IEEE NSREC reservations is at 5:00 PM Eastern Daylight Time (EDT) on July 8, 2025. Once the room block has been filled OR after the cut-off date (whichever comes first!), it is at the hotel's discretion as to whether they can book more rooms and at what room rate will be offered. Early reservations are strongly suggested!

Please be certain to notify the hotel of any change to your arrival or departure dates. When you check into the hotel, be sure to verify your departure date.

REGISTRATION AND TRAVEL

AIRPORT AND TRANSPORTATION INFORMATION

Nashville International Airport (code: **BNA**) is located approximately 8 miles from the Renaissance Nashville Hotel. Traveling outside of normal commuting hours, the drive typically takes between 15-30 minutes. During heavy commuting times, the drive can take up to 60 minutes.

TAXI SERVICE & RIDESHARE

Airport to Hotel Transportation:
There is no scheduled shuttle service between the Hotel and the Airport, but all commercial operators pick up at the Ground Transportation Center on Level 1 of Terminal Garage

1. Ride App vehicles (Uber/Lyft) pick up at the Ground Transportation Center, Level 1 of Terminal Garage 2. Click here for a diagram showing pick-up locations
   - Lyft – Picks up in Ride App Zone A (https://www.lyft.com/rider/airports/bna)
   - Uber – Picks up in Ride App Zones B & C (https://www.uber.com/)
   - KreweCar – Picks up in Ride App Zone D (https://www.krewecar.com/)

Directions to the Ground Transportation Center for Ride App vehicles:

- Exit the Main Terminal on Level 1 and turn right.
- Follow the sidewalk and pedestrian canopy to Terminal Garage 2. Overhead signs will direct you.
- The Ground Transportation Center is on Level 1.

2. Taxis pick up in the South Wing Pick Up Area

Directions to the Ground Transportation Center for Taxis:

- Exit the Main Terminal on Level 1 and turn right.
- Follow the sidewalk and overhead signs marked LIMO -TAXI will direct you.

From the airport, the meter starts at $9 and the rate is $2.50 per mile. There is a flat rate of $30 to the downtown area, plus an additional passenger charge of $2 when accompanying the original passenger and proceeding to the same destination.

*Accessible services are offered by most taxi companies during airport hours; however, to ensure an accessible taxi will be available for your use, please call the service of your choice for schedules, reservations, fees and information.
Please visit nashville.gov for information on taxicab fare

PARKING AND DRIVING DIRECTIONS

Nashville International Airport to Renaissance Nashville:

- Take I-40 West: From the airport, follow signs for I-40 West.
- Merge onto I-65 North: Merge onto I-65 North.
- Exit 209A: Take exit 209A toward US-70/US-70 S/US-431/Broadway.
- Turn right on Broadway: Turn right onto Broadway.
- Turn left on 7th Ave: Turn left onto 7th Ave.
- Turn right on Commerce Street: Go one block and turn right onto Commerce Street.
- The hotel is on the corner of 7th Ave and Commerce.

REGISTRATION AND TRAVEL

GETTING AROUND TOWN

The NSREC optional tours are the easiest way to explore the area. Still, there is much to see and do within walking distance of the hotels. The city is quite safe, so feel free to experience it at your leisure.

TIPS WHEN VISITING Nashville

Weather: July is a hot summer month in Nashville, TN, with an average temperature fluctuating between 65°F (20°C) and 90°F (32°C).

Driving: Be patient in traffic and mindful of pedestrians. Obey all traffic rules and be alert, whether driving or walking.

Restaurants & Tipping: Be aware that upscale restaurants might require reservations, especially during the busy dining hours of 6:00pm – 8:00pm. Most restaurants accept "casual" dress, although some are less "casual" than others. Standard tipping is 20 percent of the bill. Some restaurants add a "service charge" (gratuity) for groups of 6 or more, so check your bill to see if this has already been added

INDUSTRIAL EXHIBITS

Pierre Maillard
Industrial Exhibits Chair
Advanced Micro Devices

AMD

The 2025 NSREC Industrial Exhibit Event will showcase leading global suppliers of radiation-hardened products, advanced materials, specialized services, and cutting-edge research and development. This premier event offers suppliers, engineers, and technical managers a unique opportunity to connect and collaborate on the challenges and solutions for radiation-tolerant electronics in space and terrestrial systems, military applications, and other demanding environments.

The 2025 NSREC Industrial Exhibit Event is being held in the Broadway Ballroom on Tuesday, Wednesday, and Thursday. Breakfast and conference breaks will be in the Exhibit Area on Tuesday, Wednesday, and Thursday for registered attendees, with an Exhibitor Lunch held on Wednesday. NSREC badges must be worn at all times.

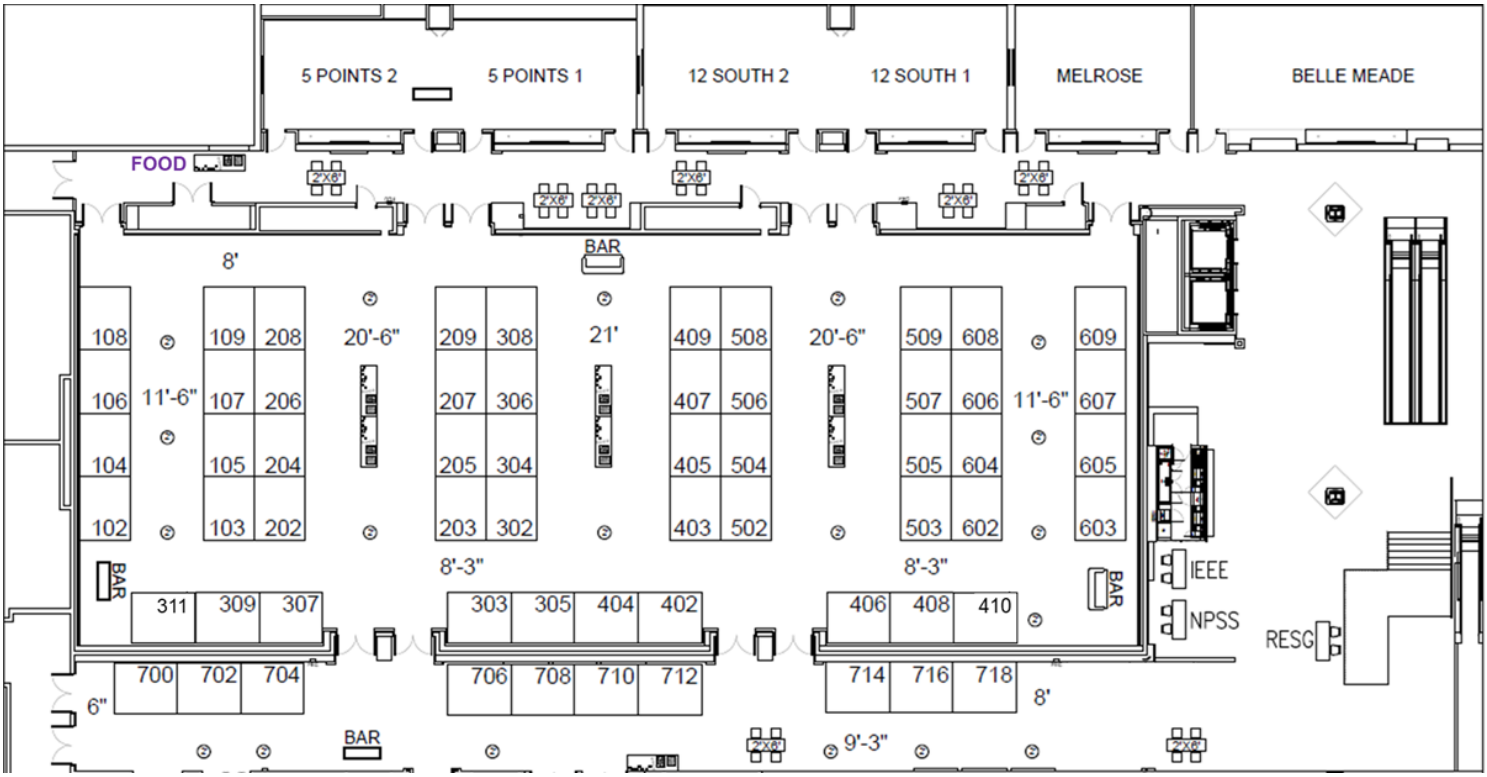
Tuesday evening, the exhibitors will host the Industrial Exhibits Reception featuring hors d'oeuvres in the Exhibit Area. The reception is open to all NSREC attendees and their guests.

NOTE: Children under 16 must be accompanied by an adult in the Exhibit Area.

For more information, contact:

- Pierre Maillard
- Phone: +1 (669)-221-4847
- Email: pierrem@amd.com

Interactive list of exhibitors: https://nsrec2025.expofp.com/



INDUSTRIAL EXHIBITS

Please check our website for a current listing of companies exhibiting at the 2025 NSREC event:
https://www.nsrec.com/industrial-exhibits-2025/

INDUSTRIAL EXHIBIT AGENDA
RENAISSANCE NASHVILLE HOTEL
BROADWAY BALLROOM

TUESDAY, JULY 15
BOOTHS OPEN
9:00AM – 4:30PM

MORNING BREAK
8:55AM – 9:25AM

AFTERNOON BREAK
2:50PM – 3:45PM

RECEPTION
5:30PM – 7:00PM

WEDNESDAY, JULY 16
BOOTHS OPEN
9:00AM – 1:00PM

MORNING BREAK

9:05AM – 9:45AM

LUNCH
11:30AM – 1:00PM

RAFFLE DRAWING
1:00PM – 1:30PM
GRAND BALLROOM 2-3

THURSDAY, JULY 17
BOOTHS OPEN
9:00AM – 12:00PM

MORNING BREAK
9:20AM – 10:00AM

All of the exhibit events are for Registered Attendees

The Exhibit Reception is for Registered Attendees and Guests

Organization	Website	Booth(s)
3D PLUS USA, INC.	https://www.3dplus.com	404
AMD	https://www.amd.com	403
BAE Systems	https://www.baesystems.com	206
Boeing	https://www.boeing.com	714
Boeing - Little Mountain Test Facility	https://www.boeing.com	505
Brookhaven National Lab	https://www.bnl.gov	309
Crane Aerospace & Electronics	https://www.craneae.com	508
Discovery Semiconductors	www.discoverysemi.com	718
EMPC	https://www.empc.com	105
EPC Space	https://epc.space/	606
EXAIL SAS	https://www.exail.com	204
Foss Therapy Services, Inc	https://fosstherapyservices.net	107
Frontgrade	https://www.frontgrade.com	509
Fuse Energy Technologies Corp.	https://www.f.energy	102
HILEVEL Technology, Inc.	https://hilevel.com	710
Honeywell	https://www.honeywell.com	718
Hopewell Design Inc	https://www.hopewelldesigns.com	106
Infineon Technologies	https://www.infineon.com	603
ISDE Vanderbilt University	https://www.vanderbilt.edu/ISDE	304, 306
IU-CREATE Indiana University	https://create.iu.edu	602
J.L. Shepherd & Associates	https://www.jlshepherd.com	209
Jazz Semiconductor Trusted Foundry	https://www.jazzsemi.com	109
JIACO Instruments	https://jiaco-instruments.com	305
Lawrence Berkeley National Laboratory	https://www.lbl.gov	410
Microchip Technology	https://www.microchip.com	302
Micropac	https://www.micropac.com	405
Micross	https://www.micross.com	712
Nanobridge Semiconductor Inc	https://nanobridgesemi.com	108
Northrop Grumman	https://www.northropgrumman.com	307
Nucleon	https://nucleonspace.com	303
PAC-G & RADNEXT	https://irtnanoelec.fr/pac-g	716
ProNova Solutions	https://provisionhealthcare.com	311
Pulscan	https://www.pulscan.com	605
QuickLogic	https://www.quicklogic.com	407
Radiation Test Solutions	https://www.radiationtestsolutions.com	609
Renesas Electronics America Inc.	https://www.renesas.com	208
Sandia National Laboratories	https://www.sandia.gov	503
SCALE (NSWC CRANE)	https://www.navsea.navy.mil	308
SkyWater	https://www.skywatertechnology.com	506
STMicroelectronics, Inc.	https://www.st.com	502, 504
Synopsys, Inc	https://www.synopsys.com	205
Teledyne Brown Engineering	https://www.tbe.com	607
Texas A&M Cyclotron Institute	https://cyclotron.tamu.edu	202
Texas Instruments	https://www.ti.com	406, 408
The Aerospace Corporation	https://aerospace.org	104
TRAD Tests & Radiations	https://www.trad.fr	507
Triad Micro Devices	https://triadmicrodevices.com	207

INDUSTRIAL EXHIBITS

Trusted Semiconductor Solutions	https://www.trustedsemi.com	103
T-Squared Research	https://www.tsquaredresearch.com	409
TTM Technologies	https://www.ttm.com	608
UNITES Systems a.s.	https://www.unites.cz	604
University of California, Davis	https://www.ucdavis.edu	402
VPT, Inc	https://www.vptpower.com	203

SOCIAL PROGRAM

Welcome to the Nashville Renaissance, a stylish haven in legendary hotel in Nashville, TN, boasting modern and inspiring features. Our Music City hotel is in the heart of downtown, attached to Fifth + Broadway and steps from attractions such as the Country Music Hall of Fame and Ryman Auditorium. We present our social program that will take you to behind the scenes of a recording session at Imagine Recordings on Music Row and to the Nashville countryside mansion and gardens of Cheekwood Estate. Get to know colleagues and explore Nashville honky tonks at the first-ever NSREC bar crawl. Come see why Nashville is among the fastest growing cities in the United States."
Andrew Kelly
BAE Systems
Local Arrangements Chair

NSREC 2025 is located at The Renaissance Nashville. Nashville, the capital of Tennessee, has a vibe that hits differently: music flows through the streets, and every corner feels like the beginning of a new adventure. Whether you're drawn to country, jazz, rock, blues, or something entirely unique, Nashville welcomes it all. Here, melodies as diverse as the people create an atmosphere where every voice and every sound have its place. It's a city that celebrates individuality while uniting through the universal language of music. With the perfect mix of style, soul, and Southern hospitality, Nashville pulls you in—and keeps you coming back for more.

Photo Courtesy Renaissance Nashville

From the beginning, music and storytelling have been a part of Nashville's culture, so it's no surprise the city's creative roots have flourished and grown into an entertainment mecca where artists share stories through music, dance, theater, the visual arts, and comedy.

The ways to immerse yourself in Nashville's creative climate are as diverse as the entertainment options. Gain a historical perspective at museums, channel your creativity with hands-on activities, and tap into the American soundtrack with live music on stages big and small throughout the city.

The Renaissance Nashville Hotel is ideally located right downtown, mere steps away from the historic sites and landmarks, and only a short drive from Nashville's international airport.

The conference committee has designed a social program that will provide you with the highlights of popular and historic sites in and around Nashville. We'll visit **Imagine Recordings** on Tuesday's companion event, receiving rare behind-the-scenes access to a genuine and carefully curated live recording session on Nashville's historic Music Row. On Thursday, we will visit down the **Cheekwood Estates**, a 55-acre botanical garden and art museum located on the historic Cheek estate.

Wednesday's conference social will be at the **Country Music Hall of Fame and Museum®**. Through exhibits, publications, and educational programs, the Museum teaches its wide range of audiences about the enduring beauty and cultural importance of country music. The Museum is located mere steps from the Renaissance Nashville.

This is Nashville, Music City. Please join us for NSREC 2025 and experience it for yourself.

Children must be accompanied by an adult during all tours and social events.

SOCIAL PROGRAM

SUNDAY, JULY 13
6:00 PM TO 9:00 PM

REGISTRATION WELCOME RECEPTION

GRAND BALLROOM 1

Join us for **complimentary refreshments** in Grand Ballroom 1. The reception is **open to Short Course attendees and registered guests** and is a great time to meet new friends and renew old acquaintances. NSREC attendees and guests must wear **NSREC badges for entrance to the Welcome Reception**. The conference registration desk is open from 5:00 to 8:00 PM to secure badges.

Photo Courtesy Renaissance

MONDAY JULY 14
6:00 PM TO 8:00 PM

IEEE YOUNG PROFESSIONALS RECEPTION

BELMONT 1 (RENAISSANCE HOTEL)

IEEE young professionals

Photo Courtesy: Renaissance Nashville

The annual IEEE Young Professionals reception will be held on Monday in Belmont 1. IEEE members who are Young Professionals (those who have graduated their first professional degree in the last 15 years; (https://yp.ieee.org) are especially invited to register (at no cost) for this unique event. This reception represents an excellent opportunity to step away from the main conference floor for a few hours to mingle with other early career attendees and a few veteran attendees as well.

We heard your suggestions last year, and we'll be mixing our reception with a little more fun this year. After the meet and greet with an experience panel, we will move to the Bridge Lounge for less formal setting to socialize at the reception. Our purpose is to encourage professional development, make new friends, and grow more comfortable within this special community at NSREC. To do that, we'll have some appetizers and drinks, a casual social environment to help work through your questions with the other Young Professionals and any veteran attendees who join us for the reception.

Have a brief question you'd like to ask the group about career options, technical growth, workplace personalities, or something else? Come with your questions!

Please join us in Belmont 1 to enjoy panel discussion and then move to the Bridge Lounge and make some new friends while taking in the fantastic, unique, location in the Renaissance Nashville.

Note: Tickets are required so check the box for this reception when you register for the conference.

SOCIAL PROGRAM

TUESDAY, JULY 15
11:00 AM TO 1:00 PM

WOMEN IN ENGINEERING LUNCHEON

GRAND BALLROOM 1

Join us for an interesting talk with Jessie Scott. She has carved out a unique place in the music industry. Her storied, multi-disciplinary career reflects her full perspective on paths and possibilities in the music business and displays the well-worn tracks of a tenacious self-starter. Her experience, coupled with her sharp ear for talent, enthusiasm for acquiring new technical skills and her downright grit, have made her a highly sought-after industry visionary. Scott is the Program Director and Afternoon host at WMOT Nashville. For the past two and a half decades, she has explored her passion for the Americana genre in print, on the radio, and with video, both at Music Fog and Live Sessions at NPR.org.

Limited Availability - Priority will be given to IEEE *WIE Members*.

TUESDAY, JULY 15
5:30 PM TO 7:00 PM

INDUSTRIAL EXHIBITS RECEPTION

BROADWAY BALLROOM

Join us for the 2025 Industrial Exhibits Reception hosted by your NSREC exhibitors. All NSREC attendees and their registered guests are invited for complimentary drinks and hor d'oeurves.

Drinks will be served in Broadway Ballroom in the Renaissance Nashville Conference Center. All registered attendees should be sure to visit the booths and participate in the raffles. NSREC attendees and guests must wear NSREC badges for entrance to the Exhibits and Reception.
A "special" LEGO promotion will be held, and each booth must be visited to gather all the pieces to build a one-of-a-kind Lego toy.

WED. JULY 16
6:00 PM TO 10:00 PM

CONFERENCE SOCIAL

COUNTRY MUSIC HALL OF FAME AND MUSEUM

Join your colleagues and friends for dinner, beverages, and entertainment at the **Country Music Hall of Fame and Museum**. A half-mile walk from the Renaissance Nashville. We encourage all attendees to walk, but, a bus will also be provided, starting at 5:30 PM for those in need.

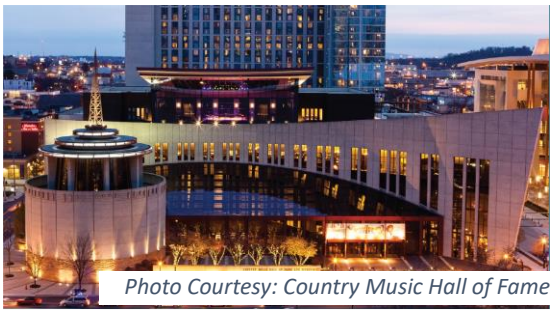


Photo Courtesy: Country Music Hall of Fame

The Country Music Hall of Fame® and Museum collects, preserves, and interprets the evolving history and traditions of country music. Through exhibits, publications, and educational programs, the Museum teaches its diverse audiences about the enduring beauty and cultural importance of country music.

Photo Courtesy: Country Music Hall of Fame

An architectural marvel steeped in history; a unique Nashville venue rental for events. Offers red carpet service, galleries brimming with music, and sweeping views of the Music City skyline. Located in the flourishing SoBro arts and entertainment district; steps away from Lower Broadway's honky-tonks, boutique hotels, and superb dining.

SOCIAL PROGRAM

Catch up with old friends and meet new ones during cocktail hour in the museum's HCA Lobby, Curb

Conservatory & Courtyard and Carlton Terrance. The sun dappled Curb Conservatory's design centers on wood, stone, and water—essential elements that honor this unique American art form. A welcoming rooftop venue adjacent to our Event Hall and HCA Lobby, the Carlton Terrace creates an idyllic setting for receptions.

Enjoy private access to the Country Music Hall of Fame Museum (a walk through American history that carries visitors from the earliest folk traditions to the music thrilling millions today) and Hall of Fame Rotunda (Bronze plaques arranged in a never-ending circle to honor the artists, songwriters, musicians, and industry titans who shaped the art form's history).

Photo Courtesy: Country Music Hall of Fame

Dinner is served in the Event Hall, with its soaring glass windows overlooking downtown, offers an unparalleled Nashville setting. Inside the kitchen, an award-winning culinary team crafts inventive, sophisticated fare, with an emphasis on locally grown ingredients and house-made preparation, all inspired by the same Southern culture that flavors the best country songs. From thoughtful food preparation to the beautiful presentation, enjoy inspired ideas and impeccable service, making evening an intimate dining experience.

Photo Courtesy: Country Music Hall of Fame

After dinner, join colleagues and friends at the 776-seat CMA Theater for a unique live concert from local a Nashville performing artist!

Tickets are not included in the conference registration so be sure to purchase them with your registration.

Timeline

- **5:45 pm: Walk to Country Music Hall of Fame (Buses available for those in need)**
- **6:00pm: Doors Open, Cocktail Hour**
- **6:00pm: Museum Galleries Open (No Food or Beverages)**
- **7:00pm: Seating for buffet dinner**
- **8:30pm: Live performance**
- **10:00pm: Event End (Buses available to those in need)**

Prices for Event:

Wed Social - Adult (Early)	**$ 65.00**
Wed Social - Child (Early)	**$ 25.00**
Wed Social - Adult (Late)	**$ 85.00**
Wed Social - Child (Late)	**$ 35.00**
Wed Social - Teen (Early)	**$ 35.00**
Wed Social - Teen (Late)	**$ 45.00**

COMPANION SOCIAL PROGRAM

TUESDAY, JULY 15
9:00 AM TO 12:30 PM

MEET BUSES IN GRAND BALLROOM 1

IMAGINE RECORDINGS AT SOUND STAGE STUDIOS

At **Imagine Recordings**, you'll enter the inner sanctum of historic **Sound Stage Studios on Music Row** where 1000 #1 hits and counting have been recorded.

During your Imagine Recordings visit, you'll watch and listen as music magic is created in the very same control room and tracking spaces that have hosted some of country music's biggest stars as they performed their most important recordings.

Photo Courtesy: Imagine Recordings

For 90 minutes, we will give you rare access to a genuine and carefully curated live recording session. You'll meet our gifted engineers and mu sicians and sit side-by-side with them as they make and record music art. Each Imagine session is different as we record fresh new songs written and performed by some of Music Row's most talented emerging artists. – so it's quite possible that you may be the first to hear tomorrow's next big hit!

Imagine Recordings' founder and Grammy-winning music producer Steve Fishell is a self-described music junkie. "I've been lucky to be in the studio playing and producing with extraordinary artists my entire life. It's a world I deeply love and a world I'm excited to share with our Imagine guests."

Whether playing steel guitar on top hits for Emmylou Harris, Eric Church, Thomas Rhett, John Prine, Lady Antebellum, Dolly Parton, Rodney Crowell and Reba McEntire, producing groundbreaking projects for Radney Foster, The Mavericks, Pam Tillis and Willie Nelson, or serving as an A&R executive for Universal Music and Sugar Hill Records, Steve has always believed that "if you get the music right, success will follow."

Each Imagine session is carefully curated by Steve, who often hosts as well. And his lifelong passion for the music and the process shines through in every authentic and entertaining recording session experience. Come visit the residence and workplace of the governor general and the grounds! Our Imagine Studio recording session will include two songs, an artist original and a cover song. Soon after your event, Imagine will send to the event organizer the cover song which will be shared with guests as an audio souvenir.

Timeline

- **9:00am** **Depart from the Renaissance Nashville to Imagine Recordings**
- **9:30am:** **Recording Session**
- **11:00am:** **Lunch**
- **12:00pm:** **Depart Imagine Recordings**
- **12:30pm:** **Arrive Renaissance Nashville**

Prices for Event:

Adult (Early)	**$ 75.00**
Child (Early)	**$ 65.00**
Adult (Late)	**$ 90.00**
Child (Late)	**$ 80.00**

COMPANION SOCIAL PROGRAM

TUESDAY, JULY 15
8:00 PM TO 10:30 PM
Meet in Grand Ballroom 1

Music City Pub Crawl

Photo Courtesy:

Join your friends and colleagues after the Industrial Exhibits Reception for a tour of Nashville's famous honkty tonk scene hosted by Music City Pub Crawl. We'll visit 5 or 6 unique bars in downtown Nashville and with access to exclusive drink specials! All the while, our tour guides entertain everyone with light-hearted Nashville history, a heaping pile of friendly competition, and a plethora of quirky games and activities *(a few examples of the latter include mechanical bull riding, karaoke, and occasional line dancing).* Music City Pub Crawl also has an endless list of proprietary games stored at each bar and prizes are awarded to the winning team at the end of the tour!

Music City Pub Crawl specializes in exhibiting bars that are off the beaten path and ones that guests would otherwise not know about, all within a few blocks of historic Broadway and Printer's Alley.

THURSDAY, JULY 17
9:30 AM TO 3:30 PM

MEET BUSES IN GRAND BALLROOM 1

CHEEKWOOD ESTATES

Photo Courtesy: Cheekwood.org

Cheekwood is a 55-acre botanical garden and art museum located on the historic Cheek estate. Originally built as the home of Leslie and Mabel Cheek in 1929, Cheekwood is one of the finest examples of an American Country Place Era estate. Since being converted into a museum of art and botanical garden in 1960, Cheekwood has presented world-class art exhibitions, spectacular gardens and an historic estate unlike anything else.

Photo Courtesy: Cheekwood.org

Experience Cheekwood's incomparable beauty and the exhilaration its historic landscape provides as a setting for outdoor contemporary sculpture. Enjoy a visually enticing stroll along a 1.5 mile woodland sculpture trail or a meandering walk through 13 distinct gardens and delight in an extraordinary array of horticultural displays. Visit the Cheek Mansion, now a museum, for a look at the lifestyle of the American Country Place Era, and walk through family rooms restored to showcase original furnishings and converted to galleries where artworks from our permanent collection or a traveling exhibition will inspire you.

Photo Courtesy: Cheekwood.org

Each year, Cheekwood welcomes over 400,000 visitors, making it one of the city's top cultural attractions, with over 20,000 member households. Visitors enjoy family activities, programming for all ages and year-round festivals celebrating the four seasons. From 250,000 blooming bulbs in the spring to one mile of holiday lights in the winter, there's always something to see at Cheekwood.

Cheekwood offers many diverse experiences, but a singularly serene environment that will leave you restored and rejuvenated. The Cheeks' hospitality, once meant for their immediate family and friends, now extends to you. Leave the world behind and indulge yourself in the beauty and magnificence of Cheekwood!

COMPANION SOCIAL PROGRAM

Timeline	Group A	Group B
9:00 AM	Load Buses & Transit: Renaissance Nashville to Cheekwood	
9:30 AM		
10:00 AM	Guided Mansion Tour	Self-Guided Garden Tours & Gift Shops
10:30 AM		
11:00 AM	Lunch & Art Galleries	
12:00 PM	Self-Guided Garden Tours & Gift Shops	Lunch & Art Galleries
1:00 PM		Guided Mansion Tour
1:30 PM		
2:00 PM		Self-Guided Garden Tours & Gift Shops
2:30 PM		
3:00 PM	Load Buses & Transit: Cheekwood to Renaissance Nashville	
3:30 PM		

Prices for Event:

Adult (Early)	**$ 55.00**
Child (Early)	**$ 20.00**
Adult (Late)	**$ 70.00**
Child (Late)	**$ 35.00**

ACTIVITIES POLICIES

Participation: All participants in the NSREC activities must be conference attendees, registered guests of a conference attendee, registered exhibitors or registered guests of an exhibitor. Any children under 18 years of age must be accompanied by an adult at all times; no children will be allowed to attend any function without this adult supervision.

Cancellation: To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and/or their companions who, for any reason, are unable to attend the conference as long as that notice is provided as follows. If your plans change after your Activities Registration form is submitted, simply request a refund by notifying John Teehan via e-mail (j.teehan@ ieee.org) by no later than June 30th.

Wheelchairs and Strollers: Both wheelchairs and strollers can be stored in the luggage compartment of the buses but please note that you must provide your own personnel to push these devices.

COMPANION SOCIAL PROGRAM

FITNESS ACTIVITIES

Olga Paillet received her PhD degree in Sports Physiology from the University of Health and Sports in Saint Petersburg, Russia in 1992. She also graduated from the University of Paris as a sport trainer in 2001, and from the Faculty of Medicine of the Paris University as a nutritionist in 2012. She has been practicing in Paris for the last 20 years. Alongside her professional activities, she is also a high-level professional and trained instructor in fitness and gymnastics, as well as a dance teacher and choreographer. She is a personal trainer and teaches Group Workout fitness.

Classes are 45-60 minutes. The workout consists of fitness cardio/strength circuit training accompanied by top-hits of popular music. The workouts have simple but efficient exercises and movements designed to boost cardiovascular health, strength, muscle tone, and endurance. Participants will receive one-on-one attention from Olga during class and can ask Olga questions before or after class. Suitable for all fitness levels. Join this fun group class workout!

Workout schedule:
Monday: 4:30 PM after sessions
Tuesday: 4:00 PM after sessions
Wednesday: 4:30 PM after the sessions
Thursday: 3:00 PM after the sessions

Classes are held in the TBD room in the Renaissance Nashville. Wear your workout clothes!

LOCAL ACTIVITIES

GENERAL INFORMATION

Fifth + Broadway

Directly connected to Renaissance Nashville, Fifth + Broadway is a premier downtown Nashville multi-level, mixed-use development with over 20 national and local retailers, exclusive restaurants and bars, multiple performance stages, and a food hall with 30+ eateries along with best-in-class office and residential offerings and a world class museum. Since opening in 2021, Fifth + Broadway has become the go-to destination for locals and visitors alike for shopping, casual and fine dining, world-class entertainment, and convenient parking.

Photo Courtesy: visitmusiccity.com

LITTLE FIB

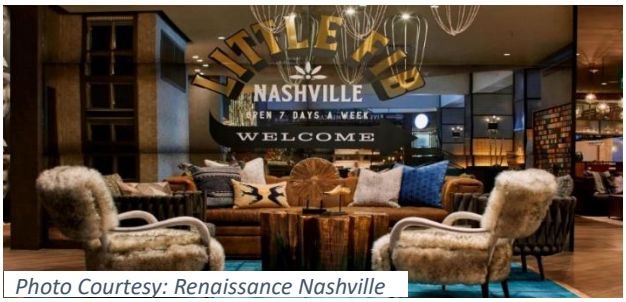


Photo Courtesy: Renaissance Nashville

Savor retro American cuisine at **Little Fib**, designed to honor the rich history of Nashville through food, music and libations. Located within the Renaissance Nashville, it's an ideal place to start your day in Nashville or refuel after exploring Broadway.

BRIDGE BAR

Take in elevated city views, live music and sports entertainment. **The Bridge Ba**r is in the glass atrium on the 3rd floor, offering a full bar and select menu.

MUSIC AND MUSEUMS

THE RYMAN AUDITORIUM

Photo Courtesy: visitmusiccity.com

A world-renowned concert hall, Rock & Roll Hall of Fame landmark, former home of the Grand Ole Opry, and music's most iconic stage, **Ryman Auditorium** is Nashville's "Mother Church." The Ryman's incomparable acoustics create an authentic and transcendent concert experience for every person in the room (even the performers). Its unique architecture and state-of-the-art sound technology make every show one of the best you've ever seen. Even skeptics have called it "spiritual," making it a sacred place for music lovers. When you walk through the doors of the historic Ryman Auditorium, one thing becomes clear right away: this isn't just another nightly music venue or daytime tourist stop. It's hallowed ground.

NATIONAL MUSEUM OF AFRICAN AMERICAN MUSIC

Photo courtesy: www.nmaam.org

The National Museum of African American Music (NMAAM) is the only museum of its kind dedicated to preserving and celebrating the history of Black music in America. The museum's expertly-curated collections share the story of the American soundtrack by integrating history and interactive technology to bring the musical heroes of the past into the present. NMAAM is the premier global destination for music lovers of all generations and inspires, educates, and transforms your appreciation of American music. The museum's mission is to educate the world, preserve the legacy, and celebrate the central role African Americans play in creating the American soundtrack.

LOCAL ACTIVITIES

FIRST ART MUSEUM

Housed in the magnificent Art Deco building that for many years served as Nashville's main post office, the Frist Art Museum is a museum dedicated to bringing the finest art in the history of the world to Nashville. With the museum's wide array of traveling and Frist-organized art exhibitions, the museum is widely known as a cultural hub of the city. Because the Frist has no permanent collection, there is always something new for visitors to see as exhibitions rotate in and out of museum galleries every few months.

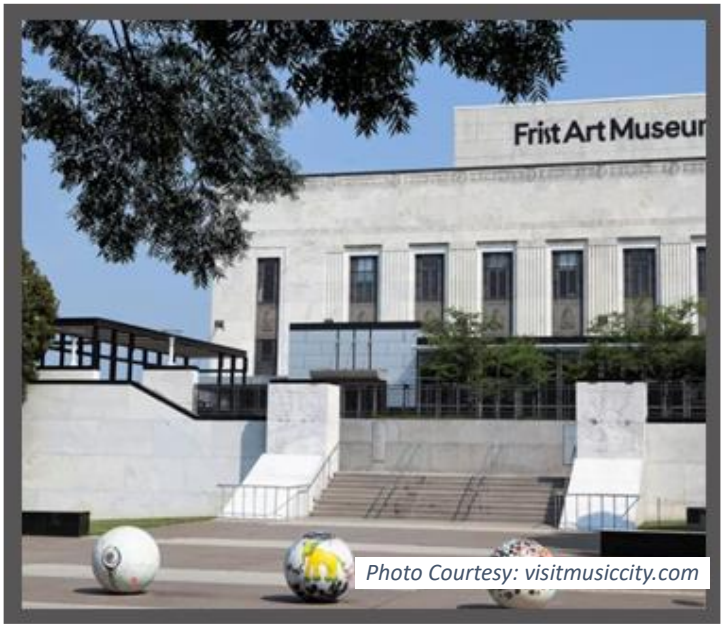


Photo Courtesy: visitmusiccity.com

The Frist is an extremely family-friendly environment. At the heart of the museum is the Martin ArtQuest Gallery featuring interactive stations inviting visitors of all ages to make their own art and become participants in the visual arts experience.

The building, which is on the National Register of Historic Places, was dedicated in 1934 and acquired by the city in 1999 from the U.S. Postal Service expressly to become the museum.

The Frist opened its doors in April 2001, and since then, has brought to Nashville and Middle Tennessee a magnificent array of exhibitions from the region, the U.S. and around the world. In addition to world-class exhibitions in the galleries, the Frist Art Museum also has an active program of cultural events including lectures, gallery talks, music, dance, film, and activities for families, students and seniors.

Admission to the Frist Art Museum is always free for Members and visitors age 18 and younger and reasonably priced for all others. The museum is a 501(c) 3 nonprofit organization.

OTHER HIGHLIGHTS TO SEE

- Nashville Parthenon: nashvilleparthenon.com
- Belmont Mansion: belmontmansion.com
- Adventure Science Center: www.adventuresci.org/
- Belle Meade Historic Site: visitbellemeade.com
- Andrew Jackson's Hermitage: thehermitage.com/
- Gaylord Opryland Resort: www.marriott.com/en-us/hotels/bnago-gaylord-opryland-resort-and-convention-center/overview/
- Jack White's Third Man Records: https://thirdmanrecords.com/pages/nashville-store

GETTING AROUND

Once you're in Music City, getting around is easy! Nashville is a walkable city with easy access to many sites on foot. Nashville also offers many transportation options such as public transit, taxi services, ride sharing and more! ***https://www.visitmusiccity.com/plan-a-trip-to-nashville/getting-around***

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ANNOUNCEMENT and FIRST CALL FOR PAPERS

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2026 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

Short Course and Radiation Effects Data Workshop

July 20-24, 2026
Puerto Rico Convention Center
San Juan, Puerto Rico

You are cordially invited to attend the 2026 IEEE Nuclear and Space Radiation Effects Conference to be held July 20-24, 2026 at the Puerto Rico Convention Center, San Juan, Puerto Rico. The conference features a technical program consisting of eight to ten technical sessions of contributed papers describing the latest observations in radiation effects, a Short Course on radiation effects issues, a Radiation Effects Data Workshop, and an Industrial Exhibit. The technical program includes oral and poster sessions.

Papers on nuclear and space radiation effects on electronic and photonic materials, devices, circuits, sensors, and systems, as well as semiconductor processing technology and design techniques for producing radiation-tolerant (hardened) devices and integrated circuits, will be presented at this meeting of engineers, scientists, and managers. International participation is strongly encouraged.

We are soliciting papers describing significant new findings in the following or related areas:

Basic Mechanisms of Radiation Effects in Electronic Materials and Devices
- Single-Event Charge Collection Phenomena and Mechanisms
- Ionizing Radiation Effects
- Displacement Damage
- Radiation Transport, Energy Deposition, and Dosimetry
- Materials and Device Effects
- Processing Related Radiation Effects

Hardness Assurance Covering Piece Parts, Systems, and Testing Approaches
- New Modeling and Testing Techniques, Guidelines, and Hardness Assurance Methodologies
- Unique Radiation Exposure Facilities, Test Facility Developments, Novel Instrumentation Methods
- Dosimetry

Radiation Effects on Electronic and Photonic Devices, Circuits, and Systems
- Single Event Effects, Total Dose, and Displacement Damage
- MOS, Bipolar, and Advanced Technologies
- Wide Bandgap Semiconductors and Power Devices
- Systems on a Chip, GPUs, FPGAs, Microprocessors, and Neuromorphic Devices
- Isolation Technologies, such as SOI and SOS
- Methods for Hardened Design and Manufacturing
- Modeling and Hardening of Devices and Circuits
- Cryogenic or High Temperature Effects
- Novel Device Structures, such as MEMS and Nanotechnologies
- Emerging Modeling and Experimental Techniques for Hardening Systems

Space, Atmospheric, and Terrestrial Radiation Effects
- Characterization and Modeling of Radiation Environments
- Space Weather Events and Effects
- Spacecraft Surface and Internal Charging
- Predicting and Verifying Soft Error Rates (SER)

New Developments of Interest to the Radiation Effects Community

Paper Summary Deadline: February 6, 2026

PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file consisting of a cover page and an informative two to four page summary describing results appropriate for 12-minute oral or poster presentation. The cover page must provide an abstract no longer than 35 words, the title, name and company affiliation of the authors, and company address (city, state, country). Identify the author presenting the paper and provide telephone, and email address. The summary must include sufficient detail about the work to permit a meaningful technical review. In the summary, clearly indicate (a) the purpose of your work, (b) significant new results with supporting technical material, and (c) how your work advances the state of the art. Show key references to other related work. The summary must be no less than two and no more than four pages in length, including figures, tables, and references. All figures and tables must be large enough to be clearly read. Note that this is more than an abstract, but do not exceed four pages. Watch Our NSREC Video on How to Prepare a Strong Summary: https://youtu.be/bbHNPofpmMs

Summaries must be received by February 6, 2026

Detailed submission and formatting instructions will be available after December 1, 2025

2. Prepare your summary in single-column or IEEE TNS standard two-column format, using 11 point or greater font size, formatted for either U.S. Standard (8.5 x 11 inch) or A4 (21 x 29.7 cm) page layout, with 1 inch (2.5 cm) margins on all four sides.
3. Obtain all corporate, sponsor, and government approvals and releases necessary for presenting your paper at an open attendance international meeting.
4. Summary submission is electronic only, through ***www.nsrec.com.*** The submission process consists of entering the paper title, author(s) and affiliation(s), an abstract no longer than 35 words, and uploading the summary. Authors are prompted to state their preference for presentation (oral, poster, or data workshop poster) and for session. Details of the submission process may be found at ***www.nsrec.com.*** The final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Papers accepted for oral or poster presentation at the technical program are expected to be submitted for publication in the IEEE Transactions on Nuclear Science (Spring 2027). Selection for this issue will be based on a separate submission of a complete paper. These papers will be subject to the standard full peer review given all papers submitted to the IEEE Transactions on Nuclear Science. Further information will be sent to prospective authors upon acceptance of their NSREC summary. It is not necessary to be an IEEE member to present a paper or attend the NSREC. However, we encourage IEEE and NPSS membership of all NSREC participants.

RADIATION EFFECTS DATA WORKSHOP

The Radiation Effects Data Workshop is a forum for papers on radiation effects data on electronic devices and systems. Workshop papers are intended to provide radiation response data to scientists and engineers who use electronic devices in a radiation environment, and for designers of radiation-hardened systems. Papers describing new simulation techniques validated or data-supported, results, or radiation facilities are also welcomed. **The procedure for submitting a summary to the Workshop is identical to the procedure for submitting NSREC summaries.** Radiation Effects Data Workshop papers will be published in a Workshop Record and are not candidates for publication in the Conference issue of the *IEEE Transactions on Nuclear Science*.

SAN JUAN, PUERTO RICO

The NSREC 2026 will be at the Puerto Rico Convention Center in San Juan. Puerto Rico is an archipelago known for its stunning beaches, vibrant culture, and rich history. The main island has a mountain range, La Cordillera Central, that runs east to west. At 4389 ft, Cerro de Punta is the highest point on the range and is in the central town of Jayuya.

In addition, PR is a tropical habitat. It boasts the only tropical rainforest in the U.S. national forest system named El Yunque. Although El Yunque is one of the smallest national forests in the U.S., it is one of the most diverse, holding 183 animal species and 225 tree species (23 of which are only encountered in PR). Wildlife is not limited to El Yunque.

One of the island's renowned wildlife species is the coquí (koh-KEE), a dime-size frog whose name comes from the sound it makes. The island also has around 320 bird species, including the emerald hummingbird (only found in PR) and the Puerto Rican parrot.

The island is full of beautiful sounds, tasty food, and lively colors. Puerto Rican music and dance are the epitome of expressions from the Island's Boricua heritage, a unique mix of Taíno, Spanish, and African traditions. The people of Puerto Rico are very proud of their culture and are eager to share it with their island's visitors. Spanish and English are the official languages of PR; however, Spanish is more commonly spoken. Come and enjoy all that Puerto Rico has to offer