NSREC 2023

July 24-28, 2023

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IEEE NPSS
NUCLEAR & PLASMA SCIENCES SOCIETY

Kansas City
NSREC 2023

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As of May 18, 2023

Technical / Exhibit

Sunday-Friday
On-Site Registration – Van Horn A
Pre-Registration (Sun/Mon Only) – The Terrace

Monday-Friday
A/V Preview Room – Benton
Side Meeting Rooms – Empire A, B, C

Monday
Short Course Sessions & Exam – Exhibit Hall B

Tuesday – Friday
Technical Sessions – Exhibit Hall B

Tuesday – Wednesday
Exhibits – Exhibit Hall A

Wednesday
Poster Session - Chicago

Thursday
REDW Session – New York
Open Meeting – Exhibit Hall B

Dining / Social

Sunday
Welcome Reception – The Terrace

Monday
Breakfast – The Terrace, Atlanta
Morning Break - Prefunction
Short Course Luncheon – The Terrace, Atlanta
Afternoon Break - Prefunction

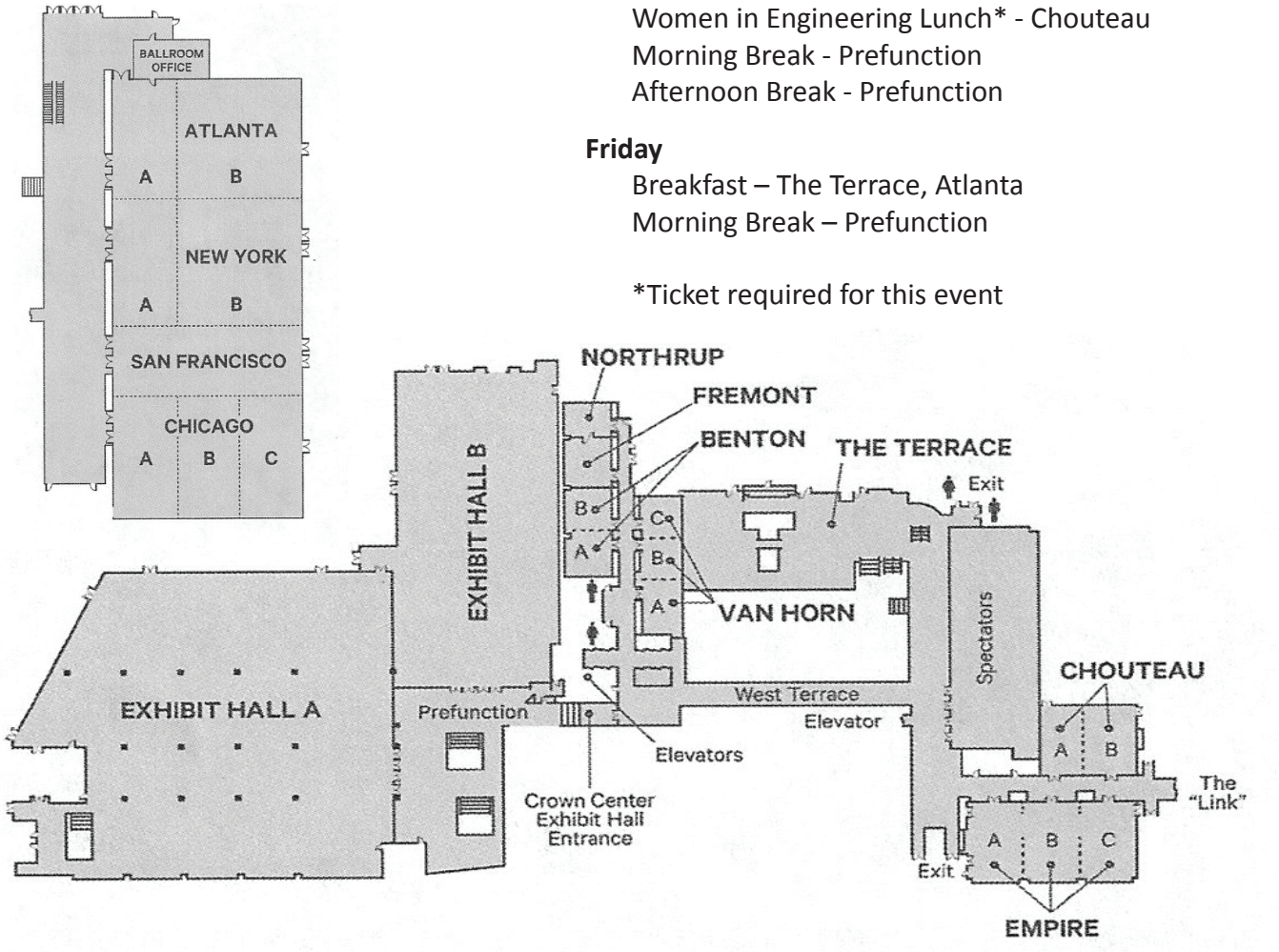
Tuesday
Breakfast, Morning Break – Exhibit Hall A
Exhibitor Lunch – Exhibit Hall A
Afternoon Break - Prefunction
Exhibit Reception – Exhibit Hall A

Wednesday
Breakfast, Morning Break – Exhibit Hall A
Exhibitor Lunch & Raffle – Exhibit Hall A
Young Professionals Lunch* - Chouteau
Afternoon Break – Prefunction

Thursday
Breakfast – The Terrace, Atlanta
Women in Engineering Lunch* - Chouteau
Morning Break - Prefunction
Afternoon Break - Prefunction

Friday
Breakfast – The Terrace, Atlanta
Morning Break – Prefunction

*Ticket required for this event



Schedule

Time	Monday July 24	Tuesday July 25	Wednesday July 26	Thursday July 27	Friday July 28
7:00	[7:00] Breakfast - The Terrace, Atlanta	[7:00] Breakfast - Exhibit Hall A	[7:00] Breakfast - Exhibit Hall A	[7:00] Breakfast - The Terrace, Atlanta	[7:00] Breakfast - The Terrace, Atlanta
7:30					
8:00	[8:00] **Short Course Introduction** Dr. Ethan Cannon, Exhibit Hall B				
8:10	[8:10] **Part I – Advancements and Challenges with Radiation-Tolerant Spaceflight Computers** Dr. Tyler Lovely				
8:15		[8:15] **Opening remarks - Awards Presentation** - Exhibit Hall B			
8:30			[8:30] **Invited Talk – Negro League Baseball—The Giants. Why is it important to us today?** Phil S. Dixon, Exhibit Hall B	[8:30] **Invited Talk – Brewing Beer: Process Overview from Grain to Package** Mr. Rob Odell and Mr. Taran Winnie, Exhibit Hall B	[8:30] **Invited Talk – Kansas City National Security Campus Through the Decades** Dr. John Jungk, Exhibit Hall B
9:00		[9:05] **Technical Session Opening Remarks** [9:10] **Session A - Radiation Effects in Devices and Integrated Circuits**			
9:30	[9:40] Break – Pre-Function		[9:35] **Session E - Hardness Assurance: Piece Parts to Systems and Testing Approaches**	[9:30] **Session F - Photonic Devices and Integrated Circuits**	[9:30] **Session H – Hardening by Design**
10:00		[10:15] Break – Exhibit Hall A	[10:20] Break – Exhibit Hall A	[10:20] Break – Pre-Function	[10:05] **Session I – Single-Event Effects: Devices**
10:30	[10:10] **Part II – Radiation Effects in FPGAs and SoCs** Dr. Nadia Rezzak and Dr. Pierre Maillard	[10:45] **Session A -** *(continued)*			[10:40] Break – Pre-Function
11:00			[11:00] **Session E -** *(continued)*	[11:05] **Session F -** *(continued)*	[11:10] **Session I -** *(continued)*
11:30	[11:40] Short Course Luncheon – Terrace and Atlanta Rooms	[11:15] **Session B - Single-Event Effects: Mechanisms and Modeling**	[11:45] **Poster Introduction -** Exhibit Hall B	[11:50] **Session G - Dosimetry and Facilities**	
12:00		[11:50] Lunch	[11:50] Lunch / Exhibitor Raffle – Exhibit Hall A — and — [11:50-12:50] IEEE Young Professionals Lunch – Chouteau Room *Ticket Required to Attend*	[12:25] **Data Workshop Introduction -** Exhibit Hall B	[12:10] Conference Closing
12:30				[11:30-1:15] Women in Engineering Lunch – Chouteau Room *Ticket Required to Attend* — and — [12:30] Lunch - On Your Own	
1:00	[1:00] **Part III – Radiation Effects in Data Links** Dr. Zachary Diggins	[1:15] **Session B -** *(continued)*	[1:45-4:30] **Poster Session -** Chicago Ballroom	[1:45-4:30] **Radiation Effects Data Workshop** New York Ballroom	
1:30					
2:00		[1:45] **Session C - Basic Mechanisms of Radiation Effects**			
2:30	[2:30] Break – Pre-Function				
3:00	[3:00] **Part IV – Experimental Evaluation of Artificial Neural Networks Reliability: from GPUs to Low-Power Accelerators** Prof. Paolo Rech	[2:50] Break – Exhibit Hall A			
3:30		[3:20] **Session D – Space and Terrestrial Environments**			
4:00		[4:10] End of Tuesday Sessions			
4:30	[4:30] Wrap-up		[4:30] End of Wednesday Sessions	[4:30] End of Thursday Sessions	
5:00	[4:40] Exam (for students requesting CEU credit only) [5:00] End of Short Course			[4:45 to 7:00] **Radiation Effects Committee Annual Open Meeting** – Exhibit Hall B	
5:30		[5:30 to 7:30] Industrial Exhibits Reception – Exhibit Hall A	[5:30] Busses load for Conference Social		
6:00			[6:00 to 10:00] Conference Social – **Negro Leagues Baseball Museum & American Jazz Museum**		
6:30					
7:00					

Chairman's Invitation

NSREC 2023

"It is my distinct honor to invite you to attend NSREC 2023 in the heart of America, Kansas City, Missouri. My Conference Committee and I are excited to host all of you with some Midwest hospitality while providing an outstanding conference and time to enjoy all of the social opportunities. Kansas City is known as the City of Fountains and home to professional sports, world class art, museums, music, and some of the best barbeque in America. The NSREC website will provide extensive links to all that Kansas City has to offer starting in September. Start planning your adventure now! On behalf of the many who make NSREC possible, I welcome you to NSREC 2023. Kansas City here we come!"

Keith Avery
NSREC 2023 General Chair
Air Force Research Laboratory

Visit us on the web at:
www.nsrec.com

On behalf of the Institute of Electrical and Electronics Engineers (IEEE), its Nuclear and Plasma Sciences Society (NPSS), the Radiation Effects Steering Group (RESG) and the 2023 Nuclear and Space Radiation Effects Conference (NSREC) committee and volunteers, it is my sincere pleasure to invite you to attend the 60th NSREC to be held July 24-28, 2023. The conference will be in heart of America, Kansas City, Missouri at the Sheraton Crown Center.

Come enjoy learning, laughing and enjoying the community we call NSREC, where a lifetime of friendships renews and begins.

The conference begins Monday, July 24th, with a one-day Short Course titled *"Radiation Considerations for Board Level Computers"*. It is organized by **Ethan Cannon** of the The Boeing Company and consists of four sections taught by leading experts in their respective fields. The short course is designed to provide an overview of radiation effects in the computing system and testing at the system level. An extensive set of written notes will be provided.

The Technical Program will be held from Tuesday, July 25th to Friday, July 28th. **Jonny Pellish**, NASA Goddard Space Flight Center, is the Technical Program Chair. Jonny and his technical committee will select the outstanding contributed papers organized into 9 sessions of oral presentations and a poster session (**Jeff George**, Los Alamos National Laboratory – Poster Chair) that supports all sessions. In addition, the technical committee will select a set of quality presentations for the Radiation Effects Data Workshop (**Andrea Coronetti**, CNES – REDW Chair). Workshop posters will present radiation effects data on electronic and photonic devices and systems, and new simulation or test facilities. Finally, Jonny plans to invite three engaging guest speakers to give general interest presentations.

The Industrial Exhibit, organized by **Ken LaBel**, SSAI in support of NASA, opens Tuesday morning. We have a full slate of exhibitors demonstrating their latest developments in areas such as radiation-hardened and radiation-tolerant electronics, engineering services, facilities, modeling, and equipment. Attendees will be able to visit the booths during scheduled breaks and during lunch on both Tuesday and Wednesday. Attendees and their their guests, are invited to a reception in the exhibit halls on Tuesday evening. The exhibits will conclude at noon Wednesday with the exhibitor raffle.

Local Arrangements Chair, **Sarah Armstrong,** NAVSEA Crane, is organizing an outstanding social program for attendees and guests. The Conference Social, on Wednesday evening, is planned to offer all a fantastic evening of entertainment as well as a taste of Kansas City. Two or three companion tours are also being planned.

On behalf of my Conference Committee, which also includes Finance Chair **Nathan Nowlin** (Sandia National Laboratory), Publicity Chair **Teresa Farris** (Archon-LLC), Awards Chair **Julien Mekki** (CNES), Webmaster **Greg Allen** (NASA/JPL), Publicity **Adrian Ildefonso** (NRL), A/V **Carl Szabo** and **Martha O'Bryan** (NASA) and Meeting Planner **John Teehan** (IEEE MCE). I invite you to join us in Kansas City for an outstanding conference.

Kansas City welcomes you as only America's Midwest can with a warm welcome, great food and activities to suit everyone.

We look forward to seeing you in person this July!

Short Course Program

RADIATION CONSIDERATIONS FOR BOARD-LEVEL COMPUTING SYSTEMS

KANSAS CITY SHERATON
EXHIBIT HALL B
JULY 24, 2023

8:00 AM	**SHORT COURSE INTRODUCTION** Dr. Ethan Cannon, *The Boeing Company*
8:10 AM	**PART I – ADVANCEMENTS AND CHALLENGES WITH RADIATION- TOLERANT SPACEFLIGHT COMPUTERS** Dr. Tyler Lovely, *US Air Force Research Laboratory*
9:40 AM	**BREAK (Prefunction)**
10:10 AM	**PART II – RADIATION EFFECTS IN FPGAS AND SOCS** Dr. Nadia Rezzak and Dr. Pierre Maillard, *Microchip Technology and AMD, respectively*
11:40 AM	**SHORT COURSE LUNCHEON** **(Terrace and Atlanta Rooms)**
1:00 PM	**PART III – RADIATION EFFECTS IN DATA LINKS** Dr. Zachary Diggins, *Cyclo Technologies*
2:30 PM	**BREAK (Prefunction)**
3:00 PM	**PART IV – EXPERIMENTAL EVALUATION OF ARTIFICIAL NEURAL NETWORKS RELIABILITY: FROM GPUS TO LOW-POWER ACCELERATORS** Prof. Paolo Rech, *UFRGS (Brazil) and University of Trento (Italy)*
4:30 PM	**WRAP-UP**
4:40 PM	**EXAM (only for students requesting CEU credit)**
5:00 PM	**END OF SHORT COURSE**

The NSREC 2023 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

COURSE DESCRIPTION

A short course, *"Radiation Considerations for Board-Level Computing Systems"*, will be presented at the 2023 IEEE Nuclear and Space Radiation Effects Conference. The ultimate purpose of the radiation effects community is to enable successful system operation in radiation environments. System-level success stems from integrating an understanding of fundamental mechanisms, and sub-component and component-level responses to radiation, with system-level analysis. A spacecraft board-level computing system represents a commonly used exemplar comprised of multiple complex components.

The short course is organized into four sections, all featuring introductory material and advanced topics. The first section introduces spaceflight computing needs and challenges, considering various architectures beyond just traditional CPUs. The second topic covers FPGAs, which are widely used due to low development cost and schedule, and have increased in both capability and complexity to become bona fide Systems on Chip. The third section addresses data links, which are critical for communication between system components, including both electrical and optical connections. Finally, the last course covers artificial neural networks used for AI applications, addressing both GPUs and specialized accelerators. The topics covered should benefit people new to the field as well as experienced engineers and scientists, by providing up-to-date material and insights.

The short course is intended for radiation effects engineers, component specialists, system designers, and other technical and management personnel involved in developing reliable systems designed to operate in radiation environments. 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)

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

Ethan Cannon
The Boeing Company
Short Course Chair

Ethan Cannon is Manager of the Advanced Microsystems Technology team in the Boeing Research & Technology—Solid-State Electronics Development organization, where his team develops revolutionary capabilities for Systems on Chip that meet current and future Military-Aerospace mission system needs. His research interests include extreme environments, high reliability applications, and hardware security. He has a Ph.D. in physics from the University of Illinois at Urbana-Champaign.

Tyler M. Lovelly is the Principal Investigator for Space Computing within the Space Electronics Technology program at the U.S. Air Force Research Laboratory (AFRL), where his research focuses on advancing on-board computing capabilities for next-generation space systems. He has worked in the area of aerospace and defense electronics and computing for over 14 years. His previous experience includes serving as a research group leader at the NSF Center for Space, High-Performance, and Resilient Computing (SHREC), supporting AFRL as a contractor with the Universities Space Research Association, and working for United Space Alliance supporting the NASA Space Shuttle program. He holds a Ph.D. in Electrical and Computer Engineering (ECE) from the University of Florida, and a faculty title with the Department of ECE at the University of New Mexico.

ADVANCEMENTS AND CHALLENGES WITH RADIATION-TOLERANT SPACEFLIGHT COMPUTERS

Dr. Tyler M. Lovelly
U.S. Air Force Research Laboratory

On-board computing demands for space systems are continually increasing due to the need for real-time sensor and autonomous processing combined with limited communication bandwidth to ground stations. Although massive investments have been made by the electronics industry to advance the state-of-the-art in computing technologies, radiation-hardened technology requires longer lead times due to funding constraints, greater design complexity, and rigorous radiation testing and qualification requirements. Thus, the capabilities of radiation-hardened processors typically lag several technology generations behind commercial state-of-the-art technology. Due to changes in the spectrum of risk tolerance and a pivot from large and expensive long-duration missions to shorter-duration missions with more rapid technology refresh, increasing numbers of programs are considering and using small satellites, leading to high interest in leveraging commercial electronics. However, there exists little data quantifying the ability of commercial processors to operate reliably in a space radiation environment. Furthermore, it remains highly challenging to keep up with the broad, diverse, and rapidly changing landscape of available architectures such as CPUs, GPUs, FPGAs, SoCs, AI/ML accelerators, and others. During this module, **Dr. Tyler Lovelly,** *U.S. Air Force Research Laboratory*, will provide an overview of the spaceflight computing technology area including recent advancements and challenges in designing, manufacturing, evaluating, and deploying radiation-tolerant computers to support the next generation of space systems.

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

- Introduction
- Spaceflight Computing
  - Missions and pervasive impacts
  - Motivations and constraints
  - Radiation considerations
- Spaceflight Processors
  - Applications and architectures
  - Radiation-hardened vs. commercial
  - Hybrid radiation-tolerant solutions
- Evaluation and Qualification
  - Performance metrics and benchmarking
  - Radiation qualification and spaceflight
  - Cyber security and trusted manufacturing
- Summary

RADIATION EFFECTS IN FPGAS AND SOCS

Dr. Nadia Rezzak
Microchip Technology
Dr. Pierre Maillard
AMD

Nadia Rezzak is the Senior Manager of Radiation Effects Technology and Development for the FPGA Business Unit at Microchip Technology, where she managers the radiation effects team and leads the development and validation of commercial and radiation tolerant FPGAs. She has over 10 years of experience with radiation effects and reliability and has over 30 conference presentations and journal publications. She received MS EE from Polytech Montpellier and MS and Ph.D. EE from Vanderbilt University.

Pierre Maillard joined AMD's Adaptive Embedded Computing Group (AECG) in 2013, where he is currently leading the Radiation Effects & RAS team. The team focuses on the architecture, development, and validation of commercial and rad. tolerant FPGA/ACAP solutions, for the Terrestrial (Telecom, Avionics, Automotive, Datacenter, etc.) and Space markets. He has over 20 presentations and publications in industry leading conferences and journals. He holds 13 issued patents in the field of radiation effects on electronics. He received his M.S. in Electrical Engineering (EE) from the universities of Montpellier II and M.S. and Ph.D. EE in from Vanderbilt University.

The ability to implement complex designs and evolving algorithms in reconfigurable devices makes Field Programmable Gate Arrays (FPGAs) attractive for many Terrestrial and Space applications, compared to fixed function Application Specific Integrated Circuits (ASICs).

Dr. Nadia Rezzak, *Microchip, Inc.* and **Dr. Pierre Maillard**, *AMD, Inc.*, will discuss Radiation Effects in FPGAs and SoCs. The first part of the course will address the basics of SRAM and non-volatile based FPGAs architecture and their evolution to modern/complex System On Chip (SoC) and Adaptive Compute Acceleration Platform (ACAP) devices. Then we will discuss Single Event Effects (SEE) and Total Ionizing Dose (TID) mechanisms, errors classification, test methodologies and representative results. The final section will focus on mitigation techniques and challenges to address requirements for Terrestrial (telecom, automotive, datacenters, avionics, etc.), Defense and Space markets.

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

- A changing world –FPGAs and SoCs use cases in modern applications
  - Adapting to an electronic driven world
  - Why do FPGAs/SoC vendors care about radiation effects and testing for them?
- Introduction to FPGAs and SoCs
  - Basic FPGA fabric Architecture and configuration types
  - FPGA/SoC Architecture (Processors, NOC, AI Engines)
  - FPGA/SoC Design Flow
- Single Event Effect (SEE) and mitigation
  - SEE signature and classification
  - Example of SEE mitigation techniques
- Single Event Effect (SEE) and Total Ionizing Dose (TID) Testing
  - Testing Facilities and conditions
  - DUT preparation for wire-bonded and Flip-Chip package
  - SEE & TID test benches and results
- Next-gen development
  - Need for R&D/Innovation to adapt to new technologies and demands
  - Beam test methodologies adoption -laser testing
- Conclusion

Zachary Diggins is the founder of Cyclo Technologies, Inc., a company created in 2022 that provides cloud software and engineering consulting services supporting electronics design for radiation environments. Previously, he was the lead radiation effects engineer for SpaceX's Starlink satellite program, working 6 years on the project from pre-prototype through system deployment and activation. His interests include up-screening of commercial-of-the-shelf components and modeling system risk. He holds a Ph.D. from Vanderbilt University in Electrical Engineering, with a thesis focused on probabilistic modeling of radiation effects on systems.

RADIATION EFFECTS IN DATA LINKS

Dr. Zachary Diggins
Cyclo Technologies

Advances in sensor and networking payloads place ever increasing demands on data links. Additionally, reliable communication between different components on a spacecraft are critical for safe operation, while also potentially contributing to the spacecraft power and weight through harnessing and PCB requirements, making data links a critical design consideration. In this course, **Dr. Zachary Diggins,** *Cyclo Technologies,* will cover the radiation effects for the various data links on a single-board computer, from basic mechanisms through part selection considerations and testing strategies. Specifically, radiation effects in SerDes links for inter-chip communication will be reviewed, including clock generation and distribution considerations. Satellite bus communication protocols will be evaluated, including options for redundancy and wireless bus communication. A focused section will be included on optical communication technologies, including fiber based and inter-satellite data links, which have total-ionizing dose and displacement damage concerns. Finally, comparisons will be made to state-of-the-art terrestrial data center architectures.

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

- Introduction
  - Elements of a Data Link
  - Industry Trends in Terrestrial Data Links
  - Industry Trends in Space Data Links
- Radiation Effects in Physical Layer of Data Links
  - ADC/DAC
  - PLL/Oscillators
  - SerDes
  - Photodiodes + Fiber
  - Wireless/RF Transceivers
- Radiation Effects on Protocol Layer of Data Links
  - Error Correction
  - Case Studies – SpaceWire/Time-Triggered Ethernet/PCIE
- Radiation Effects on Network Architecture Layer of Data Links
  - Fault Detection, Isolation, and Recovery
  - Point-to-Point/Bus/Mesh Topologies
- Environmental Considerations
  - Solar Flare Design Considerations
  - Lightly Shielded Peripherals and Space Facing Components
- Testing Strategies
  - Defining Pass/Fail Criteria
  - Benefits and Risks of System Level Testing
- Conclusions

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 2020 impact in society award from the Rutherford Appleton Laboratory, UK. In 2020 Paolo was awarded 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.

EXPERIMENTAL EVALUATION OF ARTIFICIAL NEURAL NETWORKS RELIABILITY: FROM GPUS TO LOW-POWER ACCELERATORS

Dr. Paolo Rech
University of Trento, UFRGS

Artificial Neural Networks are among the greatest advancements in computer science and engineering and are today used to classify or detect objects in a frame and to enable autonomous vehicles. Since neural networks are heavily used in safety-critical applications, such as automotive and aerospace, their reliability must be paramount. However, the reliability evaluation of neural networks systems is extremely challenging due to the complexity of the software, which is composed of hundreds of layers, and of the underlying hardware, typically a powerful parallel device.

In this course, **Dr. Paolo Rech,** *UFRGS (Brazil)* and *University of Trento (Italy),* will review fundamental concepts of Artificial Intelligence, Artificial Neural Networks, and parallel computing devices. Then, the course will detail the experimental setup required to have a deep and accurate reliability evaluation of an Artificial Neural Networks system. In particular, the guidelines for a successful neutron or heavy ion test of Graphics Processing Units (GPUs) and low-power accelerators, such as Tensor Processing Unit (TPU) or Systolic Arrays, will be provided. Specific attention will be given to the choice of the software, the neural network configuration, the input dataset, and to the experimental results analysis.

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

- Introduction and motivation
- Hardware and Software for Artificial Neural Networks executions
  - Graphics Processing Units
  - Low-Power Accelerators
  - FPGAs and ASICs
- Experimental setup
  - Host vs device under test
  - Choose the software and the inputs
  - Choose the facility
  - What to log, what to look for
- Data gathering and analysis
  - Understand radiation errors in ANNs
  - Differentiating between tolerable and critical errors
- Conclusions and future perspectives

Technical Program

TECHNICAL INFORMATION

"On behalf of the Technical Program Committee, I invite you to attend the 2023 NSREC Technical Program. Rapid advancements in microelectronics, significant new investments on the horizon, and ever-expanding mission scope make events like NSREC more important than ever. Students and seasoned professionals alike will benefit from broad topic coverage and robust technical debates. The chairpersons for these eleven sessions will assemble an exceptional program covering the latest developments in nuclear and space radiation effects. I look forward to working with all the session chairs, reviewers, and authors who will contribute to an outstanding technical program."

Jonny Pellish, NASA,
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::

- **Basic Mechanisms**
  Chair: Ani Khachatrian, U.S. Naval Research Laboratory
- **Dosimetry and Facilities**
  Chair: Richard Sharp, Radtest Ltd.
- **Hardening by Design**
  Chair: Paula Chen, AMD, Inc.
- **Hardness Assurance: Piece Parts to Systems and Testing Approaches**
  Chair: Courtney Matzkind, Missile Defense Agency
- **Photonic Devices and Integrated Circuits**
  Chair: George Tzintzarov, The Aerospace Corporation
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Rudy Ferraro, CERN
- **Single-Event Effects: Devices and Integrated Circuits**
  Chair: Françoise Bezerra, CNES
- **Single-Event Effects: Mechanisms and Modeling**
  Chair: Jason Osheroff, NASA Goddard Space Flight Center
- **Space and Terrestrial Environments**
  Chair: Scott Messenger, Northrop Grumman Corporation
- **Poster Session**
  Chair: Jeff George, Los Alamos National Laboratory
- **Radiation Effects Data Workshop**
  Chair: Andrea Coronetti, CERN

POSTER SESSION

Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session in the New York Ballroom. The formal Poster Session will be held on Wednesday from 1:45 – 4:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Jeff George from Los Alamos National Laboratory.

RADIATION EFFECTS DATA WORKSHOP

Workshop papers provide piece part radiation response data and radiation test facilities technical information. The intent of the workshop is to provide data and facilities information to support design and radiation testing activities. Workshop papers can be viewed Tuesday through Friday in the the Chicago Ballroom. Authors will be available on Thursday to discuss their work from 1:45 – 4:30 PM. A workshop record will be provided to all registered conference attendees. The Data Workshop chair is Andrea Coronetti from CERN.

Technical Program

INVITED SPEAKERS

There will be three invited speakers

- **Negro League Baseball—The Giants. Why is it important to us today?**
  Phil S. Dixon, Researcher, Writer, and Co-Founder of the Negro League Baseball Museum, Kansas City, Missouri
- **Brewing Beer: Process Overview from Grain to Package**
  Rob Odell, Filtration Supervisor,
  Taran Winnie, Brewing Team Member
  Boulevard Brewing Company, Kansas City, Missouri
- **Kansas City National Security Campus Through the Decades**
  John Jungk, Ph.D., Chief Technology Officer, Honeywell Federal Manufacturing & Technologies, Kansas City, Missouri

LATE-NEWS PAPERS

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 will be open from April 14, 2023 through May 12, 2023. Detailed instructions for submitting late-news summary will be available on the NSREC website at ***www.nsrec.com.***

Session Chairs

Ani Khachatrian,
U.S. Naval Research Laboratory
Basic Mechanisms of Radiation Effects

Richard Sharp,
Radtest Ltd.
Dosimetry

Courtney Matzkind,
Missile Defense Agency
Hardness Assurance—Piece Parts to Systems and Testing Approaches

Paula Chen,
AMD, Inc.
Hardening by Design

Rudy Ferraro,
CERN
Radiation Effects in Devices and Integrated Circuits

George Tzintzarov,
The Aerospace Corporation
Photonic Devices and Integrated Circuits

Jason Osheroff, NASA Goddard Space Flight Center
Single-Event Effects: Mechanisms and Modeling

Françoise Bezerra,
CNES
Single-Event Effects: Devices and Integrated Circuits

Scott Messenger,
Northrop Grumman Corporation
Space and Terrestrial Environments

EXHIBIT HALL B

8:15 AM **OPENING REMARKS**
Keith Avery, Air Force Research Laboratory, General Chairman

8:20 AM **AWARDS PRESENTATION**
Robert Reed, Vanderbilt University, Radiation Effects Steering Group, Executive Chair

9:05 AM **TECHNICAL SESSION OPENING REMARKS**
Jonathan Pellish, NASA Goddard Space Flight Center, Technical Program Chair

SESSION A RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS

9:10 AM SESSION INTRODUCTION
Chair: Rudy Ferraro, CERN

A-1 9:15 AM Origin of Post-Irradiation Vt-Loss Variability in 3-D NAND Memory Array

M. Kumar[1], M. Raquibuzzaman[1], M. Buddhanoy[1], T. Boykin1, B. Ray[1]
1. University of Alabama in Huntsville, USA

We measure total-ionizing-dose induced threshold-voltage (Vt) loss of commercial 64-layer 3-D NAND memory. Measurements show significant Vt-loss variability among the memory cells which we model using pre-existing trap-states in the tunnel oxide and Poly-Si interface.

A-2 9:30 AM Total Ionizing Dose Effects in 3D NAND Replacement Gate Flash Memory Cells

M. Bagatin[1], S. Gerardin[1], A. Paccagnella[1], S. Beltrami[2]
1. University of Padova, Italy
2. Micron Technology, Italy

Total ionizing dose effects in 3D NAND flash memories with replacement gate technology are evaluated. Threshold voltage shifts, underlying mechanisms, and bit error rates are studied and compared with 3D cells with floating gate technology.

A-3 9:45 AM Radiation-Induced Effects in SiC Vertical Power MOSFETs Irradiated at Ultra-High Doses

C. Martinella[1], S. Bonaldo[2], S. Race[1], N. Fuer[1], S. Mattiazzo[3], M. Bagatin[2], S. Gerardin[2], A. Paccagnella[2], U. Grossner[1]
1. ETH Zurich - APS Laboratory, Switzerland
2. University of Padova, Italy
3. University of Padova - INFN, Italy

TID effects in SiC are evaluated by DC measurements at ultra-high 10-keV X-ray doses up to 100 Mrad(SiO2). Significant parametric shifts are observed depending on the bias condition and on the technology generation.

A-4
10:00 AM

Radiation-Induced Charge Trapping in Shallow Trench Isolations of FinFETs

S. Bonaldo[1], T. Wallace[2], H. Barnaby[2], G. Borghello[3], G. Termo[3], F. Faccio[3], D. Fleetwood[4], A. Baschirotto[5], S. Mattiazzo[1], M. Bagatin[1], A. Paccagnella[1], S. Gerardin[1]

1. University of Padova, Italy
2. Arizona State University, USA
3. CERN, Switzerland
4. Vanderbilt University, USA
5. University of Milano Bicocca, Italy

TID mechanisms in Si FinFETs are investigated through DC measurements and TCAD simulations. Results show that transconductance degradation and leakage current increase due to non-uniform generation of trapped charges in STI.

10:15 AM – 10:45 AM
EXHIBIT HALL A

BREAK

A-5
10:45 AM

Ion-Induced Stuck Bits in 5-nm bulk FinFET SRAMs at High Fluences

Y. Xiong[1], N. Pieper[1], N. Dodds[2], G. Vizkelethy[2], N. Nowlin[2], B. Bhuva[1]

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

Experiments were performed to search for single-ion-induced displacement damage effects in 5-nm FinFET SRAM arrays. Stuck bits were observed that are consistent with cumulative displacement damage effects and inconsistent with other possible failure mechanisms.

A-6
11:00 AM

Total Ionizing Dose Response of 128 Analog States in Computational Charge-Trap Memory

T. Xiao[1], D. Wilson[2], C. Bennett[1], B. Feinberg[1], D. Hughart[1], V. Agrawal[3], H. Puchner[3], M. Marinella[2], S. Agarwal[1]

1. Sandia National Laboratories, USA
2. Arizona State University, USA
3. Infineon Technologies, USA

The total ionizing dose response of analog memory states (128 levels/device) in 40 nm SONOS charge-trap memory was experimentally characterized to 1.5 Mrad(Si), and the image recognition accuracy of SONOS analog accelerators under radiation was simulated.

POSTER PAPERS

PA-1 Radiation Response of Domain-Wall Magnetic Tunnel Junction Logic Devices

C. Bennett[1], T. Xiao[1], T. Leonard[2], J. Young[1], G. Vizkelethy[1], E. Bielejec[1], D. Hughart[1], M. Marinella[3], J. Incorvia[2]

1. Sandia National Laboratories, USA

2. University of Texas, Austin, USA

3. Arizona State University, USA

Domain-wall magnetic tunnel junction (DW-MTJ) parts were exposed to total ionizing doses, ion displacement damage, or both. The parts demonstrated resilience to ionizing radiation, but degraded similarly to other MTJs in response to heavy ions.

PA-2 Total-Ionizing-Dose Effects in IGZO Thin-Film Transistors with SiO2 Tunnel Layers

Z. Guo[1], E. Zhang[1], D. Fleetwood[1], R. Schrimpf[1], R. Reed[1], A. Chasin[2], J. Mitard[2], D. Linten[2], A. Belmonte[2], G. Kar[2]

1. Vanderbilt University, USA

2. imec, Belgium

TID effects are evaluated in IGZO thin-film transistors irradiated under different gate biases. The largest degradation occurs at negative bias. Comparison with back-gated devices indicates that hydrogen plays an important role in degradation.

PA-3 Impact of Back-Gate Bias on the DSOI SRAMs Under Total Ionizing Dose Irradiation

H. Ren[1], F. Liu[1], B. Li[1], Z. Han[1], S. Chen[1], L. Wang[1], S. Ma[1], G. Zhang[1], J. Li[1], P. Cui[1], J. Gao[1], J. Wan[2], H. Wang[3]

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

2. State Key Lab of ASIC and System, Fudan University, China

3. College of IoT Engineering, Hohai University, China

The impact of back-gate bias and film thickness on TID effect of Double-SOI SRAM are experimentally compared with and without floating body devices. Negative back-gate bias can efficiently improve TID tolerance with thin film.

PA-4 The Effects of Threshold Voltage and Number of Fins per Transistor on the TID Response of GF 12LP Technology

A. Vidana[1], J. Trippe[1], N. Dodds[1], N. Nowlin[1], J. Kauppila[2], L. Massengill[2], H. Barnaby[3]

1. Sandia National Laboratories, USA

2. Reliable MicroSystems, USA

3. Arizona State University, USA

We present experimental total ionizing dose data on GlobalFoundries 12LP 12 nm FinFET technology. The TID response depends on both the transistor threshold voltage and on the number of fins per transistor.

PA-5 **Bias Dependence of Total Ionizing Dose Effect in Top-Gate CNTFET**

H. Ding[1], Q. Zheng[1], H. Xu[2], C. Jiangwei[1], N. Gao[3], M. Xun[1], Y. Gang[1], C. He[1], Y. Li[1], Q. Guo[1]

1. Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences (CAS), China

2. Shanxi Institute for Carbon-based Thin Film Electronics, Peking University, China

3. Beijing Institute of Carbon-based Integrated Circuits, China

The bias dependence of TID in top-gate CNTFET is studied in this paper. ON state is the worst bias condition for the threshold voltage degradation. Abnormal shift of threshold voltage is found under TG bias.

PA-6 **Towards Ensuring SRAM-PUF Integrity Under Ionizing Radiation**

U. Surendranathan[1], H. Wilson[1], A. Milenkovic[1], B. Ray[1]

1. University of Alabama in Huntsville, USA

Power-up states of SRAM chips are routinely used to derive their PUFs. This paper shows that the data stored in SRAM during irradiation as well as the technology-node impact integrity of SRAM PUFs.

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

11:15 AM SESSION INTRODUCTION

Chair: Jason Osheroff, NASA Goddard Space Flight Center

B-1 **Depth Dependence of Neutron-induced Errors in 3D NAND Floating**
11:20 AM **Gate Cells**

S. Gerardin[1], M. Bagatin[1], A. Paccagnella[1], S. Beltrami[2], C. Cazzaniga[3]

1. University of Padova, Italy

2. Micron Technology, Italy

3. STFC, United Kingdom

The sensitivity of vertical-channel 3D NAND Flash memories to wide-energy spectrum neutrons is investigated, through experiments and simulations, as a function of cell depth in the pillars.

B-2 **Single-Event Burnout in Vertical PtOx/β-Ga2O3 Schottky Diodes with**
11:35 AM **Extreme-k TiO2 Field Plates**

S. Islam[1], A. Senarath[1], D. Ball[1], A. Sengupta[1], E. Zhang[1], D. Fleetwood[1], R. Schrimpf[1], F. Esmat[2], N. Hendricks[2], J. Speck[2]

1. Vanderbilt University, USA

2. University of California, Santa Barbara, USA

Structural and process changes to vertical β-Ga2O3 Schottky diodes enable significantly improved electrical performance. Enhanced resistance to ion-induced burnout is demonstrated via alpha particle and Cf-252 testing.

11:50 AM - 1:15 PM LUNCH
EXHIBIT HALL A

B-3 1:15 PM

Single Event Transient in Body Contacted PDSOI Technology: Compact Modeling and Statistical Experimental Calibration

N. Rostand[1], D. Lambert[1], O. Duhamel[1], M. Gaillardin[1], M. Raine[1], S. Vigne[1], M. Sall[1], C. Grygiel[1]

1. CEA, France

We propose a Single Event Transient compact model for 65nm Body Contacted PDSOI technology along with TCAD analysis and experimental statistical calibration based on the collected charge.

B-4 1:30 PM

The Contribution of Secondary Alpha Particles to Soft Error Rates in Space Systems

R. Cadena[1], N. Dodds[2], K. Warren[1], B. Sierawski[1], R. Reed[1], D. Ball[1], R. Schrimpf[1]

1. Vanderbilt University, USA

2. Sandia National Laboratories, USA

The importance of including secondary particles in environment simulations is demonstrated by comparing MRED and CREME96 simulations. CREME96 underpredicts the flux of secondary alpha particles, which can cause an artificially low soft error rate calculation.

POSTER PAPERS

PB-1

Investigation of the Impact of Angles and Rotation of Low Energy Protons in SRAM Cells Beyond 16nm

L. Artola[1], M. Glorieux[2], G. Hubert[1], C. Inguimbert[1], T. Bonnoit[2], R. Rey[1], T. Lange[2], D. Levacq[3], C. Poivey[3]

1. ONERA, France

2. IROC Technologies, France

3. ESA, Netherlands

This work presents the impact of the angle of incidence of low-energy protons in SRAM cells of several deep sub-micron technologies. Experimental data are presented and discussed with the support of multi-physics and multi-scales simulations.

PB-2

Using Track Structure Theory to Predict Heavy-Ion and Neutron Cross-Sections

D. Hansen[1], S. Resor[1], D. Czajkowski[1], B. Vermeire[1]

1. Space Micro, USA

This paper uses a track structure theory (TST) model for the calculation of 14 MeV neutron, and heavy-ion cross-sections from measured data. The TST model performs well compared to other models in the literature.

PB-3

Influence of Well Contact on Single Event Transient in Sub-20 nm FinFET Process

Q. Sun[1], Y. Guo[1], B. Liang[1], M. Tao[2], Y. Chi[1], P. Huang[1], Z. Wu[1], J. Chen[1], D. Luo[1], H. Sun[1]

1. National University of Defense Technology, China

2. College of Electrical and Information Engineering, Hunan University, China

This paper discusses the influence of well contact on SET in sub-20 nm FinFET. Experiment and high-precision TCAD simulation results show that well contact has less impact on SET, which is different from planar CMOS.

PB-4 **Quantitative Analysis on Multi-Factor Coupling Influence Effects of Single Event Transient Characteristic Dependence of 22 nm FDSOI Circuits**

L. Tongde[1], Z. Yuanfu[1]

1. Beijing Microelectronics Technology Institute, China

A 22nm FDSOI test chip is designed for obtaining SET characteristics. The contribution of the influencing factors is quantified. The research results can support the flexible selection of low-cost radiation hardened methods considering conventional performance.

PB-5 **Laser-Induced Micro-SEL Current Profile Modeling for High-Accuracy ML-Based Micro-SEL Detection**

J. Zhao[1], Y. He[1], Z. Qin[1], K. Chong[2], W. Shu[2], Y. Sun[1], P. Chan[1], J. Chang[1,2]

1. Nanyang Technological University, Singapore

2. Zero-Error Systems Pte Ltd, Singapore

We present a novel laser-induced micro-Single-Event-Latchup current-profile model for Machine-Learning-based micro-SEL detection. The detection accuracy and delay are improved to ~95% from ~73% and to the microseconds range, respectively, thereby rendering practical real-time detection.

SESSION C BASIC MECHANISMS OF RADIATION EFFECTS

1:45 PM SESSION INTRODUCTION

Chair: Ani Khachatrian, Naval Research Laboratory

C-1 1:50 PM **Effects of Interface Traps on the Low-Frequency Noise of Irradiated MOS Devices**

D. Fleetwood[1], E. Zhang[1], R. Schrimpf[1], S. Pantelides[1], S. Bonaldo[2]

1. Vanderbilt University, USA

2. University of Padova, Italy

Experimental results suggest that interface traps may contribute significantly to the low-frequency noise of some irradiated MOS devices. Hydrogen-induced trap activation and passivation are identified as likely origins of the observed fluctuations.

C-2 2:05 PM **Neutron Displacement Damage in Bipolar Junction Transistors Isolated from an Integrated Circuit**

J. Young[1], T. Ho[2], S. Banerjee[1], X. Gao[1], L. Musson[1], H. Barnaby[2], T. Buchheit[1]

1. Sandia National Laboratories, USA

2. Arizona State University, USA

Lateral pnp and vertical npn transistors were isolated from the LM741 circuit and irradiated with 14 MeV neutrons. TCAD modeling confirms shortened minority lifetime responsible for gain degradation due to displacement damage.

C-3 2:20 PM

The Effects of Heavy Ion Induced Displacement Damage on WO3-x ECRAM

M. Marinella[1], C. Bennett[2], B. Zutter[2], M. Siath[1], G. Vizkelethy[2], T. Xiao[2], E. Fuller[2], D. Hughart[2], S. Agarwal[2], Y. Li[3], A. Talin[1]

1. Arizona State University, USA
2. Sandia National Laboratories, USA
3. University of Michigan, USA

Displacement damage in WO3-x ECRAM is experimentally characterized for the first time. At moderate levels, metal oxide ECRAM does not exhibit significant changes. At high displacement per atom levels, conductivity increases with increasing vacancy concentration.

C-4 2:35 PM

Analysis of Total Ionizing Dose Effects using Electron Holography

C. Chang[1], H. Barnaby[1], D. Smith[1], M. Mccartney[1], P. Apsangi[2], K. Muthuseenu[3], K. Holbert[1], A. Privat[1], B. Kennedy[1]

1. Arizona State University, USA
2. Tower Semiconductor, USA
3. Intel, USA

Electrical characterization and electron holography on metal-oxide-semiconductor devices confirm the presence of net positive oxide charge build-up after total-ionizing dose. Holography also identifies the buildup of net negative charge trapping near oxide-metal interface.

POSTER PAPERS

PC-1

Closing the "10-100 eV Gap" for Electron Thermalization in GaN Devices from First Principles

D. Nielsen[1], C. Van de walle[2], S. Pantelides[3], R. Schrimpf[3], D. Fleetwood[3], M. Fischetti[1]

1. University of Texas at Dallas, USA
2. University of California, Santa Barbara, USA
3. Vanderbilt University, USA

We report full-band Monte Carlo simulations of electron thermalization in GaN from 100 eV, where energy-loss processes are poorly known. Electrons thermalize in ~1 ps, generating electron-hole pairs with an average energy of ~9.4 eV/pair.

PC-2

Modeling of Total Ionizing Dose Effects in SOI FinFETs at High Temperature

X. Zhang[1], F. Liu[1], B. Li[1], Y. Huang[1], S. Chen[1], J. Li[1], T. Zhang[1], Q. Zhang[1], H. Yin[1], J. Wan[2], H. Wang[3], Y. Guo[4], J. Luo[1]

1. Institute of Microelectronics and Key Laboratory of Science and Technology on Silicon Devices, Chinese Academy of Sciences, China
2. State Key Laboratory of ASIC and System, Fudan University, China
3. College of IoT Engineering, Hohai University, China
4. Nanjing University of Posts and Telecommunications, China

Considering the repair effect of fixed-trapped charges and temperature dependence of threshold voltage, an electrostatic potential model of TID effect at high temperature is proposed for SOI FinFETs. Both simulations and experiments validate it.

PC-3 **Ultra-high Energy Heavy Ion Irradiation Effects on Carbon Nanotubes**

H. Shu[1], P. Lu[1], J. Gao[1], P. Zhao[2], M. Zhu[3], J. Yan[3], B. Li[1]

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

2. Institute of Modern Physics, Chinese Academy of Sciences, China

3. School of Information Science and Technology, North China University of Technology, China

Ultra-high energy heavy ion irradiation causes physical interaction between carbon nanotubes and the SiO2 substrate, forming distinct micrometer-size damages. The damaged region close to the incident site is insulating while adjacent carbon nanotubes are relocated.

PC-4 **Investigation of Elements Migration of Organic-Inorganic Metal Halide Perovskite Films Materials Induced by Proton Irradiation**

X. Zhang[1], L. Wang[1], H. Zhu[1], P. Lu[1], X. Li[1], B. Li[1]

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

XPS and EDS analytical technology were carried out to investigate the elements migration phenomenon in perovskite materials under high fluence proton irradiation. This basic analysis is advantageous to explore the high radiation resistance of perovskite..

2:50 PM – 3:20 PM
EXHIBIT HALL A

BREAK

SESSION D **SPACE AND TERRESTRIAL ENVIRONMENTS**

3:20 PM SESSION INTRODUCTION

Chair: Scott Messenger, Northrop Grumman Corporation

D-1 3:25 PM **Global Ionizing Radiation Environment Mapping Using Starlink Satellite Data**

H. Shah[1], R. Van cleave[1], C. Jeffrey[1], K. Pham[1], Z. Fleetwood[1], S. Shermer[1]

1. SpaceX, USA

Global simultaneous spatiotemporal mapping of ionizing radiation environments is provided for the first time on the Starlink satellite fleet utilizing sensor and circuit detection methods.

D-2 3:40 PM **Radiation Environment in the Large Hadron Collider During the 2022 Restart and Related RHA Implications**

K. Bilko[1], R. Garcia[2], Y. Aguiar[2], S. Danzeca[2], S. Girard[3], M. Sebban[3], S. Uznanski[2]

1. Université Jean Monnet, France

2. CERN, Switzerland

3. Université de Saint Etienne, France

Radiation levels measured in 2022 along the CERN Large Hadron Collider are presented, focusing on the TID comparison with the 2015-2018 years. Measurements from more than 750 SRAMs distributed across the accelerator are discussed.

D-3 **NAIRAS Atmospheric and Space Radiation Environment Model**

3:55 PM *C. Mertens[1], G. Gronoff[2], Y. Zheng[3], J. Buhler[4], E. Willis[5], M. Petrenko[3], D. Phoenix[2], I. Jun[6], J. Minow[5]*

1. NASA Langley Research Center, USA
2. Science Systems and Applications, Inc., USA
3. NASA Goddard Space Flight Center, USA
4. NASA Kennedy Space Center, USA
5. NASA Marshall Space Flight Center, USA
6. Jet Propulsion Laboratory, USA

This paper describes the NAIRAS model now publicly available at NASA's Community Coordinated Modelling Center. NAIRAS predicts dosimetric and radiation flux quantities for assessing human radiation exposure and radiation effects to flight vehicle electronic systems.

4:10 PM END OF TUESDAY SESSIONS

5:30 – 7:30 PM
EXHIBITOR RECEPTION

EXHIBIT HALL A

Technical Program Wednesday

EXHIBIT HALL B
INVITED TALK
8:30 AM - 9:30 AM

Negro League Baseball—The Giants. Why is it important to us today?
Phil S. Dixon, Researcher, Writer, and Co-Founder of the Negro League Baseball Museum, Kansas City, Missouri

Phil S. Dixon is a road warrior, a veracious interviewer, a tireless researcher and writer who has interviewed over 500 players, wives and their offspring for a unique perspective of the American and Negro League baseball experience, works for which he won a SABR MacMillan Award (Society of American Baseball Researchers) for his excellence in historical research. He is best known for his 7 non-fiction books which includes "The Negro Baseball Leagues A Photographs History, 1867-1955," a Casey Award winner as the best baseball book of the year in 1992.

He is a proud member of SABR, the Missouri Writers Guild, the IBWAA (Internet Baseball Writers Association of America) and serves on the National Advisory Board for the Negro Leagues Baseball Museum. His work has been praised by a range of luminaries from Fay Vincent "Baseball Commissioner" to Stephen Jay Gould the famous "American Paleontologist." Dixon is a Humanities Kansas presenter and a past Missouri Humanities speaker. Dixon's most resent adventure was presenting in over 200 American cities and internationally into Canada with a presentation titled the "Kansas City Monarchs In Our Hometown," in an effort to improve race relations. In true barnstorming fashion, he drove the entire route that covered 17 states and over 75,000 miles. His presentations and books are a fluid mix for those who enjoy professional journalism that is both humorous and insightful. Phil's motto is "why bore your audiences and readers with sabermetrics when a touch of humor and non-sports history will suffice."

Baseball's quintessential barnstormer is a designation he embraces. His latest release, "The Dizzy and Daffy Dean Barnstorming Tour; Race, Media and America's National Pastime," continues that tradition. His writings are illustrated with stories and photographs which familiarize readers with baseball's forgotten Negro stars through primary source research obtained during his many years of dedication to this topic. In addition to books he owns copyrights for poems and a movie script. He is a true American griot and 40 years of presenting in the Negro League genre hasn't dulled his pursuit for greater knowledge.

Dixon left home at age-17 to pursue a musical career. He traveled the mid-west and Southern Chitlin' Circuit and journaled his experiences. He returned to Kansas City where he earned a bachelor's degree from the University of Missouri at Kansas City. His free-lance writing for the African American owned Kansas City Call led to a major league press pass, which eventually landed him a job with the American League Kansas City Royals where he worked in Public Relations. In 1990 he co-founded the Negro League Baseball Museum in Kansas City. Phil is the husband of Dr. (Kerry) his wife of 36 years, and father of three HBCU college graduates who represent: (Langston, Howard and Fisk). Dixon, a Kansan at birth, now makes his home in Missouri with the wife, the children, his trumpet and album collection while eagerly awaiting his weekly edition of the Kansas City Call.

EXHIBIT HALL B

SESSION E **HARDNESS ASSURANCE: PIECE PARTS TO SYSTEMS AND TESTING APPROACHES**

9:30 AM SESSION INTRODUCTION

Chair: Courtney Matzkind, Missile Defense Agency

E-1 **Quantitative Laser Testing for Predicting Heavy-Ion SEE Response – Part 1: Metrics for Assessing Response Agreement**

9:35 AM

A. Ildefonso[1], J. Hales[1], A. Khachatrian[1], G. Allen[2], D. Mcmorrow[1]

1. U.S. Naval Research Laboratory, USA

2. Jet Propulsion Laboratory, USA

An approach to quantitatively assess the agreement between laser- and ion-induced single-event transients is presented. While demonstrated with laser and ion data, this approach can be applied to other surrogates for heavy ion testing.

E-2 **Quantitative Laser Testing for Predicting Heavy-Ion SEE Response – Part 2: Accurately Determining Laser-Equivalent LET**

9:50 AM

J. Hales[1], A. Ildefonso[1], A. Khachatrian[1], G. Allen[2], D. McMorrow[1]

1. U.S. Naval Research Laboratory, USA

2. Jet Propulsion Laboratory, USA

An accessible approach for estimating the laser-equivalent LET for any laser geometry is presented and validated for various testing conditions. Such calculations are key for laser testing to serve as a surrogate for heavy-ion testing.

E-3 **In-Situ Observation of Circuit Behavior Using Pump-Probe Laser Voltage Probe Technique**

10:05 AM

M. King[1], J. Beutler[1], T. Meisenheimer[1], N. Smith[1], K. Mai[2], P. Mohan[2], O. Atli[2]

1. Sandia National Laboratories, USA

2. Carnegie Mellon University, USA

A novel combination of techniques provides feedback RHA and RHBD activities. A pump-probe TPA and LVP technique shows radiation response of a D-Flip-Flop and shows operational circuit response of simulated radiation events.

10:20 AM – 11:00 AM BREAK

EXHIBIT HALL A

E-4 **SRAM Electrical Variability and SEE Sensitivity at 5-nm Bulk FinFET Technology**

11:00 AM

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

1. Vanderbilt University, USA

2. Synposys, USA

Process-induced critical charge variability and SEE sensitivity for SRAM at 5-nm bulk FinFET technology are investigated. Results show laboratory-based electrical measurements do not accurately predict SE vulnerability of SRAMs at either cell-level or IC-level.

E-5 11:15 AM

Measuring Zero: Neutron Testing of Modern Digital Electronics

H. Quinn[1], G. Tompkins[1]

1. Los Alamos National Laboratory, USA

With the recent changes in transistor design has made it harder to measure neutron-induced single-event upset (SEU) cross sections. Statistical guidance is given for testing components that are designed to be SEU hardened.

E-6 11:30 AM

Probabilistic Risk Assessment of System-Level Radiation Effects Using Fault Tree Analysis

S. Lawrence[1], L. John[1], C. James[1], D. Loveless[1]

1. University of Tennessee at Chattanooga, USA

A new Probabilistic-Risk-Assessment methodology is used to predict radiation-induced unavailability for a system within an arbitrary environment. A study of the NASA SpaceCube processor in ISS and GEO environments justifies mitigation strategies and quantifies risk.

POSTER PAPERS

PE-1

Review of Artemis I Mission Radiation Challenges and Data for the Crew Module

C. Bailey[1], R. Gaza[1], C. Patel[2], J. Pritts[3], K. Nguyen[3]

1. NASA Johnson Space Center, USA

2. Lockheed Martin Corporation, USA

3. Jacobs Technology Incorporated, USA

We review the Artemis-I mission and corresponding radiation hardness assurance (RHA) process. We discuss the RHA methodologies employed, design challenges overcame, in-flight anomalies observed, and lessons learned from the mission and by the program.

PE-2

Under-Constrained SEE Data: Implications for Estimating and Bounding SEE Rates

R. Ladbury[1]

1. NASA Goddard Space Flight Center, USA

Increasingly scarce SEE testing resources and rapid growth of the New Space sector have in-creased the prevalence of under-constrained SEE data. We develop Monte Carlo tools to assess implications for SEE rate estimation.

PE-3

FIERA: An FPGA Emulation-based Hardware Soft Error Tolerance Evaluation Platform for SoCs

O. Atli[1], P. Mohan[1], M. King[2], K. Mai[1]

1. Carnegie Mellon University, USA

2. Sandia National Laboratories, USA

We introduce FIERA, an FPGA-accelerated flexible error injection tool 104x faster than RTL simulation-based methods. We demonstrate the FIERA by evaluating soft error vulnerabilities of SoCs under deep learning workloads and present our test chip.

PE-4 **A Confidence-Based Approach to Including Survivors in a Probabilistic TID Failure Assessment**

C. Champagne[1], B. Sierawski[1], R. Ladbury[2], M. Campola[2], D. Fleetwood[1]
1. Vanderbilt University, USA
2. NASA Goddard Space Flight Center, USA

A probabilistic TID failure assessment is extended to include survivor data. This enables a formal analysis of radiation tolerant devices tested to a maximum dose, as well as flight heritage, in a hardness assurance methodology.

PE-5 **Correlating Historical Device Degradation Data to Radiation-Induced Degradation System Effects for a LiDAR System**

R. Nederlander[1], A. Witulski[1], A. Sternberg[1], R. Reed[1], G. Karsai[2], R. Ladbury[3], E. Zhang[1], J. Evans[1], R. Schrimpf[1], K. Ryder[3], M. Campola[3], N. Mahadevan[2], R. Austin[3]
1. Vanderbilt University, USA
2. Institute for Software Integrated Systems, Vanderbilt University, USA
3. NASA Goddard Space Flight Center, USA

Bayesian fault probabilities are used to predict TID effects in systems. These probabilities are combined to predict system level effects on a LiDAR system. This model allows for efficient prescreening of radiation sensitive systems.

PE-6 **Applicability of the Accelerated ELDRS Test Method - Temperature Switching Irradiation**

X. Li[1], X. Wang[1], M. Liu[1], Y. Xin[1], Q. Zheng[1], J. Cui[1], Y. Li[1], W. Lu[1], Q. Guo[1]
1. Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, China

A temperature-switching irradiation (TSI) sequence based on first-principles understanding of inter-face-trap buildup and annealing is shown to be a conservative test for ELDRS at ultra-low dose rate in linear bipolar devices.

POSTER SESSION
11:45 AM

INTRODUCTION

Chair: Jeff George, Alamos National Laboratory

11:50 AM TO 12:50 PM
CHOUTEAU ROOM

YOUNG PROFESSIONALS LUNCH
(Ticket Required to Attend)

11:50 AM TO 1:30 PM
EXHIBIT HALL A

LUNCH / EXHIBIT RAFFLE

CHICAGO BALLROOM

END OF WEDNESDAY SESSIONS

CONFERENCE SOCIAL
NEGRO LEAGUES BASEBALL MUSEUM
AND AMERICAN JAZZ MUSEUM

EXHIBIT HALL B
INVITED TALK
8:30 - 9:30 AM

Brewing Beer: Process Overview from Grain to Package

Rob Odell, Filtration Supervisor, Boulevard Brewing Company, Kansas City, Missouri
Taran Winnie, Brewing Team Member, Boulevard Brewing Company, Kansas City, Missouri

It was the summer of 1984, and John McDonald was thirsty. On vacation in Europe, the future founder of Boulevard Brewing Company wandered into a bar specializing in Belgian beers. He tried one, then another and another, amazed by the variety, the aromas, and the flavors. He was hooked. Back home, John couldn't stop dreaming about those beers. But dreaming was all he could do, because American beers of the time were homogenous and unremarkable. Kansas City, once home to more than a dozen breweries producing a wide array of beers, had succumbed to the industrial onslaught. Nothing was left.

After art school John made his living as a carpenter, always fascinated by the creative process. He couldn't shake the memory of those amazing beers, and he began to wonder, began to consider the possibilities. He started homebrewing. He visited breweries. He put together a business plan, sold his house to raise money, and set out to find the rest of the resources he would need to start a brewery.

He didn't have to look far to get started. John lived and worked in an old brick building on Southwest Boulevard that had once housed the laundry for the Santa Fe Railroad. He moved his carpentry shop to a corner and began to build a brewery. It wasn't ideal, but it was his. It took more than a year and every bit of the money he'd raised to retrofit the building, find the equipment – including a vintage 35-barrel Bavarian brewhouse – and get everything up and running. Finally, in November 1989, the first keg of Boulevard Pale Ale was ready. John loaded it into the back of his pickup and delivered it to a restaurant just a few blocks away.

Word was spreading – Boulevard was making surprisingly good beer. The original business plan called for someday selling 6,000 barrels a year. By the third year sales passed 7,000 barrels, and continued to climb. Boulevard began selling its beers in neighboring cities and states. The original Bavarian brewhouse, designed to produce only a few thousand barrels a year, was approaching 100,000 barrels by 2004, turning out a dozen 1,000 gallon brews each and every day. But it had reached its limit, and a decision loomed.

When John built the brewery deep in the heart of a century-old urban neighborhood, he hadn't worried about outgrowing it. But it had happened. Now, consultants said the smart move was to relocate to a new site with plenty of room. But the brewery was tightly woven into the fabric of the city, and the Boulevard team was committed to its continued revitalization. So in 2006 a $25 million expansion project brought a new building with a 150-barrel brewhouse, packaging halls, offices and hospitality spaces.

For years John had been eager to drive more experimentation and innovation, but the continuing growth of Unfiltered Wheat Beer and Pale Ale meant the brewery's limited resources were devoted to the existing line-up. Now, with a new brewhouse, the team's creative energies were unleashed. The Smokestack Series was launched, featuring an ever-evolving array of even bigger, bolder beers.

Boulevard loves hosting visitors, but as time went on their limited capacity meant they were turning away tens of thousands of people every year. So, in 2016 they opened the Tours & Rec Center next door to the brewery. The fully restored 1929

building serves as a hub for tours, swag, sampling and entertainment, including an experience area with exhibits about beer and Boulevard, a gift shop, and a 10,000 square foot Beer Hall. In 2019, the Tours & Rec Center was further enhanced with the opening of the Rec Deck, a fourth floor gathering space featuring deck and tabletop shuffleboard (and of course, beer).

Mr. Odell has been with Boulevard since 2007. He has held various roles within the brewery, and is currently the Filtration Supervisor. Mr. Winnie joined the Boulevard brewing team in 2022. He's been working on the Brewhouse since arriving last year. Taran has been involved the industry since 2017 after finishing a Master's program in Brewing Science.

EXHIBIT HALL B
SESSION F **PHOTONIC DEVICES AND INTEGRATED CIRCUITS**
9:30 AM SESSION INTRODUCTION
Chair: George Tzintzarov, The Aerospace Corporation

F-1 **Online DCR Measurements in 150 nm CMOS SPADs Exposed to Low**
9:35 AM **Neutron Fluxes**
L. Ratti[1,5], P. Brogi[2,5], G. Collazuol[3,5], G. Dalla Betta[4,5], J. Delgado[3,5], P. Marrocchesi[2,5], J. Minga[1,5], F. Morsani[5], L. Pancheri[4,5], F. Pino[3,5], A. Selva[5], F. Stolzi[2,5], G. Torilla[1,5], C. Vacchi[1,5]
1. University of Pavia, Italy
2. University of Siena, Italy
3. University of Padova, Italy
4. University of Trento, Italy
5. National Institute for Nuclear Physics, Italy

Dark count rate is monitored in single- and dual-layer 150 nm CMOS SPADs, during and after irradiation with a neutron source, to investigate the dynamics of defect formation and short- and mid-term annealing.

F-2 **Effect of Energy, Flux and Bias Conditions on Proton-Irradiated CMOS**
9:50 AM **Single Photon Avalanche Diodes**
A. Jouni[1], V. Malherbe[2], B. Mamdy[2], T. Thery[2], V. Correas[2], S. De Paoli[2], V. Lalucaa[1], C. Virmontois[1], G. Gasiot[2], V. Goiffon[3]
1. CNES, France
2. STMicroelectronics, France
3. ISAE-SUPAERO, France

Different proton energies and fluxes were used to irradiate single photon avalanche diodes. Mean dark count rate increase slightly depends on the incident energy and discrepancies are underlined for different fluxes and bias conditions.

F-3 10:05 AM

Impact of Irradiation Temperature, Doping and Proton Energy on InGaAs Photodiodes

M. Benfante[1], J. Reverchon[1], C. Virmontois[2], S. Demiguel[3], V. Goiffon[4]

1. III-V Lab, France

2. CNES, France

3. Thales Alenia Space, France

4. ISAE-SUPAERO, France

In this work we show the effects of different parameters on the Dark Current-related Damage Rate. We investigate the proton energy effects with reverse bias, the effects of irradiation temperature and doping.

10:20 AM – 11:05 AM PRE-FUNCTION — BREAK

F-4 11:05 AM

Effects of High Fluence Particle Irradiation on Silicon Photonics Photodiodes

L. Olantera[1], C. Scarcella[1], M. Lalovic[1], S. Detraz[1], C. Soos[1], T. Prousalidi[1], C. Sigaud[1], U. Sandven[1], J. Troska[1]

1. CERN, Switzerland

Germanium-on-Silicon photodiodes were irradiated with highly-energetic protons and neutrons to fluences exceeding 3x1016 particles/cm2. Observed changes in responsivity, dark current, and capacitance indicate excellent radiation tolerance that meets the requirements of next-generation high energy physics experiments.

F-5 11:20 AM

Analysis of Optical Single-Event Transients in Integrated Silicon Photonics Mach-Zehnder Modulators for Space-based Optical Communications

M. Hosseinzadeh[1], J. Teng[1], B. Ringel[1], D. Nergui[1], A. Ildefonso[2], A. Khachatrian[2], D. Mcmorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. U.S. Naval Research Laboratory, USA

Integrated SiPh MZMs are exposed to pulsed-laser-induced TPA, and the sensitivity to single-event transients is measured. A numerical model to predict the SET effects on SiPh MZM is developed, as well as a simulation path to validate the model.

F-6 11:35 AM

Temperature Cycling Effects on Infrared Radiation-Induced Attenuation of Silica-based Optical Fibers

M. Roche[1], A. Morana[1], E. Marin[1], A. Boukenter[1], Y. Ouerdane[1], G. Melin[2], T. Robin[2], N. Balcon[3], J. Mekki[3], S. Girard[1]

1. Laboratory Hubert Curien, France

2. iXBlue, France

3. CNES, France

Combined radiation and temperature cycling effects on the 1550 nm radiation-induced attenuation (RIA) levels and kinetics of three commercial optical fibers with different doping (Germanium, Fluor and Phosphorus) have been investigated.

POSTER PAPERS

PF-1 **TID-Induced Loss and Optical-Power Annealing of Straight and Curved Silicon Photonic Waveguides Using Pulsed X-rays**

B. Ringel[1], J. Teng[1], M. Hosseinzadeh[1], J. Heimerl[1], Z. Brumbach[1], A. Little[2], G. Tzintzarov[2], D. Monahan[2], S. Lalumondiere[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. The Aerospace Corporation, USA

The TID response of straight and curved integrated silicon-photonic waveguides are evaluated. Transmission degradation, irrespective of curvature, was observed above 5 Mrad(Si). Optical-power-induced annealing due to heating was also observed and shown to recover performance.

PF-2 **Electrical Characteristics and Defect Dynamics Induced by Swift Heavy Ion Irradiation in ε-Ga_2O_3 Thin Films**

Y. Tang[1], Y. Yang[2], L. Wang[1], M. Li[1], H. Zhu[1], Z. Wu[2], B. Li[1]

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

2. Beijing University of Posts and Telecommunications, China

1907 MeV Ta ions were employed to irradiate epitaxial ε-Ga_2O_3 thin films. Morphological variations and crystallographic transformations are observed in the post-irradiated films. Despite obvious degradation, ε-Ga_2O_3 photodetectors still operate normally under high irradiation fluences.

PF-3 **Influence of Hydrogen on the Radiation-Induced Attenuation of Ge-doped Optical Fiber**

A. Morana[1], M. Roche[1], E. Marin[1], A. Boukenter[1], Y. Ouerdane[1], S. Girard[1]

1. Laboratory Hubert Curien, France

We studied the combined radiation and hydrogen effects on the NIR attenuation of a standard Ge-doped fiber up to a dose of 100 kGy, to characterize the influence of the molecular or bonded atomic hydrogen.

PF-4 **Alpha Particle-Induced Persistent Effects in a COTS 3D-Integrated Imager**

M. Hu[1], M. Mccurdy[1], B. Sierawski[1], R. Schrimpf[1], R. Reed[1], M. Alles[1]

1. Vanderbilt University, USA

The nature and rate of alpha-particle-induced persistent effects observed in a heterogeneously integrated COTS 3D-IC imager are shown to be dependent on operating condition and the functional layer in which the alpha particles stop.

EXHIBIT HALL B

SESSION G **DOSIMETRY AND FACILITIES**

11:50 AM SESSION INTRODUCTION

Chair: Richard Sharp, Radtest Ltd

G-1 11:55 AM

Ultra-Large Silicon Solid-State Detector for Characterizing Low-Intensity Radiation Environments

K. Bilko[1], R. Garcia[2]

1. Université Jean Monnet, France

2. CERN, Switzerland

A large silicon solid-state detector is demonstrated as a solution for low-flux radiation field monitoring. The calibration of the detector is presented, with the measurements and simulations from the spectral neutron fields, e.g., atmospheric.

G-2 12:10 PM

Progress on a Modeling Framework for GaN FinFET Time-Dependent Responses after Radiation Damage

B. Davidson[1], A. Bahadori[1], K. Huddleston[1], M. Pfeifer[1], W. Mcneil[1], D. Mcgregor[1], S. Sharma[1], E. Giunta[1]

1. Kansas State University, USA

A simulation framework was developed to predict signal formation from radiation events in GaN-based semiconductors before and after ionizing radiation exposure. Progress on modeling response of a FinFET device is shown.

POSTER PAPERS

PG-1

Mixed-Field Radiation Monitoring and Beam Characterization Through Silicon Solid-State Detectors

K. Bilko[1], R. Garcia[2]

1. Université Jean Monnet, France

2. CERN, Switzerland

Silicon solid-state detector for the monitoring of the mixed radiation field is presented with the focus on the CERN's CHARM facility. The use of the detector for indirect beam characterization is demonstrated.

PG-2

Correlative Single Event Latchup (SEL) Characterization of the ADMV1013 Wideband Microwave Upconverter at Multiple Heavy Ion Laboratories

J. Likar[1], E. Shi[1], C. Pham[1], T. Decker[2], S. Lidia[3]

1. Johns Hopkins University / Applied Physics Laboratory, USA

2. Analog Devices, Inc., USA

3. Facility for Rare Isotope Beams / Michigan State University, USA

The ADMV1013 wideband, microwave upconverter was subjected to heavy ion testing at three different accelerators. Combined results illustrate the compatibility of the Michigan State University Facility for Rare Isotope Beams Single Event Effects laboratory (FSEE).BREAK

RADIATION EFFECTS DATA WORKSHOP
12:25 PM

INTRODUCTION

Chair: Andrea Coronetti, CERN

12:30 PM
CHOUTEAU ROOM

WOMEN IN ENGINEERING LUNCH
(Ticket Required to Attend)

12:30 PM TO 1:45 PM

LUNCH
ON YOUR OWN!

RADIATION EFFECTS DATA WORKSHOP
1:45 PM - 4:30 PM

NEW YORK BALLROOM

DW-1 **Single Event Upset Results from the Radiation Hardened Electronic Memory Experiment in a Geosynchronous Orbit**

A. Vera[1], A. Cover[2], J. Love[1], D. Alexander[2]
1. IDEAS Engineering and Technology, LLC, USA
2. COSMIAC, USA

Results are presented from the Radiation Hardened Electronic Memory Experiment (RHEME-3) performed on the STPSat-6 mission in a polar orbit.

DW-2 **Proton Radiation Effect on Barrier Infrared Detector Focal Plane Arrays**

A. Azizi[1]
1. Jet Propulsion Laboratory, USA

This work reports effect of proton radiation on barrier infrared detector. The results indicate that proton radiation causes slow increase in dark current. The radiation effect on quantum efficiency of detector is not conclusive.

DW-3 **Review of TID Effects Reported in ProASIC3 and ProASIC3L FPGAs for 3D PLUS Camera Heads**

A. Bosser[1], P. Kohler[1], J. Salles[1], M. Foucher[1], J. Bezine[1], N. Perrot[1], P. Wang[1]
1. 3D PLUS, France

This paper compares original TID data from ProASIC3L FPGAs with existing literature, discusses the impact of different test flows on the TID response, and correlates the data with TID tests of 3D PLUS camera heads.

DW-4 **Investigation of the Zynq-7000 Integrated XADC Under Proton Irradiation**

J. Budroweit[1], F. Eichstaedt[1], F. Stehle[1]
1. DLR e.V., Germany

This paper presents the investigation of the Xilinx Zynq-7000 system on-chip (SoC) integrated analog to digital converter (XADC) for single event effects (SEE) under proton irradiation.

DW-5 **Investigation of the Xilinx SEM Core on a Zynq-based Software-Defined Radio Under Proton Irradiation**

J. Budroweit[1], F. Stehle[1], F. Eichstaedt[1]
1. DLR e.V., Germany

This paper presents the latest SEE test results of the Xilinx soft error mitigation (SEM) core under proton irradiation on the Zynq-7000 SoC family.

DW-6L **Total Dose and Single-Event Effects Testing of the Intersil ISL73041SEH 12 V Half Bridge GaN FET Driver**

M. Campanella[1], W. Newman[1], N. Van vonno[1], D. Wackley[1], T. Lok[1], L. Pearce[1], E. Thomson[1]
1. Renesas Electronics America, USA

We report the single event effects and low dose rate total ionizing dose test results for the ISL73041SEH radiation hardened PWM input 12 V Half Bridge GaN FET driver.

DW-7 **The Aerospace Corporation's Compendium of Recent Radiation Testing Results**

S. Davis[1], A. Yarbrough[1], R. Koga[1], A. Wright[1], J. Shanney[1], K. Pham[1], C. Cao[1], J. Dixon[1], J. Taggart[1], B. Davis[1], D. Mabry[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-8 **A53 SEE Performance in Raspberry Pi and MX8M**

S. Guertin[1]
1. Jet Propulsion Laboratory, USA

We report SEE performance of A53 processors in Raspberry Pi 3B+ (BCM2837) and MYiRTech MYC-C8MMQ6 (IMX8M). Error correction features and process SEE performance result in significant reduction in SEFI sensitivity

DW-9 **Comparison of Figure of Merit Calculations to On-Orbit Data**

R. Sean[1], C. David[1], B. Vermeire[1], D. Hansen[1]
1. Space Micro, USA

This paper compares upset rates calculated using figure-of-merit methods to on-orbit data in the literature. At GEO, the FOM overestimates the rate except for missions subject to high fluxes of anomalous cosmic rays.

DW-10 **Total Dose Performance at Low Dose Rate of Isolated Switching Regulator Evaluation Kits**

D. Hiemstra[1], S. Shi[2], L. Chen[2]

1. MDA, Canada

2. University of Saskatchewan, Canada

Results of Cobalt-60 low dose rate irradiation of isolated switching regulator evaluation kits are provided. Their performance in the space radiation environment is discussed.

DW-11 **Guide to the 2022 IEEE Radiation Effects Data Workshop Record**

D. Hiemstra[1]

1. MDA, Canada

The 2022 Workshop Record has been, reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

DW-12 **Single-Event Effects Measurements on COTS Electronic Devices for Use on NASA Mars Missions**

F. Irom[1], S. Vartanian[1], G. Allen[1]

1. Jet Propulsion Laboratory, USA

This paper reports recent single-event effects measurements results for a variety of microelectronic devices that include a voltage level translator, bus driver/buffer, DC-DC buck converter, load switch, power protection mux, transceiver, wireless transceiver, and wireless MCU.

DW-13 **NVIDIA Jetson TX2i TID and Proton SEE Testing: Results and a Comparison of Two Proton Beam Facilities**

S. Katz[1], C. Heistand[2], E. Miller[3]

1. Johns Hopkins University Applied Physics Laboratory, USA

2. STOKE Space Technologies Colorado, USA

3. Amazon.com, Inc., USA

Proton SEE test results for similar irradiations of the TX2i by two groups at different facilities show important discrepancies. APL's radiation test results (proton and TID) are presented; discrepancies are explored through particle transport modelling.

DW-14 **Recent Developments to the Texas A&M University Cyclotron Institute Radiation Effects Facility from 2019-2023**

M. Kennas[1], B. Roeder[1], B. Hyman[1], C. Parker[1], G. Tabacaru[1], G. Avila[1], G. Kim[1], H. Clark[1], H. Park[1], V. Horvat[1]

1. Texas A&M University Cyclotron Institute, USA

The Texas A&M University Cyclotron Institute Radiation Effects Facility has recently made facility developments that improved the availability of beam hours to address the growing demand for beam time in the radiation effects testing industry.

DW-15 **Qualification of a New Total Ionizing Dose Facility Using a Hopewell GR420 Irradiator**

S. Khan[1], T. Vigilant[1]

1. Texas Instruments Inc, USA

We report on the qualification of a new Total Ionizing Dose facility using a Hopewell GR420 gamma irradiator with a Cobal-60 source. Device data is correlated to the widely used Gammacell GC220-E

DW-16 **DW-16 Radiation Effects Testing of the Agilex Commercial Off-The-Shelf CMOS Field Programmable Gate Array with Protons**

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

1. The Aerospace Corporation, USA

Observations of proton induced single event effects on the 10 nm Agilex commercial off-the-shelf CMOS FPGA were made at three proton energy levels. The SRAM-based FPGA was sensitive to protons at these energy levels.

DW-17 **High-Energy Atmospheric Neutrons Characterization of Microchip LX4580**

M. Leuenberger[1], R. Stevens[1], S. Spanoche[1], D. Johnson[1]

1. Microchip Technology, USA

The high-energy atmospheric neutron single event effect characterization results of Microchip Technology 24 Channel Data Acquisition System with Synchronized Motor Control Interface IC, the LX4580, are presented.

DW-18 **Characterization of Low Dose Rate Ionizing Radiation Effect on the Micropac 66266-303 Optocoupler**

Y. Liu[1], G. Armstrong[1], B. Campanini[1], S. Messenger[2], J. Rodriguez[2]

1. Micropac Industries Inc, USA

2. Northrop Grumman Corporation, USA

This paper reports low dose rate radiation test results for the Micropac 66266-303 optocoupler and presents LDR effects on the device current transfer ratio. CTR degradations are also compared between 66266 and 66224 optocouplers.

DW-19 **Heavy-ion and proton characterization of AMD 7 nm Versal™ Multicore Scalar Processing System (PS)**

P. Maillard[1], P. Chen[1], J. Arver[1]

1. AMD Inc., USA

This paper presents the heavy-ion and proton single event responses of Xilinx's 7 nm Versal™ multicore scalar processing system (PS) using Xilinx System Validation Tool (SVT) design suite. SEU, SEFI and SEL results are presented.

DW-20 **A Rad-Hard Time-to-Digital Converter ASIC with Sub-10 ps Single-Shot Precision**

B. Van Bockel[1], S. Ali[1], N. Jadhav[1], Y. Cao[1], H. Marien[1]

1. Magics Technologies, Belgium

A rad-hard-by-design time-to-digital converter ASIC with a single-shot precision of sub-10 ps is designed and validated in a standard CMOS technology. The presented electrical characterization and radiation results demonstrate the in-spec performance of the ASIC.

DW-21 **Effects of Neutron Radiation on the Current Transfer Ratio of GaAsP and AlGaAs Optocouplers**

P. Martin Holgado[1], A. Romero Maestre[1], J. De Martin Hernandez[2], J. González Luján[2], M. Dominguez[2], Y. Morilla[1]

1. Centro Nacional de Aceleradores, Spain

2. ALTER TECHNOLOGY TÜV NORD S.A.U., Spain

This work presents the degradation of GaAsP and AlGaAs optocouplers as a result of the 14.5 MeV monoenergetic neutron displacement damage. The exponential degradation of the Current Transfer Ratio parameter is studied.

DW-22 **Consistent and Repeatable Transistor Level TID Transistor Array Measurement**

R. Melendez[1], M. Lenoardo[1], L. Clark[2], C. Youngsciortino[1], S. Guertin[1], J. Yang-scharlotta[1]

1. Jet Propulsion Laboratory, USA

2. Arizona State University, USA

We present 22 nm FDSOI transistor total ionizing dose (TID) induced threshold voltage (Vt) shifts measured on a packaged array test structure. Results demonstrate high current fidelity and Vt vs. dose consistency and repeatability.

DW-23 **SEE Test Results for SRAM and Register File structures compiled on 22 nm FDSOI (22FDX)**

R. Melendez[1], S. Guertin[1], J. Yang-scharlotta[1], L. Clark[2]

1. Jet Propulsion Laboratory, USA

2. Arizona State University, USA

SEE performance of 22 nm FDSOI compiled SRAM and Register File structures presented. SRAM and Register File showed sensitivity to the lowest tested LET (~3 MeV-cm2/mg), and an approximate saturated cross section around 10-10 cm2/bit.

DW-24 **SEU and SEFI Characterization of a Frontgrade QCOTS 512 Gb NAND Flash Nonvolatile Memory for Space Applications**

P. Nelson[1], M. Von thun[1], A. Turnbull[1], T. Meade[1], B. Baranski[1]

1. Frontgrade Technologies, USA

Single Event Upset (SEU) and Single Event Functional Interrupt (SEFI) radiation characterization was performed on a Frontgrade quantified-off-the-shelf (QCOTS) 512 Gb 3D NAND flash memory. The device was shown to be suitable for space applications.

DW-25 **Combined Displacement Damage and LDR Results of the Intersil ISL73141SEH 3.3 V Analog to Digital Converter**

W. Newman[1], N. Van vonno[1], C. Michalski[1], D. Thornberry[1], J. Harris[1], L. Pearce[1]

1. Renesas, USA

We report the combined results of the high-precision, 14-bit, 1 MSPS SAR analog-to-digital converter after exposure to 5 x 1011, 2 x 1012, and 1013 neutrons/cm2 followed by 100 krad(Si) LDR total ionizing dose.

DW-26 **SEE and TID Test Results of Radiation Hardened Superjunction P-channel MOSFETs**

R. Patel[1], O. Mansilla[1]

1. IR HiRel an Infineon Technologies Company, USA

A family of radiation hardened P-channel power MOSFETs is developed that are the first P-channel FETs based on Superjunction technology. This work discusses SEE and TID test results of -60 V, -100 V and -200 V P-channel MOSFETs.

DW-27 **Comparison of MSU and TAMU Heavy Ion Test Results and Evaluation Output Dependencies of SEUs for the LMK04832-SP (5962R1722701VXC) 3.2 GHz JESD204B Clock Jitter Cleaner with 14 Outputs**

K. Kruckmeyer[1], R. Gooty[1], S. Williams[1], V. Vanjari[1], D. Payne[1]

1. Texas Instruments, USA

The LMK04832-SP went through heavy ion testing at MSU and TAMU. SEU results from the two facilities are compared and the impact of a single ion strike on multiple outputs is evaluated.

DW-28 **NASA Goddard Space Flight Center's Current Radiation Effects Test Results**

M. Obryan[1], E. Wilcox[2], M. Joplin[2], T. Carstens[2], J. Barth[2], M. Casey[2], J. Lauenstein[2], M. Campola[2], J. Osheroff[1], E. Wyrwas[1], A. Antonsanti[3], A. Le Roch[4], L. Ryder[2], K. Ryder[2], R. Austin[2], M. Berg[1], P. Majewicz[2], J. Pellish[2]

1. SSAI, Inc., USA

2. NASA Goddard Space Flight Center, USA

3. Southeastern Universities Research Association, USA

4. NASA, Oak Ridge Associated Universities, USA

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

DW-29 **Follow-on Testing of the Xilinx Versal Prime**

H. Quinn[1], C. Corley[2], G. Tompkins[1], P. Thelen[3]

1. Los Alamos National Laboratory, USA

2. University of Texas, USA

3. Sandia National Laboratories, USA

Update results for neutron testing of the 7 nm Xilinx Versal Prime microprocessors are presented. Results show an improvement over the 2021 results.

DW-30 **Irradiation Effects on Power and Timing Characteristics of Commercial 3D NAND Flash Memories**

M. Raquibuzzaman[1], U. Surendranathan[1], M. Buddhanoy[1], B. Ray[1]
1. University of Alabama in Huntsville, USA

We explore TID effects on power and timing characteristics of 3D NAND chip. We observe a significant increase in erase time and active power dissipation during memory operations.

DW-31 **An Examination of the Radiation Sensitivity of Electronic Display Pixel Technologies**

L. Ryder[1], E. Wyrwas[1], G. Cisneros[2], J. Bautista[2], X. Xu[3], M. Campola[1], R. Gaza[2]
1. NASA Goddard Space Flight Center, USA
2. NASA Johnson Space Center, USA
3. NASA Langley Research Center, USA

64 MeV proton irradiation was conducted on pixel technologies that span the range of commercially available electronic displays for crewed missions. Human-centric optical performance metrics are discussed and reported for assessment of pixel radiation susceptibilities.

DW-32 **Proton and Heavy Ion SEE Data on NVIDIA and AMD Graphical Processing Units**

M. Cannon[1], D. Lee[1], W. Evans[1], I. Troxel[2], M. Gruber[2], D. Sabogal[2]
1. Sandia National Laboratories, USA
2. Troxel Aerospace Industries, USA

We present the single-event upset sensitivity and single-event latch-up results from proton and heavy ion testing performed on NVIDIA Xavier NX and AMD Ryzen V1605B GPU devices in both static and dynamic operation.

DW-33 **Accelerated Nuclear Radiation Effects on the Raspberry Pi3B+ and Pi4**

C. Corley[1], H. Quinn[2], E. Swartzlander, Jr.[1]
1. University of Texas, USA
2. Los Alamos National Laboratory, USA

Raspberry Pis running Linux and embedded benchmarks were subjected to radiation testing in the neutron beam at LANSCE. ARM A53 versus A72, single-core versus multi-core, and small versus large array SEE cross sections are compared.

DW-34 **DW-34 Single Event Effects and TID Characterization of the Frontgrade Technologies UT24C407 CertusTM-NX-RT FPGA for Space Applications**

M. Von Thun[1], B. Baranski[1], A. Turnbull[1]
1. Frontgrade Technologies, USA

Single Event Effects (SEE) and Total Ionizing Dose (TID) radiation characterization was performed the Frontgrade Technologies UT24C407 CertusTM-NX-RT FPGA. The device was shown to be suitable for space applications.

DW-35 **SEE and TID Characterization of the Frontgrade Technologies 1 Gb NOR Flash Nonvolatile Memory**

M. Von Thun, D. Bass[1], S. Ashenafi[1], G. Hoglund[1], A. Turnbul[1]
1. Frontgrade Technologies, USA

A Frontgrade Technologies SONOS based 1 Gb NOR Flash non-volatile memory has been designed, manufactured, and characterized for radiation effects. Heavy Ion single event effects data covering SEL, SEGR, SEU, SET and SEFI will be presented.

DW-36 **Single-Event Effects Response of 96- and 176-Layer 3D NAND Flash Memories**

E. Wilcox[1], M. Joplin[1], M. Berg[2]
1. NASA Goddard Space Flight Center, USA
2. SSAI, Inc., USA

Single-event effects testing (heavy-ion and proton) is presented for 96- and 176-layer commercially available 3D NAND flash memory, with emphasis on SEFI detection and recovery.

DW-37 **Total Ionizing Dose and Proton Single Event Effects in AMD Ryzen Processor Fabricated in a 12 nm Bulk FinFET Process**

J. Taggart[1], S. Davis[1], R. Daniel[1], B. Foran[1], D. Bohra[1], A. Hall[1], A. Wright[1]
1. The Aerospace Corporation, USA

AMD Ryzen 3200G were tested for TID and SEE effects using Cobalt-60 and 200 MeV protons. The integrated GPU experienced TID effects prior to the CPU and SEFIs were observed during proton testing.

DW-38 **Single Event Effects Results for COTS Microcontrollers and Microprocessors**

S. Vartanian[1], G. Allen[1], F. Irom[1], A. Daniel[1], S. Zajac[1]
1. Jet Propulsion Laboratory, USA

We present single event effects results for a variety of microcontrollers and microprocessors. The devices tested include Blackfin embedded processors from Analog Devices, automotive-grade TI and Infineon microcontrollers with multiple safety features, and the MSP430FR4994.

4:30 PM END OF THURSDAY SESSIONS

4:45 PM - 7:00 PM
EXHIBIT HALL B

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

EXHIBIT HALL B
INVITED TALK
8:30 - 9:30 AM

Kansas City National Security Campus Through the Decades

John Jungk, Ph.D., Chief Technology Officer, Honeywell Federal Manufacturing & Technologies, Kansas City, Missouri

The Kansas City National Security Campus (KCNSC) is a multi-mission engineering and manufacturing enterprise delivering trusted national security products and government services, producing 80% of the country's non-nuclear components. This presentation will provide a stroll through the history of the KCNSC, from its inception as the Kansas City Plant (KCP), including some pre-history of the campus in the 1920s, through the transition from the KCP to the current KCNSC in the 2010s. We'll also look briefly at the core missions served by the talented people at KCNSC, how our core capabilities have evolved and changed over time, and how KCNSC fits within the Department of Energy / National Nuclear Security Administration and the broader Nuclear Security Enterprise.

Dr. Jungk is the Chief Technology Officer at Honeywell Federal Manufacturing & Technologies (FM&T), which manages and operates the Department of Energy's KCNSC. With more than 6,000 employees in Kansas City and Albuquerque, the KCNSC provides diverse engineering, manufacturing and secure sourcing services for national security.

In his role, John is responsible for developing technology initiatives and providing direction in technology-related issues in support of the company's goals and strategies. To drive that effort, he ensures that technology roadmaps are aligned with business strategy to efficiently and intentionally integrate science-based technologies into products and services. John is also responsible for engaging with customers, partners, commercial industry, and academic institutions to develop collaborations for mutual benefit. Finally, he directs and manages the leaders in the Centers of Excellence organization (which has responsibility for developing the strategies to advance and deploy the technologies necessary to achieve the site's strategic goals), Advanced and Exploratory Systems Engineering, the Materials Engineering organization, and the Global Security Engineering organization.

John has authored/coauthored more than 18 peer reviewed journal articles and conference proceedings and is an Adjunct Professor at Missouri University of Science and Technology. He has a B.S. in Materials Science and Engineering from Washington State University, a Ph.D. in Materials Science and Engineering from the University of Minnesota, an MBA from Rockhurst University, and has more than 23 years of experience supporting of national security and defense research and development.

Honeywell Federal Manufacturing & Technologies, LLC operates the Kansas City National Security Campus for the United States Department of Energy / National Nuclear Security Administration under Contract Number DE-NA0002839.

EXHIBIT HALL B

SESSION H **HARDENING BY DESIGN**

9:30 AM SESSION INTRODUCTION

Chair: Yanran Chen, AMD, Inc.

H-1 9:35 AM **Estimation of Single-Event Upset and Performance using Back-Gate Bias in a 0.18 µm DSOI SRAM**

Y. Wang[1], S. Chen[1], F. Liu[1], B. Li[1], J. Gao[1], J. Li[1], C. Wang[1], L. Wang[1], P. Cui[1], S. Ma[1], Y. Liao[1], T. Wang[2], J. Liu[2], P. Zhao[3], J. Liu[3], C. Huang[4], Z. Han[1], T. Ye[1]

1. Institute of Microelectronics, Chinese Academy of Sciences, China

2. Space Environment Simulation Research Infrastructure (SESRI), Harbin Institute of Technology, China

3. Institute of Modern Physics, Chinese Academy of Sciences, China

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

By adjusting back-gate bias, 6T SRAM circuit has been experimentally demonstrated with extreme tolerance to SEU. A back-gate biasing strategy is proposed in DSOI SRAM circuits which significantly lowers SEU and power without performance loss.

H-2 9:50 AM **The Effect of Error Amplifiers on Analog Single-Event Transient in Two Low-Dropout Regulators on a 28 nm CMOS Technology**

F. Shen[1], J. Chen[1], B. Liang[1], Y. Chi[1], Y. Wen[1], and X. Wang[2]

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

2. College of Civil Engineering, Tongji University, China

SET sensitivity of two 28 nm CMOS low drop-out regulators with different error amplifier were studied by experiments and simulations. The regulator with rail-to-rail error amplifier has much worse response to SET.

POSTER PAPERS

PH-1

Fault-tolerant Convolutional Neural Networks with Reconfigurable Processing Element Arrays

C. Jin[1], Y. Ibrahim[1], H. Tian[1], S. Ko[1], L. Chen[1]

1. University of Saskatchewan, Canada

This paper adopts multiple processing arrays with dynamic partial reconfiguration for radiation tolerance CNNs in FPGA. Fault injection and laser experiments show that critical error rate reduces by 25x, while overall accuracy remains 99%.

PH-2

In-Situ Single-Event Effects Detection in 22 nm FDSOI Flip-Flops

K. Appels[1], R. Weigand[2], W. Dehaene[1], J. Prinzie[1]

1. KU Leuven, Belgium

2. European Space Agency, Netherlands

A novel Single-Event Effects in-situ error detection methodology for high-speed radiation tolerant integrated circuits. Two error detection flip-flops implemented in a 22 nm Silicon-on-Insulator technology are presented, compared and experimentally verified with two-photon absorption injection.

PH-3 **A Radiation-Hardened Optical Transceiver in 180 nm CMOS Technology**

Y. Luo[1], C. Hong[1], A. Anderson[1], D. Dolt[1], S. Palermo[1]
1. Texas A&M University, USA

This paper presents the design and characterization of a radiation-hardened, VCSEL-based optical transceiver operating at 0.5 Gb/s and transmitter at 2 Gb/s. Single-event effect (SEE) and Total ionizing dose (TID) have been verified for the circuit operation.

EXHIBIT HALL B

SINGLE-EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS

SESSION I

10:05 AM SESSION INTRODUCTION

Chair: Francoise Bezerra, CNES

I-1 10:10 AM **Single-Event Effects in Neutron-Irradiated High-Temperature DC Superconducting Quantum Interference Devices**

E. Auden[1], S. Wender[1], K. Gunthoti[1], P. Rech[2]
1. Los Alamos National Laboratory, USA
2. University of Trento, Italy

We present the first neutron-induced single-event effect experiment on a superconducting quantum interference device (SQUID). The measured neutron-induced electrical transients in SQUIDs provide insight to coherence loss in superconducting qubits exposed to ionizing radiation.

I-2 10:25 AM **LET and Voltage Dependence of Single-Event Burnout and Single-Event Leakage Current in High-Voltage SiC Power Devices**

A. Sengupta[1], D. Bal[1], S. Islam[1], A. Senarath[1], A. Witulski[1], R. Schrimpf[1], K. Galloway[1], E. Zhang[1], M. Alles[1], R. Reed[1], M. Mccurdy[1], J. Osheroff[2], B. Jacob[3], C. Hitchcock[3], S. Goswami[3], J. Hutson[4]
1. Vanderbilt University, USA
2. NASA Goddard Space Flight Center, USA
3. General Electric Global Research, USA
4. Lipscomb University, USA

Heavy-ion single-event burnout and leakage behavior of 1.2 kV and 3.3 kV silicon carbide power devices are analyzed based on radiation tests. The voltage capability of these devices affects the burnout and leakage thresholds differently.

10:40 AM – 11:10 AM PRE-FUNCTION BREAK

I-3 11:10 AM **Effects of Collector Profile on the SET Response of 130-nm High-Speed and High-Breakdown SiGe HBTs**

Z. Brumbach[1], D. Nergui[1], J. Teng[1], Y. Mensah[1], D. Sam[1], A. Ildefonso[2], A. Khachatrian[2], D. Mcmorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. U.S. Naval Research Laboratory, USA

SET responses of high-speed and high-breakdown SiGe HBT variants in the same technology platform were compared using laser pulses. The lower-performance, high-breakdown SiGe HBT showed a larger transient response, which is investigated using TCAD.

I-4 11:25 AM **Comparing Digital Modulation Schemes in RF Receivers for Bit Errors Induced by Single-Event Transients in the Low Noise Amplifier**

D. Nergui[1], J. Teng[1], Z. Brumbach[1], A. Ildefonso[2], A. Khachatrian[2], D. McMorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. U.S. Naval Research Laboratory, USA

Standard digital modulation schemes are compared for receiver-level SEU sensitivity using pulsed laser. Frequency shift keying demonstrated a better SEU resilience than phase shift keying despite having a worse baseline (no SET) noise performance.

I-5 11:40 AM **SET-Induced Drop-out and Recovery of Cross-Coupled and Differential-Colpitts Microwave Oscillators Using SiGe HBTs**

J. Teng[1], Y. Mensah[1], Z. Brumbach[1], A. Ildefonso[2], A. Khachatrian[2], D. McMorrow[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. U.S. Naval Research Laboratory, USA

SET responses of cross-coupled and Colpitts LC oscillators are compared using laser-induced TPA and circuit simulations. The Colpitts oscillator demonstrated smaller amplitude disturbances and faster recovery time following SET-induced drop-out.

I-6 11:55 AM **SEU Cross-Sections at High Frequencies for RHBD Flip Flop Designs at the 5-nm Bulk FinFET Node**

Y. Xiong1, N. Pieper1, Y. Qian1, S. Wodzro1, B. Narasimham2, R. Fung3, S. Wen3, B. Bhuva1

1. Vanderbilt University, USA

2. Broadcom, USA

3. Cisco Systems Inc., USA

Single-event upset cross-section trends for high frequency operation of RHBD FF designs are evaluated at the 5-nm bulk FinFET node. Results show reduced RHBD efficacy at the GHz range of frequencies.

POSTER PAPERS

PI-1 Synergism between Stress and Cosmic Ray Neutron Irradiation in 650 V Rated IGBTs for Automotive Applications

D. Bae1, S. Khan2, K. Kim1, S. Chung3, J. Kih1, S. Woo1, C. Cho1, J. Kim1, S. Yoon1, S. Wender4, Y. Kim1

1. QRT, Republic of Korea

2. QRT, Pakistan

3. QRT, USA

4. Los Alamos National Laboratory, USA

This paper investigates the potential synergism between various stress conditions (temperature, humidity, and bias) and cosmic ray neutron irradiation and its impact on single event burnout (SEB) endurance of insulate-gate bipolar-transistor (IGBT) in terrestrial environment.

PI-2 Reliability Evaluation of Convolutional Neural Network's Basic Operations on a RISC-V Processor

F. Santos[1], O. Sentieys[1], A. Kritikakou[1]

1. INRIA, France

We evaluate the neutron-induced error rate of Convolutional Neural Network basic operations on a RISC-V processor. Although executing the algorithm in parallel increases performance, memory errors are the major contributors to the device error rate.

PI-3 Impact of High-Level-Synthesis on Reliability of Neural Network Hardware Accelerators

M. Traiola[1], F. Fernandes dos santos[1], O. Sentieys[1], A. Kritikakou[1]

1. INRIA / IRISA, France

We characterize the impact of High-Level Synthesis (HLS) on the reliability of Neural Networks on FPGAs exposed to neutron. Our results show that the larger the circuit generated by HLS, the larger the error rate.

PI-4 Tensor Processing Unit Reliability Dependence on Temperature and Radiation Source

P. Bodmann[1], P. Rech[2]

1. UFRGS, Brazil

2. University of Trento, Italy

We compare high-energy neutrons and heavy ion cross-sections of Coral TPU, considering different temperatures. The TPU's cross-section for heavy ions is ~ 20x higher than for neutrons and higher temperatures reduce the neutron-induced error rate.

PI-5 Telemetry-Based Analysis of Single-Event-Induced Failures in Unmanned Aerial Vehicles

S. Wang1, D. Goloubev2, S. Wen3, C. Cazzaniga4, C. Frost4, B. Bhuva1

1. Vanderbilt University, USA

2. Cisco Systems Inc., Belgium

3. Cisco Systems Inc., USA

4. Science & Technology Facilities Council, United Kingdom

Telemetry-based data collection and analysis is used to characterize single-event effects for commercially-available drones for terrestrial-neutron beam. FIT rates for different failure mechanisms show very high vulnerability.

PI-6 Temperature Dependence of Single-Event Upsets and Multi-Cell Upsets in 5-nm FinFET SRAMs

N. Pieper[1], Y. Xiong[1], D. Ball[1], R. Fung[2], S. Wen[2], J. Pasternak[3], B. Bhuva[1]

1. Vanderbilt University, USA

2. Cisco Systems, Inc., USA

3. Synopsys, Inc., USA

Single-event upset cross-sections are investigated for SRAM cells as a function of temperature for nominal and reduced supply voltages. Experiments show SEU cross-section and MCU rates decrease with increasing temperature.

12:10 PM TO 12:15 PM CONFERENCE CLOSING

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.

Robert Reed
Chair

The Committee aids in promoting close cooperation and the exchange of technical information among its members. This is done 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, 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). The NSREC is an international forum for presentation of research papers on nuclear and space radiation effects. This includes 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. Papers presented at the NSREC are submitted for possible publication in the January issue of the IEEE Transactions on Nuclear Science.

Kay Chesnut,
Raytheon Technologies
Executive Vice-Chair

NSREC 2023 will be held in Kansas City, Missouri, July 24-28, 2023, at the Sheraton Kansas City Hotel at Crown Center. Keith Avery, Air Force Research Laboratory is the Conference Chair. Supporters of the 2023 NSREC include Analog Devices, Boeing, EMPC, EPC Space, Frontgrade, Honeywell, IR HiRel Products (an Infineon Technologies Company), Jet Propulsion Laboratory, L3Harris Technologies, Radiation Test Solutions, Renesas, Skywater Technology, Southwest Research Institute, and The Aerospace Corporation. We thank our supporters for their significant and continuing commitments to the conference and welcome other organizations to consider becoming supporters of the IEEE NSREC.

NSREC 2024 will be held in Ottawa, Ontario, Canada, July 24-28, 2024, at the Shaw Center. Heather Quinn, Los Alamos National Laboratory, is the Conference Chair. Dolores Black, Sandia National Laboratories, is the Conference Chair for NSREC 2025 in Nashville, Tennessee. Philippe Paillet was selected as the 2026 NSREC Conference Chair.

Papers presented at the 2023 NSREC are eligible for publication in the January 2024 issue of the IEEE Transactions on Nuclear Science. Authors must upload their papers prior to the conference for consideration for publication in the January 2024 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.

EDITORS
Dan Fleetwood
Vice-Chair of Publications

All papers accepted for oral or poster presentation in the technical program will be eligible for publication in a special issue of the *IEEE Transactions on Nuclear Science* (January 2024), based on a separate submission of a complete paper. Each paper will be subject to the standard full peer review given all papers submitted to the *IEEE Transactions on Nuclear Science*. All papers must be submitted on IEEE ScholarOne. Instructions for submitting papers can be found at the Conference web site ***www.nsrec.com.*** The deadline for submission of papers is July 21, 2023. Data Workshop papers are published in a Workshop Record and are not candidates for publication in the *IEEE Transactions on Nuclear Science.* The process for the Workshop Record is managed by the Workshop Chair.

The review process for papers submitted to the *Transactions* 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 *Transactions* 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 special issue of the *Transactions* or for radiation effects papers submitted throughout the year, please contact one of the editors. The editors for the 2023 NSREC are:

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

Heather Quinn, Associate Editor, Los Alamos National Laboratory
Email: hquinn@lanl.gov

William Robinson, Associate Editor, Georgia Tech Research Institute
Email: William.Robinson@gtri.gatech.edu

Steven Moss, Associate Editor, The Aerospace Corporation, retired
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Federico Faccio, Associate Editor, CERN
Email: Federico.Faccio@cern.ch

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, the IEEE NSREC and Short Course!

NPSS membership is $35. NPSS members receive a free subscription to NPSS News, and free on-line electronic access via IEEE Xplore to the IEEE Transactions on Nuclear Science (TNS) and the NSREC Data Workshop Record. Now members can search and view digital copies of all IEEE TNS papers on-line all the way back to the first IEEE NSREC in 1964. NPSS members get to vote in our NSREC elections, held at the annual open meeting held during the conference. What are you waiting for? 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 review before they are accepted for the January 2024 issue.
- ***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 2023 *IEEE Radiation Effects Data Workshop Record* and the January 2023 special NSREC issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee if the attendee registered to be listed on the attendee list.

RADITION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 27, 4:45 – 6:30 All conference attendees are encouraged to attend.

THURSDAY, JULY 27 4:45 PM – 6:30 PM

During the meeting we will discuss the 2023 conference and future IEEE Nuclear and Space Radiation Effects Conferences. A report on the nomination processes for the 2023 Junior Member-at-Large on the Radiation Effect Steering Group and the 2024 nominating committee will be presented. Voting instructions for IEEE NPSS members will be provided.

2022 OUTSTANDING PAPER AWARD

Radiation-Induced Faults Propagation in Quantum Bits and Quantum Circuits
D. Oliveira, E. Auden, and P. Rech

2022 MERITORIOUS PAPER AWARD

Fragmented High-Energy Heavy Ion Beams for Electronics Testing
R. Garcia Alia, K. Bilko, F. Cerutti, A. Coronetti, L. Esposito, S. Francesc, W. Andreas, F. Saigne

Awards

2022 OUTSTANDING STUDENT PAPER AWARD

Scaling Trends for Single-Event Cross-Section for Conventional D-FF at Bulk FinFET Technology Nodes

Y. Xiong, N. Pieper, A. Feeley, B. Narasimham, D. Ball, B. Bhuva

2022 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

A Heavy-Ion Single-Event Effects Test Facility at Michigan State University

S. Lidia, T. Glasmacher, S. Kim, G. Machicoane, P. Ostroumov, A. Stolz

2023 RADIATION EFFECTS AWARDS

The winners of the 2023 Radiation Effects and Radiation Effects Early Achievement Awards will be announced Tuesday, July 25 at the 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 early in his or her career whose technical contributions and leadership have had a significant impact on the field of radiation effects.

2024 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2024 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 2024 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.

Cash awards and plaques will be presented at the NSREC in Ottowa, Ontario, Canada in July 2024. 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 Michael Tostanoski, Member-at-Large, Radiation Test Solutions, at ***mtostanoski@radiationtestsolutions.com***

Conference Information

CONFERENCE LOCATION

NSREC 2023 will be held in **Kansas City, Missouri.** Barbecue, fountains, and jazz define Kansas City—and have since the city's original renaissance in the early 1920s. Those traditions are as strong now as they've ever been thanks to free-flowing sauce, fountains, and musical notes, each a testament to the city's culture, history, and heart.

Photo courtesy of Sheraton Crown Center

With its heritage in KC's African American community, jazz first flourished in the 1920s and '30s on 12th & Vine and in what is now the 18th & Vine Historic Jazz District.

Today, those roots still run deep—the genre is as vibrant as ever, fueling more than 40 jazz and fine-dining venues every night of the week, including local icons the **Mutual Musicians Foundation, The Blue Room, The Phoenix** and the **Green Lady Lounge.**

Kansas City's barbecue craze can be traced back to Henry Perry, who in the early 1920s started barbecuing in an outdoor pit adjacent to his streetcar barn, serving slabs of food wrapped in newspaper.

His moment became a movement. Now, more than 100 different metro restaurants smoke everything from pork, beef, and chicken to jackfruit, mushrooms, and fish. There's even the KC BBQ Experience, and an entire mobile app dedicated to exploring the culinary scene. ***https://www.visitkc.com/bbq/app***

Kansas City is home to more than 200 fountains—more than any other city in the world except Rome. From large and majestic to small and whimsical, discover waterworks dedicated to fallen firefighters, the city's children, women's leadership, and more.

The city's bubbly love affair began with a rather practical purpose; the Humane Society built the city's first fountains as water troughs for horses in the late 1800s. Now cherished works of public art, the fountains have become an attraction unto themselves—and a quintessential component of KC culture, found everywhere from Crown Center and Union Station to the Country Club Plaza.

The location for NSREC 2023 will be the **Sheraton Kansas City Hotel at Crown Center** in the Crown Center complex in Kansas City, Missouri.

Sheraton Kansas City Hotel at Crown Center, 2345 McGee Street, Kansas City, Missouri, USA. Website: ***https://www.marriott.com/en-us/hotels/mcicr-sheraton-kansas-city-hotel-at-crown-center/overview/***

The **Sheraton Kansas City** will also be the Host Hotel, accommodating all of NSREC 2023's guests in comfort and style.

Conference Information

BREAKFASTS, LUNCHES AND BREAKS

The 2023 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 breakfast and lunch on Tuesday, July 25th & Wednesday, July 26th, in **Exhibit Hall A.** There will also be an Exhibitor Reception in the evening on Tuesday, July 25th. *Breakfasts and lunches are for NSREC attendees and Exhibitor Booth Staff only.* ***The Exhibitor reception is open to all NSREC attendees and their guests.***

BUSINESS CENTER

The Sheraton Kansas City at Crown Center has a small business center on-site with limited printing capabilities. If you require color printing or multiple copies, we recommend using the local FedEx Office located at 1111 Main St Suite 111 Kansas City, Missouri 64105

ROOMS FOR SIDE MEETINGS

A few "side meeting rooms" are available for use by any registered conference attendee at the Sheraton Crown 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 in Van Horn A-C room in the Convention Center.

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.

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

NSREC encourages Pre-Registration and offers a lower registration rate, "Early Registration," if the payment is received no later than Friday, June 30. 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.

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.

John Teehan
IEEE Registration Services

ON-SITE REGISTRATION LOCATION & TIMES IN KANSAS CITY

All conference registration will occur in the Sheraton Kansas City Hotel at Crown Center. If you *have not yet registered,* go to "On-Site Registration" in Van Horn A-C. If you *have already registered,* go to "Pre-Registration" in the Terrace on the second floor.

Registration hours are:

Sunday, July 23	**5:00 PM – 8:00 PM**
Monday, July 24	**7:30 AM – 5:00 PM**
Tuesday, July 25	**7:30 AM – 5:00 PM**
Wednesday, July 26	**7:30 AM – 3:00 PM**
Thursday, July 27	**7:30 AM – 3:00 PM**
Friday, July 28	**7:30 AM – 10:00 AM**

CONFERENCE CANCELLATION POLICY

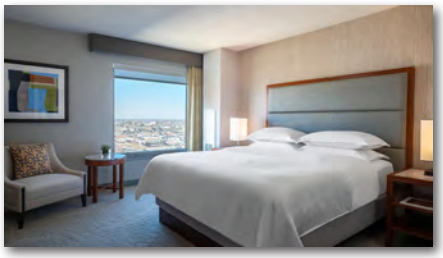
A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 17, 2023, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify NSREC at ***NSRECreg@ieee.org***

Registration and Travel

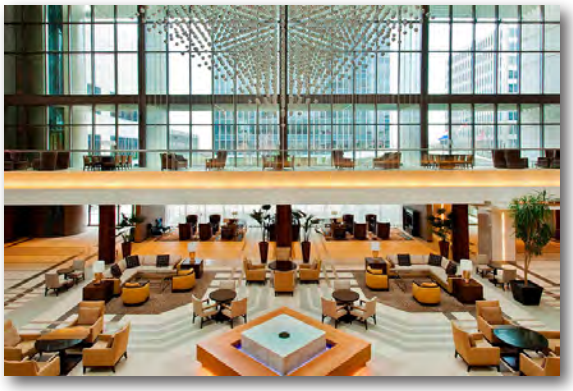
HOTEL ACCOMMODATIONS:

Sheraton Kansas City Hotel at Crown Center
2345 McGee Street
Kansas City, Missouri, USA

Accommodations for the 2023 IEEE NSREC are available at the **Sheraton Kansas City Hotel at Crown Center**



Live like a Kansas City local at Sheraton Kansas City Hotel at Crown Center. With a central downtown location near the Crown Center, travelers are welcomed with sophisticated hotel accommodations. Relax effortlessly in contemporary rooms and suites smartly accessorized with Sheraton Signature beds, flat-screen TVs, large work areas and high-speed Wi-Fi. Indulge in classic American favorites at our hotel restaurant. Enjoy a direct connection to the shops, restaurants and entertainment of Crown Center and to Kansas City's historic Union Station. Explore popular attractions including Country Club Plaza, Legoland, the Convention Center and the vibrant Power & Light District. Get your heart pumping at the contemporary fitness center or make a splash in our outdoor pool. Discover a stylish haven amid some of the Kansas City's most famous attractions at Crown Center.



Photos courtesy of Sheraton Crown Center

Sheraton Kansas City room rates for a standard king or double-Queens are:

NEGOTIATED GROUP RATE:	GOVERNMENT PER DIEM:
$175.00 single/double per night	**$124.00 single/double* per night**

*For the government rate, guests must provide current government or military ID at check-in.

Room taxes currently at 18.1% will be added to all rates listed above.

NSREC 2023 hotel rates are available three days before and after the conference, based on availability.

Registration and Travel

HOTEL RESERVATIONS

Photo courtesy of Sheraton Crown Center

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

Sheraton Kansas City Crown Center – Group rate
https://www.marriott.com/event-reservations/reservation-link.mi?id=1673022800575&key=GRP&app=resvlink

Sheraton Kansas City Crown Center – Government rate:
https://www.marriott.com/event-reservations/reservation-link.mi?id=1673023058993&key=GRP&app=resvlink

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 Central Daylight Time (CDT) on **June 30, 2023**. 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 aware that for NSREC 2023 the Cancellation Policy at the Sheraton Kansas City Hotel at Crown Center is as follows:

* Up to 48 hours prior to check-in - No fee/charge/penalty
* within 48 hours - One night's room charge cancellation fee
* Early Departure - $75 early departure fee

Cancellations should be made directly with the Sheraton Kansas City Hotel at Crown Center. For further information or additional questions, please contact the Sheraton Kansas City Directly at +1 (816) 841-1000.

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.

AIRPORT AND TRANSPORTATION INFORMATION

Kansas City International Airport (code: **MCI**) is located approximately 35 miles from the Sheraton Kansas City at Crown Center. Traveling outside of normal commuting hours, the drive typically takes between 30-40 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 there are other options.

1) Taxi Service is available at the Kansas City International Airport. Courtesy phones for taxi service are located both inside and outside the terminal at each bag claim area and at other strategic locations outside the terminal exits. Make sure that you give the dispatcher your exact location.

   Fares may be pro-rated (shared) when the originating passenger requests it and all other passengers agree.

   Rates are $2.50 plus $2.10 per mile. Rates may vary due to traffic delays and waiting time.

2) There is a Super Shuttle Express service from the Kansas City International Airport to Downtown Kansas City. Details can be found on the Super Shuttle website: ***https://www.supershuttle.com/locations/kansascity-mci/***

3) Uber Website: ***https://www.uber.com/*** - costs around $30, depending on current driver availability and conditions

4) Lyft Website: ***https://www.lyft.com/*** - costs around $30, depending on current driver availability and conditions

PARKING AND DRIVING DIRECTIONS

On-Site Parking: Daily: $25

Valet: Daily: $35

Kansas City International Airport to the Sheraton Kansas City Crown Center:

- Get on I-29 S/US-71 S in May Township from NW 120th St
- Use the left lane to merge onto NW 120th St
- Turn left onto L P Cookingham Dr
- Turn left onto NW 120th St
- Follow I-29 S to E 22nd St in Kaw Township. Take the 22nd St exit from U. S. Hwy 71 S
- Merge onto I-29 S/US-71 S
- Merge onto I-29 S/I-35 S/US-71 S
- Keep left to continue on U. S. Hwy 71
- Merge onto I-70 E/U. S. Hwy 71 S
- Use the middle 2 lanes to keep right at the fork and continue on U. S. Hwy 71 S
- Take the 22nd St exit toward The Paseo
- Continue on E 22nd St. Drive to McGee St
- Merge onto E 22nd St
- Turn left onto McGee St
- Destination will be on the left

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. Kansas City offers a FREE Streetcar service that runs throughout downtown Kansas City. Details and Streetcar routes can be found here ***https://kcstreetcar.org/***.

TIPS WHEN VISITING KANSAS CITY

Fun in the sun: On average, there may be only about 5 cloudy days in the entire month of July, so consider taking a hat, sunscreen, and sunglasses on any excursions.

Weather: July is a hot summer month in Kansas City, Missouri, with an average temperature fluctuating between 72°F (22.2°C) and 90.1°F (32.3°C).

Driving: Be patient in traffic and mindful of pedestrians. Obey all traffic rules and be alert, whether driving or walking. It is easy to navigate in the downtown Kansas City Area, but be mindful of the pedestrian traffic.

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

Ken LaBel
Industrial Exhibits Chair
SSAI, Inc./NASA Goddard
Space Flight Ctr

The **2023 NSREC Industrial Exhibits** will feature the leading worldwide suppliers of radiation hardened products, related materials, services, and research and development. This will be an excellent opportunity for key suppliers, technical engineers and managers to meet and discuss the needs and solutions for electronics used in space vehicles, military electronics, and applications requiring radiation tolerance in harsh environments.

The 2023 NSREC Industrial Exhibits will be held in Exhibit Hall A on Tuesday and Wednesday. Breakfast and conference breaks will be in the Exhibit Area on Tuesday and Wednesday, with an Exhibitor Lunch to be held on Tuesday and Wednesday. Breakfasts and lunches are for registered attendees only. NSREC badges must be worn at all times.

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

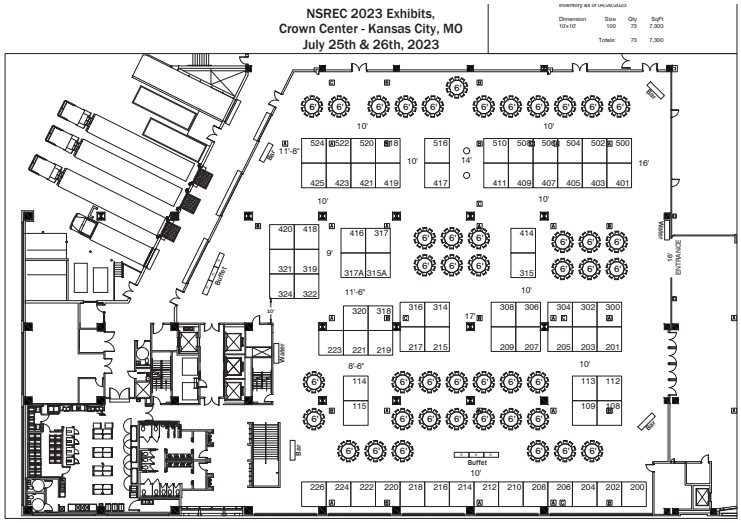
NOTE: Children under 16 must be accompanied by an adult in the Exhibit Area.

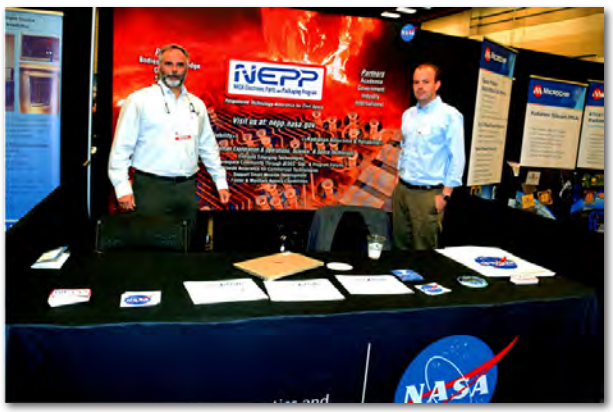
For more information, or to get on the waiting list for a booth, contact:

Ken LaBel
SSAI in support of NASA/GSFC

Phone: 1-240-988-3646
Email: kenneth.a.label@nasa.gov

Or visit the 2023 NSREC Industrial Exhibits web site:
https://www.nsrec.com/industrial-exhibits-2023/





Industrial Exhibits

Please check our web site (***www.nsrec.com***) for a current listing of companies exhibiting at 2023 NSREC.

NSREC
INDUSTRIAL EXHIBITS

CROWN CENTER

EXHIBIT HALL A

EXHIBIT HALL HOURS

TUESDAY, JULY 25

7:00 AM – 4:30 PM
10:15 AM - 10:45 AM
MORNING BREAK

11:50 AM - 1:15 PM
LUNCH

2:50 PM - 3:20 PM
AFTERNOON BREAK

5:30 PM – 7:30 PM
RECEPTION

WEDNESDAY, JULY 26

7:00 AM – 1:30 PM
10:20 AM - 11:00 AM
MORNING BREAK

11:50 AM - 1:30 PM
LUNCH

1:00 PM RAFFLES

(All of the exhibit events are for Registered Attendees; the Exhibit Reception is for Registered Attendees and Guests)

EXHIBITORS

Organization	Internet Site	Booth
3D PLUS USA, INC.	3d-plus.com	217
88-Inch Cyclotron	https://cyclotron.lbl.gov/	506
Air Force Research Laboratory – Space Vehicles Directorate	afrl.af.mil/RV/	420
Alphacore Inc.	alphacoreinc.com/en	114
ALTER Technology	altertechnology-group.com/en/home/	321
AMD	https://www.xilinx.com/	222
Analog Devices, Inc.	analog.com	308
Apogee Semiconductor	apogeesemi.com/	209
Avalanche Technology	https://www.avalanche-technology.com/	224
Boeing	boeing.com/	411
Boeing LMTF	N/A	302
Brookhaven National Laboratory	bnl.gov/nsrl/	504
Checkpoint Technologies	checkpointtechnologies.com/	207
Crane Aerospace & Electronics	craneae.com	210
Crocker Nuclear Lab/UC Davis	cyclotron.crocker.ucdavis.edu/	522
Cyclo Technologies	cyclotechnologies.com/	319
Defense Microelectronics Activity (DMEA)	dmea.osd.mil	508
Electro Magnetic Applications, Inc. (EMA)	ema3d.com/	206
EMPC	empc.com	304
EPC Space	epc.space/	314
FASTRAD®	fastrad.net	520
Fifth Gait Technologies	5thgait.com/	500
Flex Logix Technologies, Inc.	flex-logix.com	216
Foss Therapy Services, Inc.	fosstherapyservices.net/	510
FRIB Single Event Effects Facility	frib.msu.edu/fsee	418
Frontgrade (formerly CAES Space Systems Division)	frontgrade.com	516/417
Honeywell International	honeywellmicroelectronics.com	524
IEEE Future Direction IEEE Low-Earth-Orbit (LEO) Satellites & Systems	cmte.ieee.org/futuredirections /projects/leo-satellites-systems/	220
imec	imeciclink.com	115
IR HiRel, an Infineon Technologies company	infineon.com/hirel	401/403
ISOCOM Limited	http://isocom.com/	306
Jeffrey Titus (Consultant)	jlt-rad-test.com	200
JL Shepherd and Associates	http://jlshepherd.com/	226
Magics Technologies NV	magics.tech	425
McLaren Proton Therapy Center	mclaren.org/main/proton-therapy-center	315A
Microchip Technology Inc.	microchip.com/	421/423
Micropac	micropac.com	214
Micross Components	micross.com	320
MIT Lincoln Laboratory	https://www.ll.mit.edu/	223
NASA NEPP Program	nepp.nasa.gov/	315
Power Device Corporation / DDC	www.powerdevicecorp.com	502
ProNova Solutions	ProNovaRadEffects.com	324
PULSCAN	pulscan.com/	409
QuickLogic Corporation	quicklogic.com/	204
Radiation Test Solutions, Inc.	radiationtestsolutions.com	201/203
RADNEXT & PAC-G	radnext.web.cern.ch/	316
Renesas	renesas.com/us/en/products/ space-harsh-environment	112/113
Robust Chip	robustchip.com	205
Sandia National Laboratories	sandia.gov	300
SkyWater Technology	skywatertechnology.com	215
Spirit Electronics	https://www.spiritelectronics.com/	108
STMicroelectronics, Inc.	st.com	317/416
Synopsys, Inc.	https://www.synopsys.com/	109
Teledyne Brown Engineering	www.tbe.com	317A
Texas A&M University Cyclotron Institute	cyclotron.tamu.edu	518
Texas Instruments	ti.com/Space	221/219
Triad Semiconductor Inc	triadsemi.com	212
Trusted Semiconductor Solutions	trustedsemi.com	208
TTM Technologies, Inc.	www.ttm.com	322
UNITES Systems a.s.	unites-systems.com	318
Vanderbilt University (ISDE)	http://www.isde.vanderbilt.edu/	202
Vicor	www.vicorpower.com/	419
VORAGO Technologies	voragotech.com	218
VPT, Inc	www.vptpower.com/	405/407
Zero-Error Systems (ZES) Pte Ltd	zero-errorsystems.com/	414

Social Program

"Welcome to NSREC 2023 in Kansas City, Missouri. We look forward to hosting the conference in the City of Fountains, the Jazz Capital of the World, Cowtown, and the BBQ Capital of the World – all in one place. Sheraton Kansas City at Crown Center and the Crown Center Exhibit Hall will be the home of the technical program. Crown Center is a hub of activity with easy access to dining, shopping, and family-friendly activities. Please take time to enjoy the wide range of activities offered in and around this Midwestern city."

Sarah Armstrong
NSWC Crane

Downtown Provo
(Photo courtesy SkylineScenes.com)

Named after the Kansa Indians who settled along the Missouri River, **Kansas City** blends old and new, city and prairie. It's often been called the "City of Fountains" since it boasts more outdoor water features than any other city, Rome excepted. Like the fountains, music flows freely in the city, especially in the form of jazz. That legacy can still be heard at the famous 18th & Vine Historic District or at City Market. Architecture is also a prominent feature of the city, most notably the sixty-plus examples of Art Deco styling. Other attractions include Science City at Union Station, the Kansas City Zoo, and the Arabia Steamboat Museum. For grown-ups, Kansas City's riverboat casinos are inviting, as are the city's hometown teams, the NFL Chiefs, MLB Royals, MLS Sporting KC and NWSL KC Current.

Kansas City has been named as the host of the 2026 FIFA World Cup. An incredible achievement of the athletic endeavors encompassing the city. Come see the city the FIFA committee chose before the crowds arrive.

The conference committee has designed a social program that will provide you with exposure to two of Kansas City's popular attractions away from Crown Center. **The Harry S. Truman Presidential Library** will be the focus of Tuesday's companion event. Located in Independence, Missouri, this museum walks visitors through the remarkable timeline of President Truman's time in office. On Thursday, we are offering an excursion to the **Kansas City Zoo.** This trip will include lunch, an animal encounter, and ample time to explore the more than 1700 animals at this world-class facility.

Wednesday's conference social will be at **The Negro Leagues Baseball Museum and American Jazz Museum.** This unique facility brings together two of the key historical movements in Kansas City history. The facility offers many exhibits to explore, music to hear, and people to connect with.

Social Program

SUNDAY, JULY 23, 2023
6:00 PM TO 9:00 PM

REGISTRATION WELCOME RECEPTION

THE TERRACE

Join your colleagues for a reception with light snacks at **The Terrace** on the second floor of the Sheraton Atrium. This reception is open to all Short Course and Technical Session attendees and their registered guests and is a great opportunity to meet new friends and renew old acquaintances. *NSREC attendee or guest badges are required for entrance to the Registration Reception.* The conference registration desk is open from 5:00 to 8:00 PM to obtain your badges.

TUESDAY, JULY 25, 2023
9:00 AM TO 3:30 PM

TRUMAN PRESIDENTIAL LIBRARY AND (OPTIONAL) PLAZA SHOPPING

On Tuesday morning you will meet the tour coordinator and depart from the Sheraton at 9:00 AM to experience the **Truman Presidential Library.** After a short motorcoach ride, we will tour this exceptional historical exhibit of United States history for approximately two hours. Afterwards, participants will have the option of returning to the hotel or continuing to the Plaza Shopping District for lunch (on your own) and shopping. The motorcoach will return from the Plaza Shopping District to the Sheraton at 3:30 PM.

More information: ***https://www.trumanlibrary.gov/*** & ***https://countryclubplaza.com/***

Truman Presidential Library
Photo Courtesy of the Truman Presidential Library

TUESDAY, JULY 25, 2023
5:30 PM TO 7:30 PM

INDUSTRIAL EXHIBITS RECEPTION

EXHIBIT HALL A

Join us for the 2023 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to Exhibit Hall A to visit the booths, enjoy some refreshments, and participate in a raffle. (The raffle will be held Wednesday at 1:00 PM in the exhibit hall. All winners must be present.) *All attendees and registered guests must show their badges to enter the NSREC Industrial Exhibits.*

Social Program

WED. JULY 26, 2023
11:50 AM TO 12:50 PM

IEEE YOUNG PROFESSIONALS LUNCHEON

CHOUTEAU

A special lunch will be held in the Chouteau room for IEEE member attendees who are Young Professionals ***(http://yp.ieee.org/, https://www.facebook.com/ieeeyp).***

This year, we will be specifically looking to hear your inputs, whether they are new experiences, lessons learned, lessons *not* learned, plans, successes, and even failures related to radiation effects in your career. This is an excellent opportunity for newer members of the community to informally chat, network, eat lunch, and share their visions of the radiation effects field looking forward. There's no requirement to participate openly, and a few brief, anonymous questions followed by a moderated discussion will address the following topics:

Workforce Development
Let's turn the tables of workforce development and hear from the youngest employees. What's actually working in your organization? What are we missing that other young professionals need to succeed?

Engineering Resources
It's time to discuss practical, on-the-job matters. Where can the field improve its engineering quality? How can we do our jobs better?

Radiation Effects Knowledge Transfer
Many esteemed radiation effects engineers with a lifetime of experience have developed a wealth of knowledge as the field itself evolved. How well is that knowledge spreading in your organization? Who is successfully learning on the job, and where can we do a better job of passing down the skills of the trade?

Don't miss your opportunity to have your voice heard, meet new friends, and learn something new at the Young Professionals' lunch. *Tickets are required.*

WED. JULY 26, 2023
6:00 PM TO 10:00 PM

CONFERENCE SOCIAL

NEGRO LEAGUES BASEBALL MUSEUM AND AMERICAN JAZZ MUSEUM

Photo Courtesy of the Museum

Celebrate and learn about Kansas City's influential history in music and sport at the 2023 NSREC Conference Social. The joint venue of the Negro Leagues Baseball Museum and American Jazz Museum offers a broad perspective of these important cultural influences. Join your colleagues and friends for a BBQ buffet, beverages, and entertainment in the museums' shared atrium. The coaches will depart from the Sheraton between 5:30 pm and 5:50 pm and they will return starting around 9:00 pm. Wine and beer are available beginning at 6:00 PM and dinner is from 6:30 to 8:00 PM. While you are catching up with old friends and meeting new ones, explore the exhibits of both remarkable museums, listen to some live jazz music, or find a table for a conversation. Dress is casual. *Tickets are not included in the conference registration so be sure to purchase them with your registration.*
(https://www.nlbm.com/) (https://www.americanjazzmuseum.org/)

Social Program

THURSDAY, JULY 27, 2023
9:00 AM TO 4:00 PM

KANSAS CITY ZOO

Photo courtesy of The Beacon

On Thursday morning you will meet the tour coordinator and depart from the Sheraton at 9:00 AM to experience the Kansas City Zoo. The zoo is 202 acres with over 1700 animals to see and learn about during this outing. Participants will be free to explore the zoo exhibits until 11:30 AM when we will gather for lunch at a covered pavilion. A special animal encounter will follow lunch. The afternoon is open to explore the remainder of this large zoo. Bring your walking shoes! We will arrive back at the Sheraton at 4:00 PM.

THURSDAY, JULY 27, 2023
11:30 AM TO 1:15 PM

WOMEN IN ENGINEERING LUNCHEON

CHOUTEAU

A special lunch will be held in the Chouteau room for Women in Engineering and is sponsored by the IEEE NPSS society. This event is open to all attendees who are interested in discussing women's issues in engineering and other related career fields. This year's speaker is Marti McCurdy, Spirit Electronics CEO. She will be speaking on the topic *"Lessons Learned from the Barnyard to the Board Room"*.

Talk write-up: Growing up in Central Pennsylvania's Amish community has provided the ground work to be strong willed, resilient to a fault, and run the most award-winning small distribution channel for the Prime Defense contractors and Space Companies in the US. This talk will discuss lessons learned from six years in the Air Force and how it has prepared me for running companies as diverse as a motorcycle shop to patenting a child safety car seat alarm and the effects of being in proximity to technology helped foster the direction of a career in semiconductors. Spanning decades, lessons learned never expire, they continue to deepen and expand with the challenges facing today's business environment.

Speaker bio: Marti McCurdy, CEO of Spirit Electronics, is a veteran not only of the semiconductor business but also a veteran of the United States Air Force. Marti's career has been an entrepreneurial path that has driven her to start and run multiple companies. Marti acquired Spirit Electronics in September 2017, a distribution company serving military and space contractors. Marti's focus as CEO at Spirit Electronics is to offer product plus value add, turnkey solutions to the aerospace and defense industry for high reliability components. She exercises her engineering knowledge of space qualified flows and sophisticated testing to deliver space qualified components. Throughout her career as a business owner and past positions as VP, Marti's goal is to bring her high standard of customer service and cultivate relationships to serve the aerospace sector she is so familiar with. Marti holds a current patent and is a published author in ultrasonic applications.
Note: *Tickets are required* so check the box for this lunch when you register for the conference.

Social Program

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 July 5.

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.

Sources:
https://www.10best.com/destinations/missouri/kansas-city/

Local Activities

GENERAL INFORMATION

CROWN CENTER

Crown Center is the result of the vision of the late Joyce C. Hall, Hallmark Cards, Inc. founder, and his son, longtime Hallmark chairman, Donald J. Hall. In the early 1960s, the Halls looked out over the area surrounding their company's Kansas City headquarters and did not like what they saw: rutted parking lots, abandoned warehouses, the sorry remains of failed or failing businesses, and a limestone hill cluttered with signs and tarpaper shacks. They believed the industry leader in personal expression deserved a better setting for its home – and that the city which had given much to them deserved better than the blighted landscape stretched before them. They had two choices: follow the stream of businesses fleeing the city for the suburbs; or stay and make the city environment better. They chose to stay.

Crown Center Redevelopment Corporation, a Hallmark subsidiary, was formed to make the Halls' vision a reality. The Hall family sought the counsel of nationally known designers, urban planners and visionaries such as Walt Disney and James Rouse. They invested millions of dollars, and then were patient waiting for that investment to pay off, understanding that the returns on a project such as Crown Center would be realized only over the long term.

Today's Crown Center is the happy result.

Crown Center hosts shopping and dining experiences as well as attractions for all ages.

Crown Center Family Friendly Attractions:

SEA LIFE and **LEGOLAND** Kansas City – Crown Center is home to internationally recognized attractions. **SEA LIFE** is the world's largest family of aquariums and includes **SEA LIFE** Aquariums in North America. From its origins in 1979 in Oban, Scotland, **SEA LIFE** now provides immersive marine experiences in nearly 50 locations in 17 countries around the world. Their mission is to share a passion for the creatures of the oceans and to make guests fall in love with them. The **LEGOLAND** Discovery Center (LDC) attraction offers a fun, highly interactive and educational two to three-hour indoor experience ideal for families with children 3-10 years old. Based on the ever popular LEGO® brick, the LDC provides a range of interactive play areas including a 4D cinema; master classes from the LEGO® Master Model Builder; an exciting LEGO® laser ride; special party rooms for birthdays and other celebrations; as well as the MINILAND exhibit featuring iconic Kansas City buildings. Adults must be accompanied by a minor to visit **LEGOLAND**.

Kaleidoscope - Provided as a gift to the children and families of Kansas City by **Hallmark**, **Kaleidoscope** is a **FREE** center for artistic exploration and creativity for children of all ages to nourish their artistic spirit! It's a vivid, imaginative workshop where young artists use their imaginations to paint, discover, have fun, and feel good about their own special ideas! Guests use materials from Hallmark's manufacturing processes to dream up all kinds of colorful creations–some are cut into shapes, while others are left just as Hallmark sends them. Take your time to explore the whimsical space, make and create, then take home all your goodies to display your greatness!

Local Activities

Crown Center Dining:

Whether you feel like BBQ or a burger, pizza or tacos, there's something for every taste at Crown Center. From full service to fast casual, fast food to a quick snack, there is something for everyone. Try the closest BBQ restaurant to the conference hotel, **Burnt End BBQ**! Have a train deliver a burger right to your table at **Fritz's Railroad Restaurant**. Get creative with toppings at **SPIN! Pizza**. If it's fresh, locally inspired cuisine you are looking for, **Unforked** is for you. But make sure to save room for dessert with some of the best frozen custard around from **Sheridan's** or a delightful box of Kansas City Fudge® from **Chip's Chocolate Factory**. Wherever you decide to dine the options at Crown Center make your day made to order.

Crown Center Shopping:

When it comes to shopping in Kansas City, Crown Center isn't run of the mill. You'll love the unique finds at locally owned, one-of-a-kind stores. Whether you're looking for a cashmere sweater, a felt fedora, a fine pen, the ultimate Kansas City collectible, or a bag of world-famous popcorn, you'll find it here.

UNION STATION

Union Station Kansas City is a 104-year-old historical landmark and celebrated civic asset renovated and reopened to the public in 1999. Now 20 .years later, Science City, a hands-on science center, has earned the distinction of Kansas City's "Favorite Attraction" and "Favorite Family-Friendly Attraction", while Union Station as a whole is recognized as KC's "Favorite Historic Attraction" and "Best of KC". The organization -- dedicated to preserving its historic monument and its stories, inspiring lifelong learning and creating lasting memories for our community -- is home to Kansas City's internationally-awarded Science City; the new Arvin Gottlieb Planetarium; the Regnier Extreme Screen Theatre; the popular Model Railroad Experience; City Stage featuring live theater, and a selection of unique shops and restaurants. Union Station is also home to prominent area civic organizations and businesses, and regularly hosts world-class traveling exhibitions.

Local Activities

KANSAS CITY ART & CULTURE

Fountains – Kansas City is the City of Fountains. Nowhere else but in Kansas City will you find…three men and a woman roaring through turbulent waters on the backs of powerful horses…cherubs and winged sea horses seemingly dancing through raindrops…abstract flames boldly rising above softly cascading waterfalls. And the J. C. Nichols Memorial Fountain is but one of hundreds of unique and majestic fountains that make their home in our City of Fountains.

KC Parks maintains 48 fountains with the city, ensuring that they work, stay beautiful and last forever. The City of Fountains Foundation recognizes the important role our fountains play as sources of beauty and celebration and dedicates its efforts to ensuring the continued development and maintenance of Kansas City's flowing treasures as well.

Explore all 48 KC Parks fountains online and be sure to visit them in person in July!

Photo courtesy VisitKC

MUSEUMS

THE NATIONAL WWI MUSEUM AND MEMORIAL

The National WWI Museum and Memorial is the only American museum solely dedicated to preserving the objects, history and personal experiences of a war whose impact still echoes in the world today. The National WWI Museum holds the most diverse collection of World War I objects and documents in the world and is the second-oldest public museum dedicated to preserving the objects, history and personal experiences of the war. The Museum takes visitors on an epic journey through a transformative period and shares deeply personal stories of courage, honor, patriotism, and sacrifice. Designated by Congress as America's official World War I Museum and located in downtown Kansas City, Mo., the National WWI Museum inspires thought, dialogue and learning to make the experiences of the Great War era meaningful and relevant for present and future generations.

Photo courtesy VisitKC

Local Activities

THE NATIONAL MUSEUM OF TOYS AND MINIATURES.

The Midwest's largest collection of antique toys and the nation's largest collection of contemporary, fine-scale miniatures can be found at **The National Museum of Toys and Miniatures.** The museum, which is located just south of the Country Club Plaza, speaks to the art of play and imagination—and touts a collection featuring more than 72,000 objects from antique dolls and doll houses to dump trucks, ceramics, silver, erector sets, furniture, figurines and more.

THE NATIONAL ARCHIVES AT KANSAS CITY

Home to historical records dating from the 1820s to the 1990s, **The National Archives at Kansas City** is one of 15 facilities nationwide where the public has free access to Federal archival records. Visitors will find more than 50,000 cubic feet of documents—including the judgment from the landmark Brown v. Board of Education case—as well as selected military service indexes, architectural drawings, microfilmed materials, photographs and maps. The archives also feature a rotating exhibit gallery, workshops, lectures, programs and online genealogy subscription services.

COLLEGE BASKETBALL EXPERIENCE

Kansas City is home to the state-of-the-art College Basketball Experience (CBE). Sweating is almost inevitable as CBE's high-energy exhibits recreate the intensity of a college basketball game—from foul-line hecklers to a last-second buzzer beater. Each visitor's journey ends with a stop in the National Collegiate Basketball Hall of Fame, a quiet space devoted to the game's greats. Interactive kiosks offer a glimpse into each inductee's legacy.

THE MONEY MUSEUM

Located inside the Federal Reserve Bank, **The Money Museum** offers a free, one-hour tour encompassing the region's largest cash vault, interactive exhibits, a Truman Coin Collection and an area where guests can design their own digital currency. Walk-in or guided tour, **The Money Museum** is perfect for visitors of all ages. The most unique part? Every guest walks away with a free bag of money—shredded U.S. bills, that is.

MUSIC

Since the early 1900s, Kansas City has been synonymous with jazz. Today, those jazz roots still run deep and the genre is as vibrant here as ever, fueling more than 40 jazz venues on a regular basis.

The history of Kansas City jazz can be traced back to the blues, which began in the Mississippi Delta region near New Orleans, eventually migrating north. Once here, it melded with a sort of jump timber that soon became the distinctive sound the city still calls its own.

KC's jazz heyday in the 1920s and 1930s was found along 12th and 18th streets downtown, both part of the hub of the city's African-American community and where many great musicians got their start in jazz groups. As the Kansas City sound flourished, increasingly larger numbers of musicians flocked here to practice their craft in the numerous nightclubs, dance halls and vaudeville houses regularly featuring jazz music. They of course were followed by legions of fans which together helped create what is now the 18th & Vine Historic Jazz District.

Local Activities

EAT & DRINK

Barbecue in Kansas City is unique. For starters, the city invented and perfected a delicacy called the burnt end. Expect to find it on just about every barbecue menu in Kansas City, and expect to crave it long after you've left the region. Its composition: that crispy portion of the brisket not suitable for slicing, but delicious and full of flavor on its own. Pitmasters will chop it into cubes or chunks, and then submerge it into sauce, often times returning it to the smoker for even more smoking.

Kansas City is also a sauce town. Here, meat is often seasoned with a dry rub, then sauced. It's the sauce itself that defines so many of the restaurants in the region. Typically, the style is of a rounder, sweeter tone, as defined most notably by **Hillsdale Bank BBQ** and **Joe's Kansas City Bar-B-Que**. But the region's most famous sauces are both, atypically, more savory than sweet, and come from the region's two heavyweights, **Arthur Bryant's** and **Gates**.

In the not-so-distant past, the Kansas City beer scene relied mainly on just three brewing entities, **Boulevard Brewing Co., 75th Street Brewery** and **McCoy's Public House**. A small handful of beer-centric bars supported the cause, but over the course of the past few years, we've seen a sharp increase in businesses that cater to hop heads, helping to put Kansas City on the national beer map.

SHOPPING

Country Club Plaza - Kansas City's premier retail, dining and entertainment destination, offering 100+ shops and dozens of fine restaurants nestled within 15 blocks of old-world architecture. Plaza Shopping Shoppers will recognize fine stores like West Elm, The North Face and Tiffany & Co. Original Kansas City stores like Tivol and Made in KC Marketplace give local flavor to the Plaza's reputation. Pleasant surprises can be found along each block – from boutiques to delicious eateries, stylish salons and fine jewelry. Plaza Dining Contemporary American to Kansas City steaks, authentic Italian to cosmopolitan Mexican are all a part of the Plaza experience. The picturesque views of the Spanish influenced background entice Plaza visitors to dozens of outdoor dining venues.

Crossroads Arts District – Once-vacant warehouses now house carefully curated galleries in the Crossroads. It's here that visitors can truly take in the arts, both hanging in showrooms and spray-painted onto building exteriors –while restaurants, breweries, and speakeasies round out the neighborhood that the arts built.

Well Bottoms – Eclectic is just the beginning in this historic neighborhood where antique shoppers thrive and hipsters vibe. The West Bottoms touts an excellent selection of vintage and preowned stores, as well as atmospheric bars and restaurants; spend a few hours here and you'll see that it's on the cusp of something great.

Sources:
https://www.visitkc.com
https://www.crowncenter.com
Fountains Archives - KC Parks and Rec

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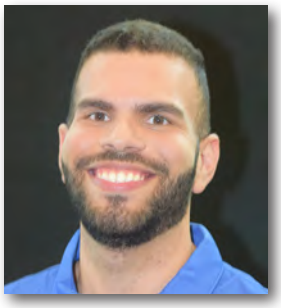

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ANNOUNCEMENT and FIRST CALL FOR PAPERS

2024 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

Short Course and Radiation Effects Data Workshop

July 22-26, 2024
Shaw Centre
Ottawa, Canada

www.nsrec.com

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You are cordially invited to attend the 2024 IEEE Nuclear and Space Radiation Effects Conference to be held July 22-26, 2024 at the Shaw Centre, Ottawa, Canada. 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-Induced 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
- 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 2, 2024

PROCEDURE FOR SUBMITTING SUMMARIES

Summaries must be received by February 2, 2024

Detailed submission and formatting instructions will be available after December 1, 2023 at www.nsrec.com

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 and tables. 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.
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 (January 2025). 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 and 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.*

OTTAWA, CANADA

The Westin Ottawa with the adjoining Shaw Centre is the location for NSREC 2024. Ottawa is Canada's capital, a dynamic showcase city of more than one million people. Located in Ontario at the Quebec border, it's a place where you'll hear English and French spoken in the streets; where you can discover Canada's proud heritage at impressive national sites and famous landmarks, including the Rideau Canal, a UNESCO World Heritage Site. It's a city steeped in culture, with world-class museums and galleries displaying stunning national collections and special exhibitions from Canada and around the world.

Courtesy Ottawa Tourism

This city is a uniquely beautiful place: an urban centre on the edge of nature where you can enjoy the great outdoors either just outside your hotel room or nearby in the surrounding countryside. There's an easy cosmopolitan vibe here, and Ottawa is known for being both welcoming and walkable. Explore the distinctive local neighbourhoods, including the historic ByWard Market: by day this area boasts a bustling farmers' market and chic shops, by night it hums with activity at the restaurants, pubs, and nightclubs.

This is also a city that enjoys the finer things in life, with a culinary community that's earning wide acclaim, unique boutiques and shopping districts, a lively local music and art scene, and always exciting nightlife. The Westin Ottawa is ideally located right downtown, mere steps away from the historic sites and landmarks, and only a short drive from Ottawa's international airport.

This is Ottawa, Canada's capital. Please join us for NSREC 2024 and experience it for yourself.