NSREC 2022

July 18-22, 2022

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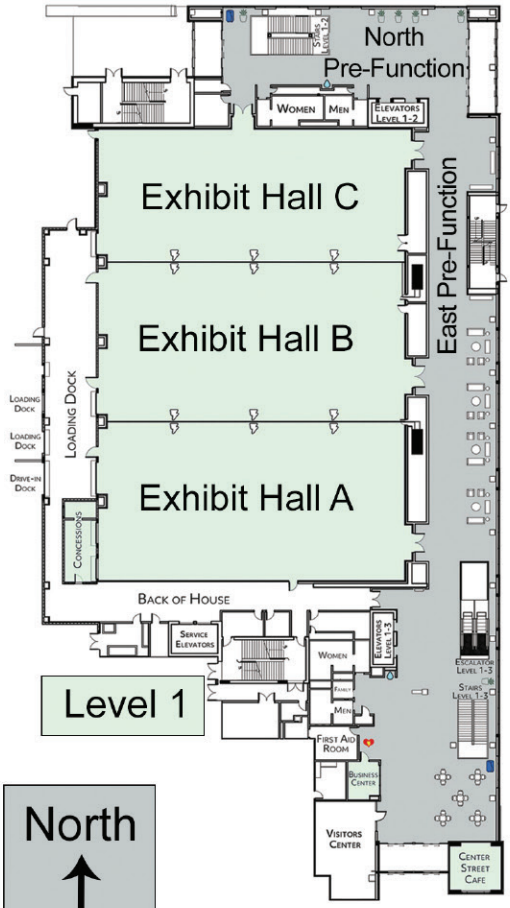


Technical / Exhibit

Sunday-Friday
- On-site Registration - Hobble Creek
- Pre-Registration - Silver Creek

Monday-Friday
- A/V Preview Room - Boardroom
- Side Meeting Rooms (offsite)
  - #1 Marriott's Aspen Room
  - #2 Marriott's Birch Room
  - #3 Marriott's Cedar Room

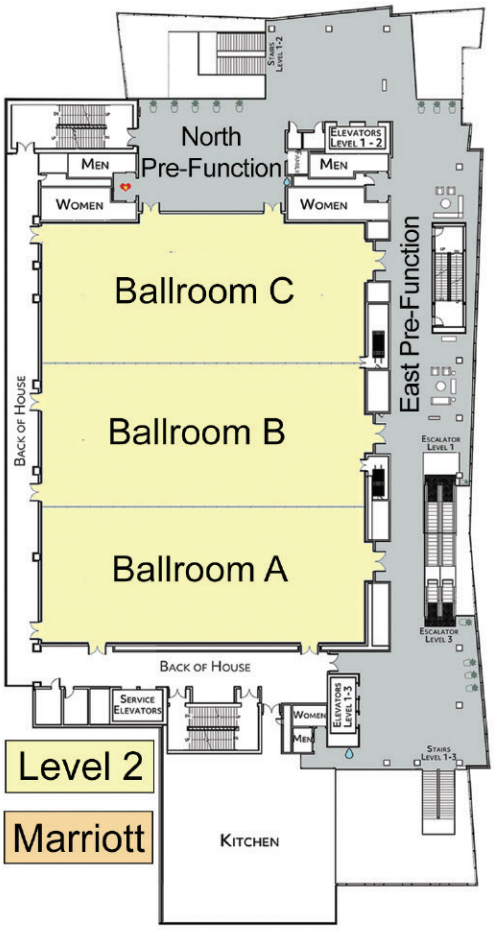
Monday
- Short Course Sessions - Ballroom B-C
- Short Course Exam - Ballroom B-C

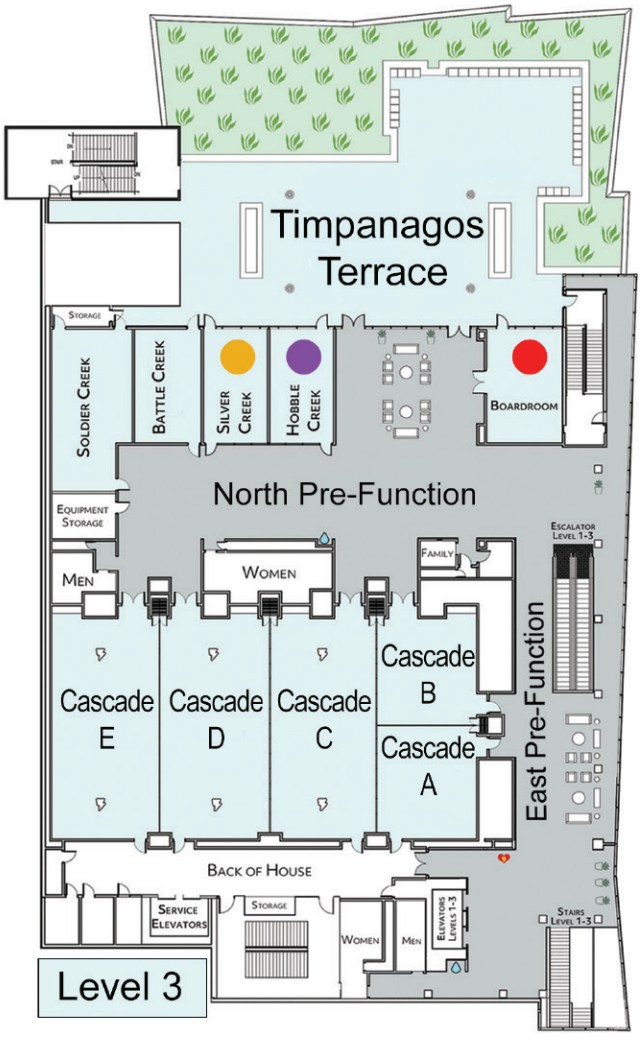
Tuesday - Friday
- Technical Sessions - Ballroom B-C

Tuesday-Wednesday
- Exhibits - Exhibit Halls A-B-C

Wednesday
- Data Workshop Sessions - Cascade C-D-E

Thursday
- Poster Session - Ballroom A
- Open Meeting - Ballroom B-C





Dining / Social

Sunday
- **Welcome Reception**
  Cascade C-D-E, North Pre-function (Level 3), Timpanagos Terrace

Monday
- Continental Breakfast - Ballroom A
- Morning Break - Ballroom A
- Short Course Luncheon - Ballroom A
- Afternoon Break - North & East Pre-Function (Level 2)

Tuesday
- Continental Breakfast, Morning Break - Exhibit Halls A-B-C
- Afternoon Break - Exhibit Halls A-B-C
- Exhibit Reception - Exhibit Halls A-B-C

Wednesday
- Continental Breakfast, Morning Break, Lunch - Exhibit Halls A-B-C
- Afternoon Break - Cascade C-D-E

Thursday
- Continental Breakfast - Timpanagos Terrace
- Young Professional Breakfast - Cascade A-B
- Morning Break - North & East Pre-Function (Level 2)
- WIE Lunch - Cascade A-B
- Afternoon Break - Ballroom A

Friday
- Continental Breakfast - Timpanagos Terrace & Cascade A-B
- Morning Break - North & East Pre-Function (Level 2)

Schedule

Time	Monday July 18	Tuesday July 19	Wednesday July 20	Thursday July 21	Friday July 22
7:00	[7:00] Breakfast - Exhibit Hall A-B-C, Level 1	[7:00] Breakfast - Exhibit Hall A-B-C, Level 1	[7:00] Breakfast - Exhibit Hall A-B-C, Level 1	[7:00-8:15] IEEE Young Professionals Breakfast – Cascade A-B, Level 3 (YP talk begins at 7:30 AM) *Ticket Required to Attend* — and — [7:00] Breakfast – Timpanogos Terrace, Level 3	[7:00] Breakfast – Timpanogos Terrace & Cascade A-B, Level 3
7:30					
8:00	[8:00] **Short Course Introduction** Prof. Sylvain Girard, Ballroom B-C				
8:10	[8:10] **Part I – From Radiation Environments to Radiation-Matter Interactions** Dr. Giovanni Santin	[8:10] **Opening remarks - Awards Presentation** - Ballroom B-C, Level 2			
8:15					
8:30			[8:30] **Invited Talk – Ultra High Energy Cosmic Rays in Utah** Professor Pierre Sokolsky Ballroom B-C, Level 2	[8:30] **Invited Talk – Dinosaurs and other Mesozoic Critters of Utah – A trip through Deep Time** Professor Brooks Britt Ballroom B-C, Level 2	[8:30] **Invited Talk – Utah Rocks!** Professor Ronald Harris Ballroom B-C, Level 2
9:00		[9:05] **Technical Session Opening Remarks** [9:10] **Session A - Single Event Effects: Mechanisms and Modeling**			
9:30	[9:40] Break – Ballroom A		[9:35] **Session E - Hardness Assurance**	[9:30] **Session G - Dosimetry**	[9:30] **Session I – Radiation Effects in Devices and Integrated Circuits**
10:00		[10:00] Break – Exhibit Hall A-B-C, Level 1	[10:10] Break – Exhibit Hall A-B-C, Level 1	[10:20] Break – North & East Pre-Function, Level 2	[10:20] Break – North & East Pre-Function, Level 2
10:30	[10:10] **Part II – Experimental Characterization of Radiation Effects Parameters for Device and Circuit Level Modeling** Dr. Philippe Paillet	[10:30] **Session B - Single Event Effects: Devices and Integrated Circuits**	[10:40] **Session F - Photonic Devices and Integrated Circuits**	[10:50] **Session H - Hardening by Design**	[10:50] **Session I –** *(continued)*
11:00					
11:30	[11:40] Short Course Luncheon – Ballroom A			[11:40] Lunch — and — [11:40] Women in Engineering Lunch – Cascade A-B, Level 3 *Ticket Required to Attend*	[11:50] End of Conference
12:00		[11:50] Lunch	[12:00] Exhibitor Lunch – Exhibit Hall A-BC, Level 1		
12:30					
1:00	[1:00] **Part III – Modeling Cumulative Radiation Effects: Devices to Integrated Ciruits** Prof. Hugh Barnaby and Prof. Ivan Sanchez Esqueda	[1:00] **Session C - Space and Terrestrial Environments**			
1:30			[1:30] **Data Workshop Introduction** - Ballrooms B-C, Level 2	[1:30] **Poster Introduction** - Ballroom B-C - Level 2	
2:00		[1:50] Break – Exhibit Hall A-B-C, Level 1	[1:35-4:30] **Radiation Effects Data Workshop** Cascade C-D-E, Level 3	[1:35-4:30] **Poster Session** - Ballroom A, Level 2	
2:30		[2:30] **Session D – Basic Mechanisms**			
3:00	[2:50] Break – Pre-Function Area				
3:30	[3:20] **Part IV – Multi-Scale, Multi-Physics Modeling and Simulation of Single Event Effects at Device and Circuit Levels** Prof. Jean-Luc Autran and Prof. Daniela Munteanu	[3:50] End of Tuesday Sessions			
4:00					
4:30			[4:30] End of Wednesday Sessions	[4:30] End of Thursday Sessions [4:30 to 6:30] **Radiation Effects Committee Annual Open Meeting** – Ballroom B-C, Level 2	
4:50	[4:50] Wrap-up				
5:00	[5:00] Exam (for students requesting CEU credit only)				
5:30	[5:30] End of Short Course	[5:30 to 7:00] Industrial Exhibits Reception – Exhibit Halls A-B-C, Level 1			
6:00			[6:00 to 10:00] Conference Social – **Wadley Farms** (Busses depart 5:30 - 5:50 PM)		
6:30					
7:00					

Chairman's Invitation

"It is my honor to invite you to attend NSREC2022 in the friendly small city of Provo, Utah. My Conference Committee and I are excited to host all of you live again with an excellent conference and enjoyable social opportunities. I would be remiss if I didn't remind you of the incredible outdoor opportunities that will surround you in Utah. The NSREC website will provide extensive links to them come September. The Wasatch Mountains will greet you daily, and Southern Utah proudly wears its necklace of 5 National Parks, starting less than 200 miles from Provo. Start planning your adventure now! On behalf of the many who make NSREC possible, I welcome you to NSREC 2022."

Thomas L. Turflinger
NSREC 2022 General Chair
The Aerospace Corporation

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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 2022 Nuclear and Space Radiation Effects Conference (NSREC) committee and volunteers, it is my pleasure to invite you to attend the 59th NSREC to be held July 18-22, 2022. The conference will be in beautiful Provo, Utah at the Utah Valley Convention Center, in the Shadow of Mt. Timpanogos and the mighty Wasatch Mountains.

Most importantly, after two tough years apart, we will be "Back to the Past", together again in a wonderful venue to renew old friendships and make new!

The conference begins Monday, July 18, with a one-day Short Course titled ***"Multi-Scale, Multi-Physics of Radiation Effects."*** It is organized by **Sylvain Girard**, University of St. Etienne, and consists of four sections taught by leading experts in their respective fields. The short course is designed to provide an overview of the use of Modeling and Simulation Tools that are critical to Implement radiation-hardened systems today. An extensive set of written notes will be provided and in 2022, all attendees will receive the complete 1980-2022 Short Course Compendium (provided in a CD or Memory stick).

The Technical Program will be held from Tuesday, July 19 to Friday, July 22. **Pascale Gouker**, MIT Lincoln Laboratory, is the Technical Program Chair. She and her technical committee will select the outstanding contributed papers organized into 9 sessions of oral presentations and a poster session (**Jonny Pellish**, NASA/GSFC Poster Chair) that supports all sessions. In addition, the technical committee will select a set of quality presentations for the Radiation Effects Data Workshop (**Zach Fleetwood**, Space-X REDW Chair). Workshop posters will present radiation effects data on electronic and photonic devices and systems, and new simulation or test facilities. Finally, Pascale plans to invite three engaging guest speakers to give general interest presentations.

The Industrial Exhibit, organized by **Tara Luther**, Skywater Technologies, opens Tuesday morning. We anticipate 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, with their guests, are invited to a reception in the exhibit halls on Tuesday evening. The exhibits will conclude at noon Wednesday with an attendee luncheon.

Local Arrangements Chair, **Daniel Loveless**, University of Tennesee-Chattanooga (ably assisted by **Mike Wirthlin**, Brigham Young University), is organizing an outstanding social program. The Conference Social, on Wednesday evening, is planned to offer all a fantastic evening of entertainment as well as a taste of Utah. Two companion tours are also being planned.

On behalf of my Conference Committee, which also includes Finance Chair **Matt Gadlage** (NAVSEA Crane), Publicity Chair **Teresa Farris** (Archon-LLC), and Awards Chair **Sarah Armstrong** (NAVSEA Crane), I invite you to join us in Provo for a wonderful conference: Live again!!

Southern Utah is truly one of the most breath-taking and awe-inspiring parts of the United States.

We look forward to seeing you in person next July!

Short Course Program

MULTI-SCALE, MULTI-PHYSICS OF RADIATION EFFECTS

UTAH VALLEY CONVENTION CENTER
BALLROOM B AND C
JULY 18, 2022

8:00 AM **SHORT COURSE INTRODUCTION**
Prof. Sylvain Girard, *University of St Etienne*

8:10 AM **PART I – FROM RADIATION ENVIRONMENTS TO RADIATION-MATTER INTERACTIONS**
Dr. Giovanni Santin, *ESA/ESTEC*

9:40 AM **BREAK (Ballroom A)**

10:10 AM **PART II – EXPERIMENTAL CHARACTERIZATION OF RADIATION EFFECTS PARAMETERS FOR DEVICE AND CIRCUIT LEVEL MODELING**
Dr. Philippe Paillet, *CEA*

11:40 AM **SHORT COURSE LUNCHEON (Ballroom A)**

1:00 PM **PART III – MODELING CUMULATIVE RADIATION EFFECTS: DEVICES TO INTEGRATED CIRCUITS**
Prof. Hugh Barnaby and Prof. Ivan Sanchez Esqueda, *Arizona State University*

2:50 PM **BREAK (Pre-Function Area)**

3:20 PM **PART IV – MULTI-SCALE, MULTI-PHYSICS MODELING AND SIMULATION OF SINGLE EVENT EFFECTS AT DEVICE AND CIRCUIT LEVELS**
Prof. Jean-Luc Autran and Prof. Daniela Munteanu, *Aix-Marseille University & CNRS*

4:50 PM **WRAP-UP**

5:00 PM **EXAM (only for students requesting CEU credit)**

5:30 PM **END OF SHORT COURSE**

Short Course attendees will receive the 1980-2022 Short Course Compendium

Short Course

COURSE DESCRIPTION

A short course, *"Multi-Scale, Multi-Physics of Radiation Effects"*, will be presented at the 2022 IEEE Nuclear and Space Radiation Effects Conference. A comprehensive understanding of radiation effects on modern microelectronics requires combining experimental and theoretical tools in order to assess the physical processes occurring at various scales. First, the relevant radiation environment should be determined and radiation transport through any materials surrounding the circuit or device of interest should be modeled. Then, the deposited energy can be evaluated as well as its conversion into charges or defects. The transport and recombination of these charges in the semi-conductor and insulator regions, their trapping in insulators or at the interfaces are at the basis of the description of electrical impact of radiation-induced defects and of the cumulative or transient effects at device, circuit or system levels.

The short course is organized into four sections, all featuring introductory material and advanced topics, with an emphasis on the physics involved in the radiation effects on microelectronics. The first section addresses the natural and man-made radiation environments, with emphasis on the simulation toolkits for the radiation-matter interactions. The second part focuses on the basics of radiation effects on microelectronic components and systems, discussing the single-event and total ionizing dose effects and focusing on their experimental characterizations. The third section illustrates the multi-scale approaches and associated simulation tools that can be used to model the cumulative dose effects at the various scales, from the device to the circuits. The final course deals with the existing multiscale simulation tools for Single Event Effects. 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

Sylvain Girard
University of St Etienne
Short Course Chair

Sylvain Girard obtained his PhD in Optics, Photonics in 2003 from Université Jean Monnet (UJM) in France. He joined the CEA in 2004 and became a CEA Senior Expert in 2011. He was investigating the vulnerability and radiation hardening of optical components for the Laser Mégajoule. In 2012, Sylvain joined the UJM as Full Professor. He is today leading the MOPERE research group of Laboratoire Hubert Curien and is one of the founders of the LabH6 joint research lab between UJM, CNRS and the industrial iXblue. His main research axis deals with the development of a coupled simulation/experiments approach to build predictive models for the behavior of photonic technologies in harsh environments. He serves the radiation effects community in several positions, in particular as Member-at-Large on the IEEE NPSS Radiation Effects Steering Group and as one of the Associate Editors of IEEE Transactions on Nuclear Science (2008-2018). He has authored or co-authored more than 240 articles in peer-reviewed journals. Sylvain received the 2013 IEEE NPSS Early Achievement Awards and the 2014 Léon-Nicolas Brillouin Award from IEEE/SEE. Sylvain is a Senior Member of the IEEE.

Giovanni Santin s senior analyst at the European Space Agency, and Honorary Visiting Fellow at the University of Leicester. He received his PhD in physics from the University of Trieste, Italy. He worked at CERN (for the University of Geneva) and the University of Lausanne, before joining in 2002 the Space Environments and Effects Analysis section of ESA/ESTEC. Giovanni's current research interests are in radiation monitoring, dosimetry, radiation transport and effects modelling for manned and unmanned missions. He is a specialist in radiation transport codes for Monte-Carlo simulations. His work has supported ESA projects including Cosmic Vision exploration missions, with radiation assessments and countermeasures against the harsh particle environments. He is also responsible for several developments aimed at improving shielding effectiveness and spacecraft radiation effects predictions, and at making advanced Geant4-based physics and analysis techniques available and viable in engineering environments.

FROM RADIATION ENVIRONMENTS TO RADIATION-MATTER INTERACTIONS

Dr. Giovanni Santin
ESA/ESTEC

Dr. Giovanni Santin, ESA/ESTEC, will address natural and man-made radiation environments and their propagation in structures and sensitive elements. An overview will be provided of the features of the diverse radiation fields to which electronics and humans are exposed in space and terrestrial environments. The relevant physical interaction processes and related concepts and terminology will be introduced, with particular attention to the multi-physics and multi-scale aspect of the interactions in modern technologies, in space and at ground accelerator and laser test facilities. Experimental measurement techniques will be described for dosimetry and transients at small scale, together with modelling techniques for simulation of radiation transport up to the sensitive components (e.g. sensors or microelectronic circuits) and for the interactions therein, as a starting point for radiation effect calculation.

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

- Introduction
- Natural and man-made radiation environments
  - Space radiation environment components
  - Natural atmospheric and ground radiation sources
  - Man-made radiation environments
- Mechanisms of radiation-matter interaction
  - Physical processes in semiconductor, insulator and surrounding materials
  - Energy deposition and radiation exposure quantities for cumulative phenomena
  - Energy deposition and single events: charged particles and laser
  - Experimental characterization: dosimetry and transients at small scales
  - Radiation transport tools: multi-physics, multi-scale challenges
- Summary

Philippe Paillet (M'97–SM'04–F'18) received his Master's degree in Electrical Engineering from the Université Aix-Marseille I, France, in 1989 and his PhD degree in Electrical Engineering from the Université Montpellier II, France, in 1995. He joined the Commissariat à l'Energie Atomique (CEA) in Arpajon, France in 1995, and is CEA International Expert. Philippe has been involved in numerous programs developing radiation-hardened electronic and optoelectronic technologies, characterizing the physical mechanisms responsible for radiation response of components and ICs, modeling the effects of radiation in MOS technologies and the creation of radiation-induced defects, and developing hardness assurance approaches. Philippe has authored or co-authored more than 250 publications, articles, short courses and book chapters, including three Best Papers at RADECS, two Meritorious Paper Awards at NSREC, one Best Paper Award at HEART, and five Outstanding Paper Awards at NSREC. He is currently serving as Vice-president of the RADECS Association and RADECS Liaison to the IEEE Radiation Effects Steering Group.

EXPERIMENTAL CHARACTERIZATION OF RADIATION EFFECTS PARAMETERS FOR DEVICE AND CIRCUIT LEVEL MODELING

Philippe Paillet
CEA

Modeling radiation effects is a complex and challenging task faced by the community, since it requires not only the understanding of basic mechanisms of radiation effects, but also of their multi-physics nature. Therefore modeling can only be addressed using multi-scale tools. At device level, it requires the knowledge of basic mechanisms induced by radiation interaction with the different layers constituting a modern device. At circuit level, the complexity grows even further, since circuit response to radiation will depend on device architecture, circuit layout and operating condition. This part of the Short Course will introduce the main key parameters that can be extracted from the experimental characterization of radiation effects in devices and circuits. Some of these parameters are needed as input for design of radiation-aware device and circuit models, others are required to check the validity of the simulations obtained using these models. This course will begin with the description of the main basic mechanisms of radiation effects, both cumulative (such as Total Ionizing Dose or Displacement Damage) and transient (such as Single Event Upset or Single Event Transient)). It will then explain the way to experimentally determine the relevant parameters to be taken into account for a meaningful modeling of these different effects at each level.

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

- Introduction
- Cumulative effects induced by Total Ionizing Dose
  - Mechanisms leading to damage in insulating materials
  - Experimental characterization in device and integrated circuit
  - Extraction of relevant parameters for modeling
- Cumulative effects induced by Displacement Damage
  - Mechanisms leading to damage in Semiconductor Materials
  - Experimental characterization in device and integrated circuit
  - Extraction of relevant parameters for modeling
- Transient effects induced by radiations
  - Mechanisms leading to damage in Semiconductor Materials
  - Experimental characterization in device and integrated circuit
  - Extraction of relevant parameters for modeling
- Summary

Hugh Barnaby, Professor of Electrical Engineering at Arizona State University, has been an active researcher in the microelectronics field for over 28 years in both industry and academics, presenting and publishing more than 300 peer-reviewed papers during this time. He is an IEEE fellow and has served as journal Associate Editor for the IEEE Transactions on Nuclear Science and served many roles at NSREC, including general chairperson in 2020. His primary research focuses on the analysis, modeling, and experimental characterization of radiation effects in semiconductor materials, devices, and integrated circuits.

Ivan Sanchez Esqueda, Assistant Professor of Electrical Engineering at Arizona State University, has conducted research in electronic nanotechnologies since 2012, presenting and publishing over 40 peer-reviewed articles during this time. He is an IEEE senior member, has served as journal Associate Editor for the IEEE Transactions on Nuclear Science. His primary research focuses on the development, characterization, and modeling of nanoscale electronic devices.

Professors Barnaby and Sanchez Esqueda hold several joint patents on radiation and reliability effect modeling in semiconductor devices.

MODELING CUMULATIVE RADIATION EFFECTS: DEVICES TO INTEGRATED CIRCUITS

Hugh Barnaby and Ivan Sanchez Esqueda
Arizona State University

Designing integrated circuits requires accurate models to capture the physics of a circuit's fundamental devices. Transistors are the workhorse circuit elements and by far the most complex. Successful modeling of transistor operation has been one of the great achievements in physics and engineering in the past 100 years. New models are constantly being updated for new transistor technologies as well as for addressing new challenges for older ones. Models are particularly important when we considered the unique challenges posed by cumulative radiation damage on devices. Accurate modeling at the device-level is critical to helping us understand the basic mechanisms of damage to transistors and helps us model radiation effects in circuits, through compact models that are radiation-aware. In this course, the presenters will review device physics and modeling of the two most prominent transistor families: Complimentary MOS (CMOS) field-effect transistors (FETs) and Bipolar Junction Transistor (BJT). Once the mechanisms of ionization and displacement damage in these transistors have been presented discussed, the instructors will describe, in detail, the various methods that are used to model these cumulative effects, from devices to integrated circuits.

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

- Course Overview
  - The Need for Modeling
  - Technologies
- Mechanisms for Ionizing Damage in Semiconductors
- Modeling TID Effects in CMOS
  - Device Level Modeling
  - Compact and Circuit Modeling
- Modeling TID and DD Effects in COT BJT
  - Device Level Modeling
  - Compact and Circuit Modeling
- Summary

Jean-Luc Autran is Distinguished Professor of Physics and Electrical Engineering at Aix- Marseille University and Honorary Member of the University Institute of France (IUF). Head of the Institute for Materials, Microelectronics and Nanosciences of Provence (IM2NP, UMR 7334), he is also Director of the "Radiation Effects and Electrical Reliability" (REER) Joint Laboratory between IM2NP and STMicroelectronics. Having worked for 30 years in the field of semiconductor interface defects, physics of advanced CMOS devices and radiation effects in microelectronics, his current research interests focus on the physics of single event effects, including characterization, analytical modeling and numerical simulation topics. Jean-Luc Autran is the author or a coauthor of 350 papers published in international journals and conferences. With Daniela Munteanu, he coauthored the book "Soft errors: from particles to circuits" (CRC Press, 2015).

Daniela Munteanu is Director of Research at the National Center for Scientific Research (CNRS). Fellow researcher at the Institute for Materials Microelectronics and Nanoscience of Provence (IM2NP), she has 25 years of experience in characterization, modeling and simulation of semiconductor devices. Her current research interests include emerging CMOS devices, compact modeling, numerical simulation in the domains of nanoelectronics and radiation effects on components and circuits. Daniela Munteanu is the author or a coauthor of more than 250 papers published in international journals and conferences. She has supervised 15 Ph.D. thesis and coauthored with Jean-Luc Autran the book "Soft errors: from particles to circuits" (CRC Press, 2015).

MULTI-SCALE, MULTI-PHYSICS MODELING AND SIMULATION OF SINGLE EVENT EFFECTS AT DEVICE AND CIRCUIT LEVELS

Jean-Luc Autran & Daniela Munteanu
Aix-Marseille University & CNRS

Prof. Jean-Luc Autran and Prof. Daniela Munteanu, Aix-Marseille University & CNRS, will provide a state-of-the-art overview of modeling and simulation of single event effects (SEE) at device and circuit levels. The presentation will primarily focus on the specific multi-scale, multi-physics, multi-domains nature of SEEs and on the main underlying physical mechanisms that leads to the occurrence of soft errors in digital circuits. In a first part, a meticulous analysis will address the different ways to model and simulate both in space and time this complex sequence of mechanisms from the particle-material interaction up to the electrical response of a given circuit. In a second part, the presentation will explore some specificities of modern technologies subjected to SEEs in terms of material diversity, device architectures or circuit complexity. The susceptibility of electronics in different environments (natural, artificial) or subjected to a combination of electrical and radiative degradations will be finally presented through the prism of modeling and simulation. This presentation will conclude by some perspectives of works and challenges ahead to anticipate the SEE susceptibility of future nanodevices and related circuits.

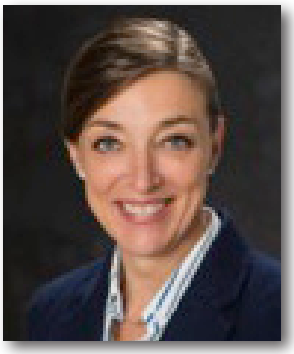
A top-level outline of the presentation is as follows:

- Introduction
- Understanding the nature of the SEE problem
  - Definition and classification
  - Main steps to produce SEEs in a circuit (summary)
  - Multi-physics, multi-scale, and multi-domain nature of SEEs
- Principal modeling and simulation approaches
  - Types of methodologies: what simulation level, what input, what output?
  - Collected charge versus collected current approaches
  - Analytical, compact, and full numerical methods at device/cell level
  - Mixed-mode device and circuit simulation
  - High-level description at system level
- Specific features of modern technologies
  - Advanced bulk
  - FinFETs
  - FD-SOI
  - MBCFETs
- Anticipating reliability under various environments and operating conditions
  - New radiation environments (high energy physics, power fusion)
  - Synergy effects (electrical degradation, high temperature operation)
- Challenges for future nano-devices
  - New materials: exploring the periodic table
  - Integrated silicon photonics devices
  - Beyond CMOS: the case of spintronics
  - The horizon of quantum computing
- Conclusion

The short-course will be presented by Jean-Luc Autran.

Technical Program

TECHNICAL INFORMATION



"On behalf of the Technical Program Committee, I would like to invite you to attend the 2022 NSREC Technical Sessions. The chairpersons for these nine sessions will assemble an exceptional program covering the latest developments in the nuclear and space radiation effects fields. I look forward to working with the session chairs, authors and reviewers who will contribute to an outstanding technical program."

Pascale Gouker, MIT Lincoln Laboratory, 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 of Radiation Effects**
  Chair: Daisuke Kobayashi, ISAS/JAXA
- **Dosimetry**
  Chair: Ethan Cascio, Massachusetts General Hospital
- **Hardness Assurance**
  Chair: Christian Poivey, European Space Agency
- **Hardening by Design**
  Chair: Ethan Cannon, The Boeing Company
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Enxia Zhang, Vanderbilt University
- **Photonic Devices and Integrated Circuits**
  Chair: Cedric Virmontois, CNES
- **Single-Event Effects: Mechanisms and Modeling**
  Chair: Joel Hales, Naval Research Laboratory
- **Single-Event Effects: Devices and Integrated Circuits**
  Chair: Jeffrey Black, Sandia National Laboratories
- **Space and Terrestrial Environments**
  Chair: Gregory Ginet, MIT Lincoln Laboratory

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 Ballroom A. The formal Poster Session will be held on Thursday from 1:30 – 4:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Jonathan Pellish from NASA GSFC.

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 Cascade C-D-D. Authors will be available on Wednesday to discuss their work from 1:30 – 4:30 PM.. A workshop record will be mailed to all registered conference attendees. The Data Workshop chair is Zachary Fleetwood from SpaceX.

INVITED SPEAKERS

There will be three invited speakers

- **Ultra High Energy Cosmic Rays in Utah**
  Pierre Sokolsky, Distinguished Professor of Physics and Astronomy Emeritus, University of Utah
- **Dinosaurs and other Mesozoic critters of Utah – A trip through Deep Time**
  Brooks Britt, Chair, Geological Sciences, Brigham Young University, Provo, Utah
- **Utah Rocks!**
  Ron Harris, Professor of Geological Sciences, Brigham Young University, Provo, Utah

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 deadline for submission is May 13, 2022. Detailed instructions for submitting late-news summary are available on the NSREC website at ***www.nsrec.com.***

Session Chairs

Daisuke Kobayashi, ISAS/ JAXA
Basic Mechanisms of Radiation Effects

Ethan Cascio, Massachusetts General Hospital
Dosimetry

Christian Poivey, European Space Agency
Hardness Assurance

Ethan Cannon, The Boeing Company
Hardening by Design

Enxia Zhang, Vanderbilt University
Radiation Effects in Devices and Integrated Circuits

Cedric Virmontois, CNES
Photonic Devices and Integrated Circuits

Joel Hales, Naval Research Laboratory
Single-Event Effects: Mechanisms and Modeling

Jeffrey Black, Sandia National Laboratories
Single-Event Effects: Devices and Integrated Circuits

Gregory Ginet, MIT Lincoln Laboratory
Space and Terrestrial Environments

BALLROOM B, C

8:10 AM **OPENING REMARKS**
Thomas Turflinger, Aerospace Corporation, General Chairman

8:15 AM **AWARDS PRESENTATION**
Robert Reed, Vanderbilt University, Radiation Effects Steering Group, Executive Chair

9:05 AM **TECHNICAL SESSION OPENING REMARKS**
Pascale Gouker, MIT Lincoln Laboratory, Technical Program Chair

SESSION A **SINGLE EVENT EFFECTS: MECHANISMS AND MODELING**

9:10 AM SESSION INTRODUCTION
Chair: Joel Hales, U.S. Naval Research Laboratory

A-1 **Single Event Effects in 3D NAND Flash Memory Cells with Replacement**
9:15 AM **Gate Technology**

M. Bagatin[1], S. Gerardin[1], A. Paccagnella[1], A. Costantino[2], V. Ferlet-Cavrois[2], A. Pesce[2], S. Beltrami[3]

1. University of Padova, Italy
2. ESA, Netherlands
3. Micron Technology, Italy

We studied the heavy-ion single event effect response of 3D NAND Flash memory cells with replacement gate technology. Threshold voltage shifts and underlying mechanisms are discussed and compared with previous generation cells with floating-gate architecture.

A-2 **Proton Direct Ionization Upsets at Tens of MeV**
9:30 AM

A. Coronetti[1,2], R. Garcia[1], D. Lucsanyi[1], J. Wang[3], F. Saigné[2], A. Javanainen[4,5], P. Leroux[3]

1. CERN, Switzerland
2. University of Montpellier, France
3. KU Leuven, Belgium
4. University of Jyväskylä, Finland
5. Vanderbilt University, USA

Experimental measurements show an unusually high proton upset cross-section at few tens of MeV for a low core-voltage SRAM. G4SEE simulations confirm that this mechanism is due to proton direct ionization.

A-3 **Leveraging the Wavelength Dependence of Optical Charge Generation**
9:45 AM **to Correlate Ion- and Laser-Induced Transients in Modern SiGe HBTs**

A. Idelfonso[1], J. M. Hales[1,2], A. Khachatrian[1], P. D. Cunningham[1], D. Nergui[3], G. N. Tzintzarov[3], A. P. Omprakash[4], J. D. Cressler[3], D. McMorrow[1]

1. U.S. Naval Research Laboratory, USA
2. Jacobs, Inc., USA
3. Georgia Institute of Technology, USA
4. Raytheon, USA

Single-event transients were measured in SiGe HBTs using carrier injection via two-photon absorption (TPA) at different wavelengths. Experiments and simulations indicate that the choice of wavelength has important implications for ion/laser correlation when using TPA.

POSTER PAPERS

PA-1 Influence of Radiation Environment Variability on Cumulative Heavy-Ion-Induced Leakage Current in SiC Power Devices

R. A. Johnson[1,2], A. F. Witulski[1], K. F. Galloway[1], B. D. Sierawski[1], A. L. Sternberg[1], M. L. Alles[1], D. R. Ball[1], R. A. Reed[1], R. D. Schrimpf[1], J. M. Hutson[1,3], J.-M. Lauenstein[4]

1. Vanderbilt University, USA

2. Ball Aerospace, USA

3. Lipscomb University, USA

4. NASA GSFC, USA

Previously reported methods for characterizing SELC in SiC devices are used to translate environmental fluence spectra into cumulative leakage current increases. Shielding thickness and operating voltage are shown to influence the cumulative leakage current increase.

PA-2 Effect of Biased Field Rings to Improve Charge Removal After Heavy Ion Strikes in Vertical Geometry β-Ga_2O_3 Rectifiers.

R. Sharma[1,2], M. E. Law[1], F. Ren[1], S. J. Pearton[1]

1. University of Florida, USA

2. Infineon, USA

The response to a heavy-ion strike and the resulting single effect burnout on beta-Ga_2O_3 Schottky diodes with biased field rings is investigated via TCAD. The charge removal after simulated heavy-ion strikes is greatly improved.

PA-3 Examination of Trapping Effects on Single Event Transients in GaN HEMTs

T. Nelson[1], D. G. Georgiev[1], M. R. Hontz[2], R. Khanna[1], A. Ildefonso[3], A. D. Koehler[3], A. Khachatrian[3], D. McMorrow[3]

1. University of Toledo, USA

2. Naval Surface Warfare Center, Philadelphia Division, USA

3. U.S. Naval Research Laboratory, USA

The role of threading dislocations on single event radiation effects in GaN HEMTs is examined. Threading dislocations are introduced into a calibrated TCAD model via cylindrically symmetric trap profiles and compared against pulsed laser data.

PA-4 Using Track Structure Theory to Calculate Proton Cross-Sections from Heavy-Ion Data

D. L. Hansen[1], B. Vermeire[1]

1. Space Micro, USA

This paper uses track structure theory for the calculation of proton SEU cross-sections from heavy-ion data. Evaluating the model using data in the published literature gives a good agreement between calculated and measured values.

PA-5 **Mechanisms of Heavy Ion-, Focused X-Ray-, and Pulsed Laser-Induced Single Event Transients in an Epitaxial Silicon Diode**

K. L. Ryder[1,2], L. D. Ryder[1,2], A. L. Sternberg[2], J. A. Kozub[2], E. X. Zhang[2], S. D. Lalumondiere[3], D. M. Monahan[3], J. P. Bonsall[3], A. Khachatrian[4], S. Buchner[4], D. McMorrow[4], J. M. Hales[4], Y. Zhao[5], L. Wang[5], C. Wang[5], R. A. Weller[2], R. D. Schrimpf[2], S. M. Weiss[2], R. A. Reed[2]

1. NASA Goddard Space Flight Center, USA

2. Vanderbilt University, USA

3. Aerospace Corporation, USA

4. U.S. Naval Research Laboratory, USA

5. Beijing Microelectronics Technology Institute, China

Mechanisms of heavy ion, focused X-ray, and pulsed laser SET experiments are identified, confirming the role of potential modulation. Differences in charge generation distributions are responsible for observed differences in device response.

10:00 AM – 10:30 AM
EXHIBIT HALL A-B-C

BREAK

SESSION B **SINGLE EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS**

10:30 AM SESSION INTRODUCTION

Chair: Jeffrey Black, Sandia National Laboratories

B-1 10:35 AM **Radiation-Induced Faults Propagation in Quantum Bits and Quantum Circuits**

D. Oliveira[1], E. Auden[2], P. Rech[3]

1. Federal University of Paraná, Brazil

2. Los Alamos National Laboratory, USA

3. University of Trento, Italy

Through GEANT4 simulations and circuit-level fault-injection we investigate neutron-induced faults generation and propagation in quantum circuits. We discuss the fault model for quantum bits and how to measure the faults impact in the circuit output.

B-2 10:50 AM **Towards Predicting Single-Event Transients in an Operational Amplifier Using a Quasi-Bessel Beam Pulsed-Laser Approach**

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

1. U.S. Naval Research Laboratory, USA

The prediction of heavy-ion-generated single-event transients in an operational amplifier is explored using a quasi-Bessel beam pulsed-laser approach. By tuning to the appropriate laser-equivalent LET, the complicated transient response is accurately reproduced.

B-3 11:05 AM

Low-Energy Ion-Induced Single-Event Burnout in Gallium Oxide Schottky Diodes

R. Cadena[1], D. R. Ball[1], R. D. Schrimpf[1], D. M. Fleetwood[1], R. A. Reed[1], M. L. Alles[1], M. W. McCurdy[1], S. T. Pantelides[1], K. F. Galloway[1], A. F. Witulski[1], E. Farzana[2], J. Speck[2]

1. Vanderbilt University, USA

2. University of California Santa Barbara, USA

Low-energy ion-induced single-event burnout is experimentally observed in β-Ga_2O_3 Schottky diodes at 10% of device lectrical breakdown voltage. TCAD simulations suggest that the SEB is due to ion-induced impact ionization.

B-4 11:20 AM

Characterizing Deep Neural Networks Neutrons-Induced Error Model

F. Fernandes dos Santos[1], A. Kritikakou[1], O. Sentieys[1], P. Rech[2]

1. INRIA, France

2. University of Trento, Italy

We characterize the fault models for Deep Neural Networks (DNNs) in GPUs exposed to neutrons. We observe tolerable and critical errors and show that ECC is not effective in reducing critical errors.

B-5 11:35 AM

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

Y. Xiong[1], N. Pieper[1], A. Feeley[1], B. Narasimham[2], D. Ball[1], B. Bhuva[1]

1. Vanderbilt University, USA

2. Broadcom, USA

Single event cross-section scaling trends for bulk FinFET nodes are experimentally investigated for D-FF designs with different threshold-voltage options. Results for operating voltage and particle LET show a trend reversal at the 5-nm node.

POSTER PAPERS

PB-1

SEEs Analysis of Placement Solutions for Multi-Core Accelerators on Xilinx UltraScale+ Under Proton Irradiation Test

A. Portaluri[1], S. Azimi[1], C. De Sio[1], D. Rizzieri[1], E. Vacca[1], L. Sterpone[1], D. Merodio Codinachs[2], C. Poivey[2]

1. Politecnico di Torino, Italy

2. European Space Agency, Netherlands

We performed a high-energy proton radiation campaign in order to analyze how different placement layouts of multiple accelerator processing cores can affect the single-event-effect sensitivity of radiation-induced errors on Xilinx Ultrascale+ SRAM-based FPGAs.

PB-2

Single-Event Upset and Transient Response in 22-nm Fully Depleted Silicon-on-Insulator Logic

J. D'Amico IV[1], S. Vibbert[1], A. Watkins[1], B. Fahrenkrug[1], T. Haeffner[1], D. Ball[1], A. Sternberg[1], J. Kauppila[1], L. Massengill[1]

1. Vanderbilt University, USA

Single-event upset and single-event transient responses of logic in a planar 22-nm fully depleted SOI technology are presented alongside several parameters affecting this response. Results indicate relatively small single-event cross sections compared to other technologies.

PB-3 **Impact of Low Energy, Low-Range Ions on Failure Rate Considerations in SiC Power Diodes**

A. Sengupta[1], D. Ball[1], A. Witulski[1], R. Schrimpf[1], K. Galloway[1], R. Reed[1], M. Alles[1], M. McCurdy[1], A. Sternberg[1], R. Johnson[2], M. Howell[1]

1. Vanderbilt University, USA

2. Ball Aerospace, USA

Experimental and simulated heavy-ion responses of SiC power diodes are presented. Results indicate that ions having range less than the epitaxial thickness do not cause degradation or catastrophic failure even above the rated breakdown voltage.

PB-4 **SRAM Multi-Cell Upset Vulnerability at the 5-nm FinFET Node**

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

1. Vanderbilt University, USA

2. Synopsis, USA

Single-event multi-cell upsets for single-port and two-port SRAM designs as a function of supply voltage for different radiation beams are characterized at the 5-nm bulk FinFET node.

PB-5 **Depth-Dependent Single-Event-Effect Analysis of a COTS 3D-Integrated Imager**

M. Hu[1], F. Padgett III[1], M. McCurdy[1], R. Schrimpf[1], R. Reed[1], M. Alles[1]

1. Vanderbilt University, USA

The area of observed pixels impacted by single alpha particles in a heterogeneously integrated COTS 3D-IC imager is determined by onboard image processing. Spatial profiling reveals SEL in peripheral circuitry of the sandwiched DRAM layer.

PB-6L **The Impact of Inductor Sensitivity and Single-Event Frequency Transients in LC-tank Oscillators**

J. Prinzie[1], G. Adom-bamfi[1], S. Biereigel[2]

1. KU Leuven, Belgium

2. CERN, Switzerland

This paper presents a novel radiation effect in on-chip inductors. Experimental results from irradiation with heavy-ions and protons are shown. A discussion is made on the impact of the PLL bandwidth and system level implications.

11:50 AM - 1:00 PM LUNCH
EXHIBITS ARE OPEN IN HALLS A-B-C

SESSION C **SPACE AND TERRESTRIAL ENVIRONMENTS**
1:00 PM SESSION INTRODUCTION
Chair: Gregory Ginet, MIT Lincoln Laboratory

C-1 **Charging Current and Proton Flux Measurements from Medium Earth**
1:05 PM **Orbit and the Slot Region**
A. Hands[1], K. Ryden[1], P. Morris[2], C. Dyer[3]
1. University of Surrey, United Kingdom
2. Airbus Defence and Space, United Kingdom
3. CSDRadConsultancy, United Kingdom

We present radiation measurements from the sister instruments Merlin and CREDANCE. 18 years of directly comparable data from medium Earth orbit and the slot region reveal new insights into the trapped radiation environment.

C-2 **Initial In-flight Error Rates for 16 MB SRAM as Flying on the Double**
1:20 PM **Asteroid Redirection Test (DART) Mission**
J. Likar[1], C. Pham[1], D. Wilson[1], A. Coburger[1], J. Atchison[1], J. Porter[1]
1. JHU APL, USA

Initial in-flight SRAM SBE error rates are compared to a series of rate prediction methods in an effort to demonstrate methods for uncertainty propagation and reduction.

C-3 **Single Event Effects and Total Dose Considerations for NASA's Interstellar**
1:35 PM **Probe mission**
J. Likar[1], M. Donegan[1], J. Porter[1], J. Kinnison[1], A. Haapala[1]
1. JHU APL, USA

Single event effects and total ionizing dose design and operational impacts are considered for an ambitious, >50 year, mission to the Local Interstellar Medium.

1:50 PM – 2:30 PM BREAK
EXHIBIT HALL A-B-C

SESSION D **BASIC MECHANISMS AND RADIATION EFFECTS**
2:30 PM SESSION INTRODUCTION
Chair: Daisuke Kobayashi, ISAS/JAXA

D-1 **Non-Linear Coupling Effects in Fully Depleted SOI Transistors**
2:35 PM
M. Spear[1], H. Barnaby[1], T. Wallace[1], J. Solano[1], D. Wilson[1], O. Forman[1], I. Sanchez Esqueda[1], A. Privat[2], M. Turowski[3], R. VonNiederhausern[4]
1. Arizona State University, USA
2. IceMOS Technology Corporation, USA
3. Alphacore Inc., USA
4. Air Force Research Lab., USA

Experimental results are shown that do not fit the standard threshold-voltage coupling factor between back and front gates in fully depleted SOI transistors. A new derivation of the coupling factor is derived.

D-2 2:50 PM

Low-Frequency Noise and Border Traps in Irradiated nMOS and pMOS Bulk Si FinFETs With SiO_2/HfO_2 Gate Dielectrics

K. Li[1], X. Luo[1], M. Rony[1], M. Gorchichko[1], G. Hiblot[2], S. Huylenbroeck[2], A. Jourdain[2], M. L. Alles[1], R. A. Reed[1], E. X. Zhang[1], D. M. Fleetwood[1], R. D. Schrimpf[1]

1. Vanderbilt University, USA

2. imec, Belgium

Temperature and gate-voltage dependencies of 1/f noise are compared in irradiated nMOS and pMOS FinFETs. Differences are found in the energy dependence of near-interfacial electron and hole traps in SiO_2/HfO_2 gate dielectrics.

D-3 3:05 PM

Total-Ionizing-Dose Effects and Low Frequency Noise in N-type Carbon Nanotube Field-Effect Transistors with HfO_2 Gate Dielectrics

P. Darmawi-Iskandar[1], A. Aaron[1], E. X. Zhang[1], B. L. Bhuva[1], J. S. Kauppila[1], J. L. Davidson[1], M. L. Alles[1], D. M. Fleetwood[1], L. W. Massengill[1]

1. Vanderbilt University, USA

TID irradiation leads to significant radiation-induced charge trapping in carbon nanotube FETs. Percolation-path switching and border traps contribute to low-frequency noise, with a more prominent role for border traps after irradiation.

D-4 3:20 PM

The Effect of 20 MeV Electron Radiation on Long Term Reliability of SiC Power MOSFETs

K. Niskanen[1], A. Javanainen[1], H. Kettunen[1], M. Lahti[1], M. Rossi[1], J. Jaatinen[1], D. Soderstrom[1], S. Lüdeke[1]

1. University of Jyväskylä, Finland

The effect of 20 MeV electron radiation on the lifetime of the silicon carbide power MOSFETs was investigated. Accelerated stress was applied on the pristine and irradiated devices and time-to-breakdown of gate oxide were compared.

D-5 3:35 PM

In-Situ Measurement of 1.8MeV Proton Radiation Effects on Comb-Drive MEMS Resonators

J. Lee[1], M. McCurdy[2], R. Reed[2], R. Schrimpf[2], M. Alles[2], P. Feng[1]

1. University of Florida, USA

2. Vanderbilt University, USA

We report on the first in-situ measurement of proton radiation effects on vibrating comb-drive microelectromechanical resonators built on silicon-on-insulator (SOI) technology. The devices exhibit high responsivity to proton radiation while maintaining robust resonance operations.

POSTER PAPERS

PD-1

Transient Measurement of Radiation-Induced Interface Traps Based on Non-Equilibrium Body Potential Under Pseudo-MOSFET Configuration

T. Zhang[1], F. Liu[2], Y. Huang[2], S. Chen[2], J. Zhang[2], X. Zhang[2], Y. Li[2], Y. Wang[2], Z. Zheng[2], F. Zhao[2], B. Li[2]

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

A new transient method has been adapted to estimate the interface-trap density induced by radiation for SOI. This method relies on non-equilibrium body potential, which shows advantages in fast testing and simple data processing.

PD-2 **Correlating Percent In-Package Hydrogen to Hydrogen Concentration in Oxide After Ionizing Radiation Exposure**

P. Apsangi[1], S. Roark[1], A. Privat[1], H. Barnaby[1], H. Hjalmarson[2], K. Muthuseenu[1], K. Holbert[1]

1. Arizona State University, USA

2. Sandia National Laboratories, USA

Radiation-induced interface trap buildup is a strong function of hydrogen content in the semiconductor materials, which is quantitatively mapped to percent of hydrogen in the semiconductor packaging using a combination of experimental and simulation-based approaches.

PD-3 **Transient Photocurrent from High-Voltage Vertical GaN Diodes Irradiated with Electrons: Simulations and Experiments**

S. Koukourinkova-Duncan[1], W. Wampler[1], A. Colon[1], B. Doyle[1], G. Vizkelethy[1], G. Pickrell[1], E. Bielejec[1]

1. Sandia National Laboratories, USA

Simulations of the transient photocurrent in gallium nitride vertical diodes produced by electron irradiation are compared to experimental results. The simulations uncover the true diode response and physical mechanisms obscured by circuit effects in experiments.

PD-4 **Improvement in Performance of Carbon Nanotube Field-Effect Transistors Under Electron Irradiation**

M. Li[1], H. Zhu[1], S. Chen[1], Y. Tang[1], H. Shu[1], S. Peng[2], B. Li[1], J. Zhang[3], F. Zhao[1]

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

2. High-Frequency High-Voltage Device and Integrated Circuits R&D Center, Institute of Microelectronics, Chinese Academy of Sciences, China

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

Effects of electron irradiation on CNT-FETs were investigated. Significant improvements in device uniformity and electrical parameters were observed. The decomposition of organics and adsorbates on CNT surface after irradiation contributes to the device performance improvement.

3:50 PM END OF TUESDAY SESSIONS

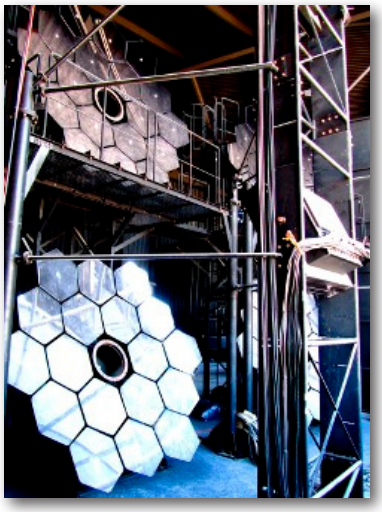
5:30 – 7:00 PM
EXHIBITOR RECEPTION

EXHIBIT HALL A-B-C

BALLROOM B-C
INVITED TALK
8:30 - 9:35 AM

Ultra High Energy Cosmic Rays in Utah

Pierre Sokolsky, Distinguished Professor of Physics and Astronomy Emeritus, University of Utah, Salt Lake City, Utah



The flux of cosmic rays bombarding the Earth's atmosphere from beyond our solar system extends over eleven orders of magnitude to above 10^{20} eV. The study of the highest energy cosmic rays (above 10^{17} eV) is difficult because of the extremely low flux (1/km^2/century at the highest energies). Detection techniques which can cover thousands of square kilometers have been developed to pursue this. I will describe the pioneering research done in Utah over the last 40 years utilizing the air fluorescence technique as well as very large area ground arrays of scintillation detectors. Since the 1980s a series of experiments, the Fly's Eye, the High-Resolution Fly's Eye, the Telescope Array, and Telescope Array x 4, have been deployed in the west deserts of Utah. Results from these experiments, as well as the complementary Auger detector array in Argentina, have helped to elucidate the nature and origin of these mysterious particles. Recent data point to an extra-galactic origin, associated with the large-scale structure of the universe. However, significant puzzles remain, including the observation of a few extraordinary events of macroscopic energy (3.6 x 10^{20} eV or ~ 50 Joules) which do not seem to be associated with any known sources.

Pierre Sokolsky, Distinguished Professor of Physics and Astronomy Emeritus at the University of Utah, received his PhD in Experimental Particle Physics from the University of Illinois in 1973. He was an Assistant Professor at Columbia University where he was involved in pioneering neutrino experiments at Brookhaven National Laboratory. In 1982, he moved to the University of Utah to join the Fly's Eye Detector group that was developing the first successful implementation of the atmospheric air-fluorescence technique to study ultra-high energy cosmic rays. Since then, he has played a leading role in a series of upgrades and expansions of the technique, including the High-Resolution Fly's Eye (HiRes), Telescope Array (TA), Telescope Array Low Energy Extension (TALE), and the Telescope Array expansion (Tax4).

This series of experiments resulted in significant discoveries relating to the nature of ultra-high energy cosmic rays. These include the first observation of the Greisen-Zatsepin-Kuzmin cutoff in the cosmic ray spectrum, predicted to occur due to the interaction of particles with the cosmic black-body radiation, the determination of the cosmic ray composition, and the observation of significant anisotropy in the arrival direction of cosmic rays in the Northern Hemisphere.

He is a Fellow of the American Physical Society, and has received Sloan Foundation and Guggenheim Foundation Fellowships. Recipient of the Wolfgang Panofsky Prize of the American Physical Society for the development of the air fluorescence technique, he is the author of the book "Introduction to Ultrahigh Energy Cosmic Ray Physics" and co-editor of "Large Area Networked Detectors for Particle Astrophysics." He was Chair of the University of Utah Physics Department from 2002 to 2006 and Dean of the College of Science from 2007-2014.

BALLROOM B-C

SESSION E **HARDNESS ASSURANCE**

9:35 AM SESSION INTRODUCTION

Chair: Christian Poivey, ESA

E-1 9:40 AM **Detection of Single Event Transients in Arbitrary Waveforms Using Statistical Window Analysis**

J. Carpenter[1], B. Dean[1], R. Young[1], S. Lawrence[1], D. Reising[1], D. Loveless[1]

1. University of Tennessee at Chattanooga, USA

A statistical window-analysis methodology, Ionizing Radiation Effects Spectroscopy (IRES), is demonstrated to detect anomalies within arbitrary waveforms. IRES does not require thresholding and identifies SETs within analog, digital, and RF signals.

E-2 9:55 AM **Correlation on Different Radiation Sources for Neutron-Induced SE tests at the 5-nm Node**

Y. Chiang[1], B. Bhuva[2]

1. Taiwan Semiconductor Manufacturing Company, Ltd., Taiwan

2. Vanderbilt University, USA

The work presents the correlation on SEU test between terrestrial neutrons, D-T neutrons, and protons by Monte-Carlo simulation and silicon validation in N5 flip flop. D-T neutron is recommended to proxy terrestrial neutron.

POSTER PAPERS

PE-1 **Fragmented High-Energy Heavy Ion Beams for Electronics Testing**

R. Garcia[1], K. Bilko[1], F. Cerutti[1], A. Coronetti[1], L. Esposito[1], S. Francesc[1], W. Andreas[1], F. Saigne[2]

1. CERN, Switzerland

2. Institut d'Electronique du Sud, Université de Montpellier II/CNRS, France

Fragmented heavy ion beams obtained from the interaction of highly energetic ions with cm thick targets are proposed to mimic the LET spectrum present in space and test electronics.

PE-2 **Monte-Carlo Tools for Assessing SEE Data Quality for Different Types of Analyses**

R. Ladbury[1]

1. NASA GSFC, USA

We apply a Monte-Carlo tool using a simplified GLM SEE data-fitting routine to assess how data quality affects SEE rate bounding, estimation and determination of fit parameters for σ vs. LET.

PE-3 **Comparison of Neutron Radiation Testing Approaches for a Complex SoC**

W. Stirk[1], E. Poff[1], J. Smith[1], J. Goeders[1], M. Wirthlin[1]

1. BYU, USA

We present bare-metal and Linux approaches to measuring the radiation sensitivity of SoC devices. The methods test individual components in round-robin fashion. Results from both methods match each other and expected values, supporting their validity.

10:10 AM – 10:40 AM BREAK
EXHIBIT HALL A-B-C

SESSION F **PHOTONIC DEVICES AND INTEGRATED CIRCUITS**
10:40 AM SESSION INTRODUCTION
Chair: Cedric Virmontois, CNES

F-1 **Proton-Induced Displacement Damage in 2D and Stacked CMOS**
10:45 AM **SPADs: Study of DCR Degradation**
A. Jouni[1,2,3], M. Sicre[2], V. Malherbe[2], B. Mamdy[2], J. Belloir[1], D. Soussan[2], S. De Paoli[2], G. Gasiot[2], V. Goiffon[3], V. Lalucaa[1], V. Lorquet[2], C. Virmontois[1]
1. CNES, France
2. STMicroelectronics, France
3. ISAE-SUPAERO, France

Displacement damage effects produced by proton irradiation on 40-nm CMOS SPADs are studied for different biasing conditions. Mean dark count rate increase and activation energy measurements are performed to characterize the induced bulk defects.

F-2 **Electric Field Enhanced Generation Current in Proton-Irradiated**
11:00 AM **InGaAs Photodiodes**
M. Benfante[1,2,3,4], O. Gilard[2], J. Reverchon[1], C. Durnez[2], V. Goiffon[3], S. Demiguel[4], T. Dartois[4], C. Virmontois[2]
1. III-V Lab, France
2. CNES, France
3. ISAE Supaero, France
4. Thales Alenia Space, France

The degradation of the dark current due to proton irradiation is studied on InGaAs PIN photodiodes. The combination of dark current and capacitance measurements allows extracting an electric field dependent damage factor.

F-3 **Design, Annealing, and Electric Field Effects on a Proton Irradiated**
11:15 AM **MWIR HgCdTe Focal Plane Array**
S. Dinand[1], N. Baier[2], E. De Borniol[2], C. Durnez[3], V. Goiffon[4], O. Gravrand[2], S. Rizzolo[5], O. Saint-Pé[5], C. Virmontois[3]
1. Airbus DS, CEA Leti, ISAE-SUPAERO, France
2. CEA-Leti, France
3. CNES, France
4. ISAE-SUPAERO, Université de Toulouse, France
5. Airbus Defense and Space, France

This work presents the performance degradation of a multi pixel-designs n/p mid-wavelength infrared HgCdTe focal plane array, induced by both total ionizing dose and displacement damage dose through proton irradiation and annealing.

F-4 11:30 AM

Influence of the Irradiation Protocol on the Degradation of the Electrical Performances of MidWave InfraRed T2SL Detectors

C. Bataillon[1], J. Perez[1], R. Alchaar[1], O. Saint-Pe[2], O. Gilard[3], P. Christol[1]

1. Institut d'Electronique et des Systèmes, France

2. Airbus Defense and Space, France

3. Centre National des Etudes Spatiales, France

Irradiations were performed with 60 MeV protons and fluences up to $8x10^{11}$ H^+/cm^2 on T2SL detector at 100 K or 300 K, showing a different degradation of the electrical performances according to the temperature of detector during irradiation.

F-5 11:45 AM

Temperature Dependence of Radiation-Induced Attenuation of Fluorine- Doped Optical Fibers at InfraRed Wavelengths

A. Morana[1], C. Campanella[1], G. Melin[2], T. Robin[2], E. Marin[1], A. Boukenter[1], Y. Ouerdane[1], S. Girard[1]

1. Laboratory Hubert Curien, France

2. iXblue, France

Combined temperature and radiation effects on F-doped fiber transmission in the IR are studied between -80 °C and 80 °C, up to 10 kGy(SiO_2) dose. Losses are slightly higher at -80 °C than at 20 °C.

POSTER PAPERS

PF-1

Radiation Effects on Microlenses, Color Filter Arrays, and Polarizing Filters in CMOS Image Sensor

C. Virmontois[1], A. Antonsanti[1,2], V. Lalucaa[1], C. Durnez[1], P. Panuel[1], V. Goiffon[2], M. Estribeau[2], O. Saint-Pé[3], E. Berdin[3], F. Larnaudie[3], L. Chavanne[1], J. Belloir[1]

1. CNES, France

2. ISAE-SUPAERO, France

3. Airbus, France

In addition to providing insights on dark current degradation after irradiation in modern CIS, this work studies the response of optical systems at the pixel level such as color filter arrays, polarized filters, and microlenses.

PF-2

Characterization of Single-Photon Avalanche Diodes Under High Proton Irradiation

M. Wu[1], E. Ripiccini[1], C. Fenoglio[1], F. Gramuglia[1], P. Keshavarzian[1], E. Kizilkan[1], E. Charbon[1]

1. EPFL, Switzerland

We characterized SPAD under 10 and 100 MeV proton irradiation up to DDD of 1 PeV/g. We focused our study on DCR and after-pulsing, which appear to be sensitive to low-energy protons and high flux.

PF-3

Laser Annealing Protocols for Healing Radiation-Damaged Single-Photo Detectors

J. Krynski[1], N. Sultana[1], Y. Lee[2], T. Jennewein[1], J. Lim[1], V. Makarov[1,3]

1. University of Waterloo, Canada

2. Photonic Inc., Canada

3. Russian Quantum Center, Russian Federation

Radiation-induced dark count rate in previously irradiated silicon avalanche photo diodes is significantly reduced in a thermal vacuum environment through annealing of the detector active area with a high-power laser using varying annealing protocols.

PF-4 **Direct Measurement of Total-Ionizing-Dose-Induced Phase Shift in Commercial, Integrated Silicon-Photonic Waveguides**

G. Tzintzarov[1], J. Teng[1], D. Nergui[1], S. Lalumondiere[2], D. Monahan[2], J. Cressler[1]

1. Georgia Tech, USA

2. Aerospace Corporation, USA

Silicon photonic waveguides were exposed to a micro-beam x-ray source. Non-monotonic radiation-induced phase shifts were measured. Causes and physical mechanisms are discussed.

PF-5 **Functionalized Microstructured Optical Fiber for Magnetic-field Sensing in Radiation Environments**

A. Dufour[1], D. Jamon[1], E. Marin[1], S. Neveu[2], F. Arnould[1], A. Morana[1], S. Girard[1], F. Royer[1]

1. Laboratoire Hubert Curien, France

2. Laboratoire PHENIX, France

A functionalized microstructured optical fiber displaying important polarimetric magneto-optical effects underwent 350 kGy X-ray irradiation with a 10 Gy/s(SiO_2) dose rate. In-situ effects were monitored to study its resistance to harsh environments.

PF-6 **Linear and Nonlinear Optical Properties of Fused Silica and Sapphire in Extreme Radiation and Thermal Environments**

B. Morgan[1], M. Van Zile[2], C. Petrie[3], P. Sabharwall[4], M. Burger[1], I. Jovanovic[1]

1. University of Michigan, USA

2. Ohio State University, USA

3. Oak Ridge National Laboratory, USA

4. Idaho National Laboratory, USA

We report the initial results from post-irradiation examination of bulk optical materials exposed to simultaneous effects of irradiation and thermal annealing, examined by a Z-scan experiment to measure nonlinear optical properties, and linear absorption experiment.

PF-7 **Perovskite $CsPbBr_3$ Single Crystal Detector Stability and Polarization Under High Flux X-ray irradiation**

L. Pan[1], Y. He[1], I. Pandey[1], A. Miceli[2], D. Chung[2], V. Klepov[1], M. De Siena[1], M. Kanatzidis[1,2]

1. Northwestern University, USA

2. Argonne National Laboratory, USA

The performance, regarding signal stability and polarization, of melt grown $CsPbBr_3$ detectors under X-ray flux of 10^5-10^9 photons/s/mm^2 was experimentally investigated with detector working in pulse mode or current mode.

PF-8L **Influence of ambient light on the radiation-induced attenuation of germanosilicate optical fibers at the telecommunication wavelengths**

C. Campanella[1], A. Morana[2], A. Meyer[3], F. Mady[4], M. Benabdesselam[4], H. Desjonqueres[5], S. Poirier[5], C. Monsanglant-louvet[5], E. Marin[2], Y. Ouerdane[2], A. Boukenter[2], S. Girard[6]

1. *Laboratoire Hubert Curien, France*
2. *Laboratory Hubert Curien, France*
3. *Université Jean Monnet, France*
4. *Institut de Physique de Nice, France*
5. *Institut de Radioprotection de Sûrete Nucléaire (IRSN), France*
6. *Université de Saint Etienne, France*

The influence of ambient light on the Radiation-Induced Attenuation (RIA) levels and kinetics of germanosilicate optical fibers at the telecommunication wavelengths is investigated, revealing the importance of this environmental parameter when performing RIA measurements.

EXHIBIT HALL A-B-C
12:00 PM – 1:30 PM EXHIBITOR LUNCH AND RAFFLES

RADIATION EFFECTS DATA WORKSHOP
1:30 PM - 4:30 PM
CASCADE C-D-E

INTRODUCTION

Chair: Zachary Fleetwood, SpaceX

DW-1 **Neutron-Induced SEEs in the Xilinx Versal Prime**

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

1. *LANL, USA*
2. *University of Texas, USA*
3. *SNL, USA*

Results for neutron testing of the 7-nm Xilinx Versal Prime are presented. Results show an improvement in neutron sensitivity from previous Xilinx parts and other manufacturer's microprocessors.

DW-2 **Proton Induced Single Event Effects on the Arria 10 Commercial Off-the-Shelf CMOS Field Programmable Gate Array**

R. Koga[1], S. Davis[1], A. Yarbrough[1], J. Shanney[1], K. Pham[1], C. Cao[1], K. Pham[1]
1. The Aerospace Corporation, USA

We present observations of proton induced single event effects on the Arria 10 commercial off-the-shelf CMOS FPGA at three proton energy levels. The SRAM-based FPGA was sensitive to protons below 50 MeV.

DW-3 **64MeV Proton Single-Event Evaluation of Xilinx Single Event Mitigation (XilSEM) Firmware on Xilinx 7-nm ACAP Devices**

Y. Chen[1], P. Maillard[1], R. Devi Veggalam[1], S. Reddy Madem[1], E. Crabill[1], J. Barton[1], M. Voogel[1]
1. Xilinx, Inc, USA

Xilinx Single Event Mitigation (XilSEM) firmware shows SEFI immunity on Xilinx 7nm ACAP™ characterized using a 64 MeV proton source. XilSEM CRAM scrubbing and NPI scanning functionality and error coverage is presented.

DW-4 **Neutron and > 60MeV Proton Characterization of Xilinx 7nm VersalTM Multicore Scalar Processing System (PS)**

P. Maillard[1], Y. Chen[1], J. Arver[1], A. Shui[1], M. Voogel[1], V. Merugu[1]
1. Xilinx, Inc, USA

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

DW-5 **Compendium of Current Heavy Ion Single-Event Effects Test Results for Candidate Electronics for NASA Johnson Space Center**

J. Pritts[1], R. Gaza[1], C. Bailey[1], N. Kyson[1]
1. NASA JSC, USA

We present radiation effects test results and analysis produced by NASA JSC in 2021 for candidate electronic components and devices. Devices tested include integrated circuits, MOSFETs, DC-DC converters, and various commercial solutions.

DW-6L **Extended Compendium of Total Ionizing Dose (TID) Test Results for the Europa Clipper Mission**

S. Zajac[1], A. Bozovich[1], R. Davies[2], A. Woo[1], B. Rax[1], J. Davila[1], D. Nguyen[3], W. Parker[1], A. Kenna[1], J. Thomas[1]
1. NASA JPL, USA
2. University of St. Thomas, USA
3. Northrop Grumman, USA

Results of total ionizing dose (TID) tests and analysis on Electric, Electronic, and Electromechanical (EEE) parts, performed by the Jet Propulsion Laboratory in support of the Europa Clipper Mission.

DW-7 **A Study of Neutron Induced Single-Event Damage in AlGaN/GaN HEMTs**

H. Gao[1], D. Ahsanullah[1], R. Baumann[1], B. Gnade[1]

1. Southern Methodist University, USA

Accelerated neutron study results of gallium nitride power devices are reported. Hundreds of devices were irradiated while stressed with drain voltages of up to 400V. The observed failures enable an accurate assessment of terrestrial reliability.

DW-8L **100SW1502 Optocoupler TID & DDD Tests**

Z. Olson[1], R. Monreal[1], J. Vloet[1]

1. Southwest Research Institute, USA

A novel optocoupler 100SW1502 was developed in-house and tested for various parameter degradations at doses up to 300 kRad TID and 1.510^{12} n/cm2 DDD.

DW-9 **Characterization of the Effects of 250 MeV Proton-Induced Total Ionizing Dose and Displacement Damage on the 66266 Optocoupler**

S. Messenger[1], M. Mishler[1], J. Hack[1], P. Dudek[1]

1. Northrop Grumman Corporation, USA

This paper explores the combined effects of total ionizing and displacement damage dose caused by 250 MeV protons on the Micropac 66266 optocoupler. Proton fluences up to 4×10^{12} p^+/cm^2 were used for this radiation test.

DW-10L **Single Event Effects Susceptibilities of Select Commercial-Off-The Shelf Components for Space**

D. Lo[1], T. Tran[1]

1. Northrop Grumman Systems Corporation, USA

We report the results of single event effects (SEE) testing with heavy ions of COTS (commercial-off-the-shelf) electronic components considered for space missions.

DW-11 **Single Event Upset and Total Ionizing Dose Response of 12LP FinFET Digital Circuits**

J. Neuendank[1], M. Spear[1], T. Wallace[1], D. Wilson[1], J. Solano[1], G. Irumva[1], I. Sanchez Esqueda[1], H. Barnaby[1], L. Clark[1], J. Brunhaver[1], M. Turowski[2], E. Mikkola[2], D. Hughart[3], J. Manuel[3], S. Agarwal[3], B. Vaandrager[3], G. Vizkelethy[3], M. King[3], M. Marinella[3]

1. Arizona State University, USA

2. Alphacore Inc, USA

3. Sandia National Laboratories, USA

Experimental results showing the total ionizing dose response of 12-nm bulk FinFET digital circuits to 60 keV x-ray are presented. Single event upset cross-sections vs. ion linear energy transfer for digital flip-flop chains are extracted.

DW-12 **SET Characterization of a High and Low Side Gate Driver (RIC7S113) Using Pulsed Laser and Heavy Ion Testing**

J. Warner[1], E. Faraci[2], C. Pham[1]

1. JHUAPL, USA

2. IR HiRel, an Infineon Technologies Company, USA

The SET response of the RIC7S113 gate driver was characterized using pulsed laser and heavy ion accelerator testing. The SET response between the two methods are compared.

DW-13 Neutron-Induced Single-Event Effects and Total Ionizing Dose Response in Embedded Radios

E. Auden[1], M. Caffrey[1]

1. Los Alamos National Laboratory, USA

Neutron-induced single-event effects, displacement damage, and total ionizing dose are characterized for a commercial-off-the-shelf embedded radio. The radio's radiation tolerance is investigated as part of an evaluation for possible spaceflight on short-term exploratory satellites.

DW-14 SEL and SEU In-Flight Data from Memories On-Board PROBA-II Spacecraft

C. Poivey[1], R. Harboe-Sorensen[2]

1. ESA, Netherlands

2. RHS consulting, Netherlands

This paper presents an analysis of the SEE in-flight data of memories on board Proba-II spacecraft. Proba-II spacecraft has been flying on a LEO orbit since November 2009. Observed in-flight error rates are compared with predictions based on ground test data.

DW-15 Total Ionizing Dose Response of Commercial 22-nm FD-SOI CMOS Technology

J. Solano[1], D. Wilson[1], T. Wallace[1], O. Forman[1], M. Spear[1], I. Sanchez Esqueda[1], H. Barnaby[1], A. Privat[1], N. Turowski[2], V. Rudolf[3]

1. Arizona State University, USA

2. Alphacore, USA

3. Spacecraft Component Branch, Air Force Research Lab, USA

Experimental results showing the response of 22-nm fully depleted silicon on insulator devices (FD-SOI) are presented. Gate voltage shift at a constant drain current is extracted and compared across all similar devices of varying widths.

DW-16 Debugging Xilinx Zynq-7000 SoC Processor Caches During Linux System Execution Under Proton Irradiation

J. Mattis[1], J. Budroweit[1], S. Ferdinand[1]

1. DLR e.V., Germany

In this paper we present a deeper insight on the CPU caches of a Zynq-7000 SoC, their influence in a running operating system and possible reasons for their malfunction by using a 230-MeV proton beam.

DW-17 Single Event Characterization of Power Components Under Heavy Ion Irradiation

N. Aksteiner[1], J. Budroweit[1]

1. DLR e.V., Germany

Three power control devices were characterized under heavy ion irradiation. Two LT3007 LDOs showed many transients and breakdown. A single sample of the LT8610 Buck converter showed significant transients. The ADM1270 hot-swap controller showed various SEE.

DW-18 **TID and SEE Evaluation on a Universal Input, 10-Output Low Impedance LVCMOS Buffer**

J. Budroweit[1], N. Aksteiner[1]
1. DLR e.V., Germany

This paper presents the latest TID and SEE test results of the Texas Instruments CDCLVC1310, a universal input, 10-output low impedance LVCMOS buffer.

DW-19 **NASA Goddard Space Flight Center's Recent Radiation Effects Test Results**

A. Topper[1], E. Wilcox[2], M. Casey[2], J. Barth[2], M. Joplin[2], M. Berg[1], T. Carstens[2], M. Campola[2], D. Cochran[1], M. Obryan[1], J. Pellish[2], P. Majewicz[2]
1. SSAI, USA
2. NASA GSFC, USA

Total ionizing dose, displacement damage dose, and single event effects testing were performed to characterize and determine the suitability of candidate electronics for NASA space utilization. Devices tested include FPGAs, optoelectronics, digital, analog, and bipolar devices.

DW-20 **Radiation Assessment of Two Automotive-Grade N-Channel MOSFETs**

J. Ward[1], J. Mckoy[1], I. Jeffrey[1], D. Ross[2], P. Ferguson[1]
1. University of Manitoba, Canada
2. Magellan Aerospace, Canada

Radiation assessment is performed for two automotive-grade N-MOSFETs for qualification for use in low Earth orbit satellites. Decreases in threshold voltage are observed during total dose screening. Parts may be suitable for use in low Earth orbit satellites.

DW-21 **The Aerospace Corporation's Compendium of Recent Radiation Testing Results**

S.C. Davis[1], A.D. Yarbrough[1], R. Koga[1], A.W. Wright[1], J.A. Shanney[1], K.G. Pham[1], C. Cao[1], K.G. Pham[1], S. Lin[1], B. Dooley[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 performed using protons and heavy ions.

DW-22 **Single Event Effects and Total Ionizing Dose Characterization of a 1.25Gbps LVDS Repeater**

A. Turnbull[1], M. Von Thun[1], E. Serna[1], J. Yount[1]
1. CAES, USA

Single Event Latch-up (SEL), Single Event Transient and Total Ionizing Dose (TID) radiation characterization was performed on a CAES UT54LVDS454 1.25Gbps LVDS repeater. The device was shown to be suitable for space applications.

DW-23 **First Extensive Radiation Characterization of Double Capacitive SiO_2 Isolation Barrier Technology using TI's ISOS141-SEP as a Test Vehicle**

M. Saul[1], R. Gooty[1], S. Williams[1], S. Khan[1], K. Elnashar[1]
1. Texas instruments, USA

Double capacitive SiO_2 isolation is a modern system isolation solution with improved radiation results such as single event latchup, single event dielectric rupture, total ionizing dose, and neutron displacement damage.

DW-24 **Radiation Evaluation of the TPS7H4010-SEP Step-Down Voltage Converter**

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

Single events effects (SEE) characterization results for TPS7H4010-SEP Step-Down Converter are summarized, showing very robust SEE performance up to LET_{EFF}=43 MeV-cm^2/mg.

DW-25 **A Heavy-Ion Single-Event Effects Test Facility at Michigan State University**

S. Lidia[1], T. Glasmacher[1], S. Kim[1], G. Machicoane[1], P. Ostroumov[1], A. Stolz[1]
1. Facility for Rare Isotope Beams, Michigan State University, USA

Michigan State University has commissioned a new SEE test facility based on the recently completed Facility for Rare Isotope Beams superconducting LINAC. We review the facility design, capabilities, and commissioning status.

DW-26 **Displacement Damage and Total Ionizing Dose at High and Low Dose Rate Performance of an Optocoupler**

Z. Yang[1], D. Hiemstra[2], S. Shi[1], C. Jin[1], Z. Li[1], L. Chen[1]
1. University of Saskatchewan, Canada
2. MDA, Canada

Results of proton and Cobalt-60 irradiation of an optocoupler are presented. Performance in the space radiation environment is discussed.

DW-27 **Single Event Upset Characterization of the Intel Movidius Myriad X VPU and Google Edge TPU Accelerators Using Proton Irradiation**

D. Ramaswami[1], D. Hiemstra[2], Z. Yang[1], S. Shi[1], L. Chen[1]
1. University of Saskatchewan, Canada
2. MDA, Canada

Proton induced SEU cross-sections of the Movidius Myriad X VPU and Google Edge TPU are presented. Upset rates in the space radiation environment are estimated and found to be acceptable for low orbit missions.

DW-28 **Guide to the 2021 IEEE Radiation Effects Data Workshop Record**

D. Hiemstra[1]
1. MDA, Canada

The 2021 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

DW-29 **Total Dose Performance at High 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 high dose rate irradiation of isolated switching regulator evaluation kits are provided. Their performance in the space radiation environment is discussed.

DW-30 **Single Event Effect Measurements of Micron Technology 128Gb Single-Level NAND Flash Memory**

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

1. Jet Propulsion Laboratory, USA

Heavy ion single-event measurements on 128Gb Micron Technology single-level NAND flash memory are reported. Two single event effects phenomena were investigated: single bit upsets and single effect functional interrupts.

DW-31 **Neutron Induced Displacement Damage in Commercial Power Management Integrated Circuits**

G. Koli[1], E. Auden[2], H. Quinn[2]

1. Arizona State University, USA

2. Los Alamos National Laboratory, USA

Atmospheric neutrons can produce damaging effects in power management integrated circuits (PMICs). Three commercial PMICs have been irradiated with neutrons to investigate displacement damage effects in low drop-out (LDO) and stepdown (Buck) voltage regulators.

DW-32 **Combined Neutron and TID Results of the Intersil ISL70321SEH**

W. Newman[1], N. van Vonno[1], L. Pearce[1], D. Turner[1]

1. Renesas, USA

We report the combined results of the ISL70321SEH after exposure to 5 x 10^{11}, 2 x 10^{12}, and 1 x 10^{13} neutrons/cm^2 followed by 100 krad(Si) HDR total ionizing dose.

DW-33L **Laser Techniques for Mitigation of Single Event Effects in a PWM Controller**

T. Bernard[1], E. Thomson[1], L. Pearce[1], H. Tim[1], A. Eberts[1]

1. Renesas Electronics America, USA

Presenting the results of the Buck PWM Controller Single Event Functional Interrupts (SEFI) on the initial silicon, and the efforts to discover root cause of the SEFI/SET through diagnostic testing, design simulations, and laser testing.

DW-34 **Radiation Results for Modern GaN-on-Si Power Transistors**

R. Strittmatter[1], B. Sun[1], S. Zhang[1], M. Zafrani[2], A. Lidow[1]
1. Efficient Power Conversion Corporation, USA
2. EPC Space, USA

GaN-on-Si power transistors launched in 2021 and early 2022 specifically designed for high radiation resistance and low dynamic on-resistance are characterized for single event and dynamic on-resistance, demonstrating improvement over all prior generation GaN-on-Si devices.

DW-35 **Single Event Effects Characterization of Microchip Programmable Current Limiting Power Switch LX7712**

M. Leuenberger[1], R. Stevens[1], D. Johnson[1], N. Rezzak[1]
1. Microchip Technology, USA

The heavy ions single event effect characterization results of Microchip Technology's radiation-hardened programmable current limiting power switch IC, the LX7712, are presented. The data shown are based on single event campaign of September 2021

DW-36 **Radiation Evaluation of the DP83561-SP Radiation Hardened, 10/100/1000 Ethernet PHY Transceiver with SEFI Handling Sub-System**

R. Gooty[1]
1. Texas instruments, USA

High reliability gigabit ethernet PHY transceivers designed for the high-radiation environment with SEFI handling sub-system radiation effects are evaluated.

DW-37 **Improving the Total Ionizing Dose and Single Event Performance of a High Voltage 180nm CMOS Trusted Foundry Process**

M. Hamlyn[1], I. Donnelly[1], A. Ghoshal[1], A. Quiroz[1]
1. Apogee Semiconductor, USA

Developing radiation hardened components in 180nm CMOS process is a challenge due to total ionizing dose (TID) effects. TID performance was improved from 30krad to 300krad using TID improved transistors and results will be shown.

DW-38 **Accelerated Nuclear Radiation Effects on the Raspberry Pi 3 B+**

C. Corley[1], H. Quinn[2], E. Swartzlander, Jr.[1]
1. University of Texas, USA
2. LANL, USA

The Raspberry Pi3B+ running Linux-derivative RaspberryPi OS and benchmarks was subjected to radiation testing in the neutron beam at LANSCE. Cross sections for SEUs, SEFIs, and crashes/hangs were recorded. Testing this complex system is discussed.

DW-39 **Raspberry Pi Zero and 3B+ SEE and TID Test Results**

S. Guertin[1], S. Vartanian[1], A. Daniel[1]
1. NASA JPL, USA

We report SEE and TID testing of Raspberry Pi Zero and Raspberry Pi 3B+ computers. SEFI modes, display errors, and file transfer failures dominated the responses.

DW-40 **Total Ionizing Dose and Reliability Evaluation of the ST-DDR4 Spin-Transfer Torque Magnetoresistive Random Access Memory (STT-MRAM)**

S. Vartanian[1], J. Yang-scharlotta[1], G. Allen[1], A. Daniel[1], F. Mancoff[2], D. Symalla[2], A. Olsen[2], D. Costanzo[1]

1. NASA Jet Propulsion Laboratory, USA

2. Everspin Technologies, USA

We present total ionizing dose (TID) evaluation of the Everspin Technologies 1Gb non-volatile ST-DDR4 spin-transfer torque MRAM, and its effects on the reliability of the magnetic tunnel junctions (MTJs).

DW-41L **Total-Ionizing-Dose Effects on Threshold Voltage Distribution of 64-Layer 3D NAND Memories**

M. Kumar[1], M. Raquibuzzaman[1], M. Buddhanoy[1], M. Wasiolek[2], K. Hattar[2], B. Ray[1]

1. University of Alabama in Huntsville, USA

2. Sandia National Laboratories, USA

We measure and model total-ionizing-dose induced threshold voltage (Vt) loss of commercial 64-layer TLC 3-D NAND memory using user-mode commands. Measured data shows Vt loss is linear with TID for the highest programmed Vt.

DW-42 **Total Dose and Ion Beam Radiation Response of Spin-Transfer Torque MRAM**

A. Cao[1], L. Wang[1], J. Zhang[1], C. Gou[1], L. Liu[1], X. Li[1], X. Bi[1], Z. Li[1], X. Han[1], B. Wang[2], Y. Zhao[1]

1. Beijing Microelectronics Technology Institute, China

2. The School of Integrated Circuit Science and Engineering, Beihang University, China

The total dose and ion beam radiation responses of a commercial STT-MRAM are evaluated. The results indicate that MTJ is inherently radiation tolerant, while the peripheral circuit exhibits soft errors during ion beam irradiation.

DW-43 **Temperature Control Equipment for SEE and TID Tests**

A. Bakerenkov[1], V. Felitsyn[2], P. Chubunov[1], A. Koziukov[1], N. Bondarenko[1], M. Maltseva[1]

1. Branch of JSC "United Rocket and Space Corporation" - "Institute of Space Device Engineering", Russian Federation

2. National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Russian Federation

Equipment for temperature control of integrated circuits in the range from -60 °C to +125 °C during radiation tests was developed and described. The equipment can be used for both SEE and TID tests.

4:30 PM END OF WEDNESDAY SESSIONS

6:00 PM (Busses leave 5:30 - 5:50 PM) **CONFERENCE SOCIAL**

Technical Program Thursday

CASCADE A-B
7:00 - 8:15 AM

BREAKFAST WITH YOUNG PROFESSIONALS PRESENTATION
(Ticket Required to Attend)

BALLROOM B-C
INVITED TALK
8:30 - 9:30 AM

Dinosaurs and other Mesozoic critters of Utah – A trip through Deep Time

Professor Brooks Britt, Chair, Geological Sciences, Brigham Young University, Provo, Utah

Utah has long been renowned for its dinosaurs and spectacular geology. I will show you how the BYU Museum of Paleontology's team of paleontologists collects dinosaurs and their cohorts, what the rocks that contain their bones reveal about the ancient environments in which they lived, and how we obtain the ages of the rocks. Contrary to what you've seen in movies, where the rock is quickly brushed from the bones, I will show the reality of excavating – which involves giant bulldozers, high-explosives, and CAT-scans to extract the bones from their stony tombs. Finally, you will learn about a spectacular fossil site located on the edge of a cliff in northeastern Utah - the Saints & Sinners Quarry. There, over 20,000 bones have been collected. These bones represent an array of animals, ranging from dinosaurs to pterosaurs to drepanosaurs. All died of dehydration, along the shores of a drying oasis. This oasis was surrounded by dunes hundreds of feet high in the midst of a desert covering 2.2 million square kilometers some 208-million-years ago.

Brooks is from the Tacoma/Seattle area of Washington State. At the age of 14 he and a cousin planned and executed a dinosaur hunting expedition via bicycle near Vernal, Utah. They found and opened a dinosaur site the first day and they operated it over three summers. Both became paleontologists.

He obtained bachelor's and master's degrees from Brigham Young University (BYU) and a Ph.D. from the University of Calgary/Royal Tyrrell Museum of Paleontology in Alberta, Canada. Before returning to BYU as a professor he was a museum curator and a museum director.

He has worked primarily on theropod and sauropod dinosaurs, but his current focus is a Late Triassic fauna from northeastern Utah and the Early Cretaceous Cedar Mountain Formation fauna.

BALLROOM B-C
SESSION G
9:30 AM

DOSIMETRY
SESSION INTRODUCTION
Chair: Ethan Cascio, Massachusetts General Hospital

G-1 9:35 AM

Charge Collection in SOI Microdosimeters and Their Radiation Hardness

V. Pan[1], L. Tran[1], Z. Pastuovic[2], D. Hill[1], J. Williams[1], M. Povoli[3], A. Kok[3], S. Peracchi[2], D. Boardman[2], S. Guatelli[1], M. Petasecca[1], M. Lerch[1], A. Rosenfeld[1]

1. University of Wollongong, Australia

2. ANSTO, Australia

3. SINTEF, Norway

A negative pulse has been observed in a new batch of SOI microdosimeters originating from the substrate. CCE studies have been conducted to investigate this pulse as well as radiation hardness studies on the device.

G-2 9:50 AM

Mirror-Assisted Radioluminescent Optical Fibers for X-ray Beam Monitoring

J. Vidalot[1],[2], F. Fricano[2], A. Morana[2], C. Campanella[2], D. Lambert[1], J. Michalon[2], Y. Ouerdane[2], A. Boukenter[2], M. Raine[1], P. Paillet[1], S. Girard[2]

1. CEA / université Jean Monnet St Etienne, France

2. Laboratoire Hubert Curien - université Jean Monnet - CNRS UMR 5516 - IOGS - St Etienne - France

We investigate the performances of an Aluminum mirror-assisted radioluminescent nitrogen-doped optical fiber to monitor X-ray fluxes from 0.05 to 1.5 Gy/s.

G-3 10:05 AM

Towards an Embedded and Distributed Optical Fiber-based Dosimeter for Space Applications

A. Meyer[1], A. Morana[1], L. Weninger[1], N. Balcon[2], G. Mélin[3], J. Mekki[2], T. Robin[3], A. Champavère[4], F. Saigné[5], J. Boch[5], T. Maraine[5], A. Aït-ali-saïd[6], E. Marin[1], Y. Ouerdane[1], A. Boukenter[1], S. Girard[1]

1. Université Jean Monnet, France

2. CNES, France

3. iXblue, France

4. GuidOptix, France

5. Université de Montpellier, France

6. TRAD, France

We investigated the performance under γ and X-rays of an optical-fiber-based distributed dosimeter consisting of an embedded Optical Time-Domain Reflectometry (OTDR) interrogator operating at 1610 nm and a phosphorus-doped, single-mode, size-reduced optical fiber.

POSTER PAPERS

PG-1

New Real-Time Fluence Correction Method with SRAM Dosimeter for High Accuracy Single-Event Effect Evaluation System

R. Yoon[1], D. Bae[1], K. Kim[1], S. Chung[1], H. Lee[1], S. Woo[1], C. Cho[1], J. Yoo[1], S. Wender[2], Y. Kim[1]

1. QRT, Republic of Korea

2. LANSCE, USA

Even when there is no beam information, we propose SEE system including reference dosimeter and generalization equation that can be reflected in the SEU measurement with real-time beam analysis.

10:20 AM – 10:50 AM NORTH & EAST PRE-FUNCTION — BREAK

SESSION H — **HARDENING BY DESIGN**
10:50 AM — SESSION INTRODUCTION
Chair: Ethan Cannon, Boeing

H-1 10:55 AM — **An RHBD FPGA with Distributed SEU Sensors, Embedded Error Handler, and Embedded MRAM Configuration Storage in 22nm FinFET CMOS**

O. Kibar[1], A. Atli[2], P. Mohan[2], M. King[3], K. Mai[2]
1. Nvidia, USA
2. Carnegie Mellon University, USA
3. Sandia National Laboratories, USA

This study examines the design and single-event response of a custom-designed RHBD FPGA in a 22nm bulk FinFET process that employs strike sensors and embedded MRAM configuration storage. Heavy-ion single-event upset testing results are presented.

H-2 11:10 AM — **A Radiation Tolerant Charge-Pump PLL with Low Static Phase Offset in 65nm CMOS technology**

J. Prinzie[1], S. Biereigel[2], S. Kulis[2], P. Leitao[2], R. Francisco[2], P. Moreira[2]
1. KU Leuven, Belgium
2. CERN, Switzerland

This paper presents a novel radiation tolerant charge-pump PLL with state-of-the-art static-phase error variability suitable for high-performance clock systems in high-dose radiation environments. The circuit has been experimentally verified with X-rays up to 180 Mrad.

H-3 11:25 AM — **Efficacy of Transistor Stacking on Flip-Flop SEU Performance at 22-nm FDSOI Node**

Z.-R. Li[1], C. Elash[1], C. Jin[1], L. Chen[1], M. Rathore[2], S.-J. Wen[2], R. Fung[2], J.-S. Xing[1], S.-T. Shi[1], Z.-W. Yang[1], B. Bhuva[3]
1. University of Saskatchewan, Canada
2. Cisco Systems, USA
3. Vanderbilt University, USA

SE performance of multiple flip-flop designs using the stacked-transistor technique at the 22-nm FDSOI technology is presented. Irradiation results show significant reductions in SE cross-sections for hardened designs compared to a conventional design.

POSTER PAPERS

PH-1 SE Performance of Schmitt-Trigger-Based Flip-Flops at 22-nm FDSOI Technology Node

Z.-R. Li[1], C. Elash[1], C. Jin[1], L. Chen[1], M. Rathore[2], S.-J. Wen[2], R. Fung[2], J.-S. Xing[1], S.-T. Shi[1], Z.-W. Yang[1], B. Bhuva[3]

1. University of Saskatchewan, Canada

2. Cisco Systems, USA

3. Vanderbilt University, USA

Multiple SE hardened flip-flop designs based on Schmitt-trigger circuits are presented. Alpha particles and heavy ions results show significant reductions in SEU cross-sections compared with the conventional design.

PH-2 A Single-Event Transient Mitigation Technique for Bandgap Reference Utilizing in Space Application

J. Liu[1], B. Liang[1], J. Chen[1], Y. Chi[1], D. Luo[1], Y. Guo[1]

1. National University of Defense Technology, China

This paper proposes a radiation-hardened-by-design (RHBD) technique targeting single-event transient (SET) mitigation in bandgap circuits. Laser experiments are conducted for evaluation, which illustrate that SET perturbations are almost eliminated with the proposed technique.

PH-3 Neutron Radiation Testing of Different TMR Soft Processors on SRAM-based FPGAs

A. Wilson[1]

1. Brigham Young University, USA

Soft processors are often used within FPGA designs in radiation hazardous environments. This paper presents neutron radiation results of five different TMR soft processors. The TMR processors achieved a 65x improvement in SEU-induced mean fluence.

PH-4 Vertical Integration of Physics-Based Radiation Models in a Hierarchical Integrated Circuit Design Flow

J. Kauppila[1,2], D. Vibbert[1], K. Warren[1,2], D. Ball[2], T. Haeffner[2], S. Vibbert[2], J. D'Amico[2], A. Watkins[2], E. Zhang[2], C. Moyer[1], A. Sternberg[2], L. Massengill[1,2]

1. Reliable MicroSystems, LLC, USA

2. Vanderbilt University, USA

A vertically integrated radiation aware design (VIRAD) approach is presented. The analysis methods are demonstrated on sub-50nm partially depleted SOI designs. Analysis results are compared to heavy ion test results on DICE flip flops.

Technical Program Thursday

CASCADE A-B
11:40 AM - 1:30 PM

LUNCH WITH WOMEN IN ENGINEERING (WIE) PRESENTATION
(Ticket Required to Attend)

POSTER SESSION
1:30 PM - 4:30 PM
BALLROOM B-C

INTRODUCTION

Chair: Jonathan Pellish, NASA

4:30 PM

END OF THURSDAY SESSIONS

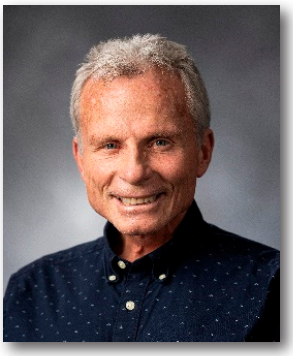
4:30 PM - 6:30 PM
BALLROOM B-C

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

BALLROOM B-C
INVITED TALK
8:30 - 9:30 AM

Utah Rocks!

Ron Harris, Professor of Geological Sciences, Brigham Young University, Provo, Utah



Utah is the Ute Tribe word for people of the mountains. The mountains and canyons of Utah harbor many geological secrets of how Earth works. The secrets unfold like a journey back through time, through a palimpsest of former worlds encrypted in the crag.

Millions of visitors every year come to Utah to see its rocky landscapes. Disguised as 'scenery', the rocks reveal a story in pattern language of worlds where continents collide and rip apart, seas invade and retreat, land shaped by fire and ice, infusions of precious mineral and energy resources, deadly earthquakes, and some of Earth's largest volcanic explosions, and clues of how climates change. These events represent three phases of mountain building involving the accumulation, convergence, and collapse phases. Throughout the slow changes of land and sea, life evolved leaving fossil traces of everything from Earth's earliest single-celled life forms to its increasingly complex and diverse progeny.

My talk will not only provide a brief introduction to the geological evolution of Utah, but it will hopefully help you make geological interpretations of your own whereever you are.

Dr. Ron Harris is a Professor of Geological Sciences at Brigham Young University who specializes in mountain building processes and associated natural hazards. He was born and raised in Oregon and received his BSc. in Geological Sciences from the University of Oregon. He also has a master's degree in Geophysics from the Geophysical Institute of Alaska, and a Ph.D. in Geodynamics from University College London in the U.K.

Ron has worked for oil, mining, and environmental companies, for the US Geological Survey, and with the governments of several developing countries threatened by natural hazards. Dr. Harris' research in geodynamics integrates many sub-disciplines including neotectonics, structural geology, petrology, geochemistry, geochronology, geophysics, and computer modeling. Dr. Harris has taught at universities in the U.S., Great Britain, Oman, Taiwan and Indonesia. He has been invited to make over 200 presentations, has more than 75 peer-reviewed publications and garnered several research grants and awards. He recently published the second edition of his book about hiking the geology of the Wasatch Range, which is written for those who know very little about geology. ***https://linuslearning.com/product/exploring-the-geology-of-little-cottonwood-canyon/***

Perhaps the most distinguishing feature of Dr. Harris' career is his success in connecting advances in geological hazards research with societal needs. He is the founder of the non-profit organization "In Harm's Way" that identifies areas of the world most vulnerable to natural disasters and helps community-based organizations in these areas access and communicate risk of natural hazards, and implement effective disaster risk-reduction strategies that have saved thousands of lives. See ***inharmswayhelp.org.***

BALLROOM B-C

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

9:30 AM SESSION INTRODUCTION

Chair: Enxia Zhang, Vanderbilt University

I-1 **Cryogenic Total-Ionizing-Dose Response of 4th-Generation SiGe HBTs**
9:35 AM **using 1-MeV Electrons for Europa-Surface Applications**

J. Teng[1], G. Tzintzarov[1], D. Nergui[1], J. Heimerl[1], Y. Mensah[1], J. Moody[1], D. Thorbourn[2], L. Del Castillo[2], L. Scheick[2], M. Mojarradi[2], B. Blalock[3], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. Jet Propulsion Laboratory, USA

3. University of Tennessee Knoxville, USA

SiGe HBTs are exposed to 1-MeV electrons to 5 Mrad(Si) at 300, 200, and 115 K. Improved TID tolerance is exhibited at lower temperatures, and the physical mechanisms behind this improved tolerance are explored.

I-2 **Layout Dependence of Total Ionizing Dose Effects on 12-nm Bulk FinFET**
9:50 AM **Digital Structures**

T. Wallace[1], M. Spear[1], A. Privat[2], J. Neuendank[1], G. Irumva[1], D. Wilson[1], I. Sanchez Esqueda[1], H. Barnaby[2], M. Turowski[3], E. Mikkola[3], D. Hughart[4], M. Marinella[4], R. Von Niederhausern[5]

1. Arizona State University, USA

2. ASU, USA

3. Alphacore Inc., USA

4. Sandia National Laboratories, USA

5. Spacecraft Component Branch, Air Force Research Lab, USA

This summary reports on layout dependent TID susceptibility in a commercial 12nm FinFET technology. While current scales to drive strength prior to irradiation, after exposure, layout location becomes the dominant factor in TID response.

I-3 **RF Performance and TID Hardness Trade-offs in Annular 45-nm RF SOI**
10:05 AM **CMOS Devices**

B. Ringel[1], J. Teng[1], D. Nergui[1], M. Hosseinzadeh[1], K. Li[2], E. X. Zhang[2], D. M. Fleetwood[2], J. Cressler[1]

1. Georgia Institute of Technology, USA

2. Vanderbilt University, USA

The TID response of 45-nm annular RF SOI nFETs is evaluated against standard layouts. RF performance and TID susceptibility trade-offs are demonstrated. TCAD is used to isolate critical oxides and damage mechanisms in annular layouts.

10:20 AM – 10:50 AM BREAK
NORTH & EAST
PRE-FUNCTION

BALLROOM B-C
SESSION I (cont'd)

I-4 10:50 AM
Total Ionizing Dose Effects in FDSOI SRAM- Based XNOR IMC Synaptic Array

X. Han[1], M. Spear[1], J. Seo[1], D. Wilson[1], T. Wallace[1], O. Forman[1], J. Solano[1], M. Turowski[2], M. Marinella[1], H. Barnaby[1]

1. Arizona State University, USA

2. Alphacore, Inc, USA

SRAM-based XNOR in-memory computing has been proposed as a synaptic device for neural networks. The impact of total ionizing dose on the XNOR-and-accumulate computation (XAC) synaptic array is analyzed for a 22-nm FDSOI design.

I-5 11:05 AM
Total-Ionizing Dose Effects on 3D Sequentially-Integrated Ring Oscillators

S. Toguchi[1], E. X. Zhang[1], D. M. Fleetwood[1], R. D. Schrimpf[1], S. Moreau[2], P. Batude[2], L. Brunet[2], F. Andrieu[2], M. L. Alles[1]

1. Vanderbilt University, USA

2. CEA, LETI, France

Switched-bias during irradiation results in worst-case frequency decreases in ring oscillators built in FDSOI 3DSI technology due primarily to threshold-voltage shifts and transconductance degradation in the pull-up pMOSFETs.

I-6 11:20 AM
Effects of Geometry and Cycling on the Radiation Response of Charge-Trapping NAND Memory Devices with SiON Tunneling Oxide

J. Cao[1], E. X. Zhang[1], R. A. Reed[1], M. L. Alles[1], R. D. Schrimpf[1], D. M. Fleetwood[1], A. Arreghini[2], M. Rosmeulen[2], J. Bastos[2], G. Van den Bosch[2], D. Linten[2]

1. Vanderbilt University, USA

2. imec, Belgium

Effects of geometry and cycling are evaluated for charge-trapping NAND memory devices with SiON tunneling layers. Scaling to smaller dimensions enhances programmability, endurance, and radiation tolerance. Excellent endurance is demonstrated before and after irradiation.

I-7 11:35 AM
Effect of Total Ionizing Dose on Low-Power Artificial Intelligence Edge Processing Application-Specific Integrated Circuits for Space-Based Applications

M. Casey[1], J. Goodwill[1], E. Wyrwas[1], S. Stansberry[2], R. Austin[1], M. Carts[1], N. Gorius[3], C. Wilson[1], S. Aslam[1], J. Pellish[1]

1. NASA GSFC, USA

2. SSAI, USA

3. Catholic University of America, USA

The effects of total ionizing dose on two artificial intelligence application-specific integrated circuits are examined. Some post-irradiation failure analysis has been conducted to identify the source of the failures.

POSTER PAPERS

PI-1 TID Responses of Floating Body and Body-Contacted 45-nm PDSOI NMOS Transistors

A. Butterfield[1], M. Hu[1], E. X. Zhang[1], S. Vibbert[1], A. Watkins[1], J. Damico[1], B. Fahrenkrug[1], D. Ball[1], T. Haeffner[1], J. Kauppila[1], L. Massengill[1]

1. Vanderbilt University, USA

Measurements show transistors fabricated in a current 45-nm PDSOI process are resistant to ionizing radiation effects through 300 krad(SiO_2). Additionally, body contacted devices show a greater resistance to TID-induced degradation than comparable floating body devices.

PI-2 Total Ionizing Dose Effects on SRAM Power-up State

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

1. The University of Alabama in Huntsville, USA

The power-up state of commercial SRAM chips is significantly altered after irradiation, preventing its use for generating SRAM-PUFs in radiation-prone environments. The SRAM-PUF bit error rate increases monotonically with TID, exceeding 15% after 100 krad(Si).

PI-3 Predictive Study of the Performance Characteristics Degradation of Optocouplers Combining TID-DD Effects with Gamma and Proton Irradiation

P. Martin-Holgado[1], A. Romero-Maestre[1], J. De-Martin-Hernandez[2], J. Ramirez-Garcia[2], J. Gonzalez-Lujan[2], A. Ricca-Soaje[2], M. Sacristan Barbero[3], R. Ferraro[4], R. Garcia[5], M. Dominguez[6], Y. Morilla[1]

1. Centro Nacional de Aceleradores, Spain

2. Alter Technology, Spain

3. CIEMAT - CERN, Switzerland

4. CERN, France

5. CERN, Switzerland

6. ALTER, Spain

Optocouplers are crucial components in harsh environments, and therefore a prediction of their degradation due to radiation is highly demanded. This work shows a successful predictive tool for the CTR parameter based on archival data.

11:50 AM END OF CONFERENCE

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
Executive Chairman

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 2022 will be held in Provo, Utah, July 18-22 2022 at the Utah Valley Convention Center. Thomas Turflinger, The Aerospace Corporation, is the Conference Chair. Supporters of the 2022 NSREC include The Aerospace Corporation; Analog Devices; Boeing; CAES; EMPC; EPC Space; Honeywell; IR HiRel Products, an Infineon Technologies Company; Jet Propulsion Laboratory; L3Harris; Radiation Test Solutions; Renesas; Skywater Technologies; and Southwest Research Institute. We thank our supporters for their significant and continuing commitments to theconference and welcome other organizations to consider becoming supporters of the IEEE NSREC.

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 Chairman. Heather Quinn is the Chairwoman for NSREC 2024 in Ottawa, Ontario, Canada at the Shaw Center. Dolores Black, Sandia National Laboratories, was selected as the 2025 NSREC Chairwoman.

Papers presented at the 2022 NSREC are eligible for publication in the January 2023 issue of the IEEE Transactions on Nuclear Science. Authors must upload their papers prior to the conference for consideration for publication in the January 2023 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 2023), 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 16, 2022. 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 seven 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 December issue of the *Transactions* or for radiation effects papers submitted throughout the year, please contact one of the editors. The editors for the 2022 NSREC are:

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

Dennis Brown, Associate Editor, IEEE NPSS
Email: brownden_1@yahoo.com

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

William Robinson, Associate Editor, Vanderbilt University
Email: william.h.robinson@vanderbilt.edu

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

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

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

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

Daniel Loveless, Guest Editor, University of Tennessee at Chattanooga
Email: daniel-loveless@utc.edu

RESG NEWS / Awards

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 2023 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 2022 *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 21, 4:30 – 6:30 All conference attendees are encouraged to attend.

THURSDAY, JULY 21 4:30 PM – 6:30 PM

During the meeting we will discuss the 2022 conference and future IEEE Nuclear and Space Radiation Effects Conferences. A report on the nomination processes for the 2022 Junior Member-at-Large on the Radiation Effect Steering Group and the 2021 nominating committee will be presented. Voting instructions for IEEE NPSS members will be provided.

2021 OUTSTANDING PAPER AWARD

An SRAM SEU Cross Section Curve Physics Model
D. Kobayashi, K. Hirose, K. Sakamoto, Y. Tsuchiya, S. Okamoto, S. Baba, H. Shindou, O. Kawasaki, T. Makino, T. Ohshima

2021 MERITORIOUS PAPER AWARD

Using Machine Learning to Mitigate Single-Event Upsets in RF Circuits and Systems
A. Ildefonso, J. Kimball, J. Cressler, D. McMorrow

Awards

2021 OUTSTANDING STUDENT PAPER AWARD

Response of Integrated Silicon RF pin Diodes to X-ray and Fast Neutron Irradiation

J. Teng, D. Nergui, H. Parameswaran, G. Tzintzarov, H. Ying, C. Cheon, S. Rao, A. Ildefonso, N. Dodds, N. Nowlin, M. Gorchichko, E. X. Zhang, D. M. Fleetwood, J. D. Cressler

2021 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

First Results on BJTs in Space: ELDRS Experiment on NASA Space Electronic Testbed

A. Benedetto, H. Barnaby, C. Cook, M. Campola, A. Tender

2021 IEEE/NPSS RADIATION EFFECTS AWARD

Lloyd W. Massengill, Vanderbilt University received the 2021 IEEE/NPSS Radiation Effects Award for contributions for technical contributions to understanding radiation effects in microelectronics and leadership in the radiation effects community.

2021 MERIT AWARD

Dr. Ron Schrimpf is the Orrin Henry Ingram Professor of Engineering and Director of the Institute for Space and Defense Electronics at Vanderbilt University. He received his B.E.E., M.S.E.E., and Ph.D. degrees from the University of Minnesota and was a professor at the University of Arizona for ten years, before joining Vanderbilt in 1996. His research is related to semiconductor devices, particularly radiation effects and reliability. The projects on which he works include semiconductor-device design and simulation, atomic-scale analysis of radiation-induced defects, application and development of design and simulation tools for radiation effects, total-dose and single-event effects in electronic devices and circuits, and development of radiation-effects and hardness-assurance test methodologies. Ron has received three of Vanderbilt's highest awards: the Chancellor's Cup (given for "the greatest contribution outside the classroom to undergraduate student-faculty relationships in the recent past"), the Harvey Branscomb Distinguished Professor Award (given "to recognize, and thereby to encourage in others, that combination of talents and achievements which we identify as desirable in the University faculty member: creative scholarship; stimulating and inspiring teaching which results in learning of a high order; and service to students, colleagues, the University at large, and society at large", and the Chancellor's Award for Research (recognizing excellence in research, scholarship, or creative expression). He has served as the President of the IEEE Nuclear and Plasma Sciences Society, Chair of the Radiation Effects Steering Group, and Chair of the Nuclear and Space Radiation Effects Conference. He received the NPSS Early Achievement Award and was elected a Fellow of the IEEE in 2000. Ron was the first Faculty Head of House for Memorial House in Vanderbilt's residential college program for first-year students: The Martha Rivers Ingram Commons. As one of the founding Heads of House, he was involved in defining the direction of the first-year experience at Vanderbilt, which has been recognized nationally. As part of the Commons experience, Ron led and resided in Memorial House with his wife, Kathy, and eighty first-year students.

Citation: *For contributions to the understanding of radiation effects in semiconductor devices and integrated circuits.*

2022 RADIATION EFFECTS AWARD

The winners of the 2022 Radiation Effects and Radiation Effects Early Achievement Awards will be announced Tuesday, July 19 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.

2023 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2023 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 2023 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 Kansas City, Missouri in July 2023. 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 Ruben Garcia, Member-at-Large, CERN at ***ruben.garcia.alia@cern.ch.***

Conference Information

CONFERENCE LOCATION

Provo is Utah's third-largest city and is situated between the beautiful Wasatch mountains on the east, extensive Utah Lake on the west, and Salt Lake City to the north. The views are dramatic, and the city is charming, walkable, and full of delightful things to do. Within a short drive, you can enjoy hiking, biking, and fishing, or you can visit some natural wonders such as Mt. Timpanogos Cave National Monument, Bridal Veil Falls, Cascade Springs, and Provo Canyon.

Along with the exceptional fishing, hiking, and biking, you can also experience some unusual types of entertainment in Provo, such as ax throwing, an escape house, interactive mystery theater, and more. This is truly a unique and innovative small city!!!

In 1847, Utah was settled by members of the Church of Jesus Christ of Latter-Day Saints (also known as Mormons) who were escaping religious persecution in the eastern and mid-western U.S. Now, Utah has the highest population of Mormons in the United States. They have endured, creating a special and unique culture to this day. For more information on Utah's fascinating history, visit the website ***https://www.history.com/news/why-the-mormons-settled-in-utah***

On the north side of Provo, you'll find Brigham Young University. This institution is the largest church-affiliated university in the U.S. The vast campus offers sites you can visit, including the BYU Museum of Art, the Museum of Paleontology, the Bean Life Science Museum, and the Museum of Peoples and Cultures. The art museum is one of the largest in the west, with over 14,000 works, ranging from Renaissance to Modern. The Museum of Paleontology features dinosaur and early mammal exhibits. There is much to enjoy and, fortunately, admission to these museums is free.

Partially because of the number of international students and returning missionaries who live in Provo, restaurants are abundant with all types of cuisine available. Ethnic options include East Indian, Mexican, Brazilian, Chilean, Chinese, Italian, American Indian, Korean, Peruvian, and Thai. Some innovative chefs "stir things up" a bit with "fusion" dishes, a combination of cuisines to create something new. Many restaurants serve alcoholic beverages, and some do not (see "Provo Tips" on a later page.) But you'll discover that although Mormons discourage alcoholic drinks, they excel at creating alternative, tasty soft drinks and herbal teas. Try them. . . they are quite refreshing on a hot summer day.

The Utah Valley Convention Center (UVCC), located in the heart of downtown Provo, will be the home-base facility for the NSREC's sessions and exhibition. With exclusive use of the UVCC's three floors for most of the week, there is plenty of room to spread out!

Photo courtesy of Utah Valley Convention Center

Utah Valley Convention Center, 220 W. Center Street, Provo, Utah 84601
Website: ***https://www.utahvalleycc.com/about-uvcc***

The two host hotels, the **Provo Marriott Hotel** and the **Hyatt Place Provo Hotel**, are conveniently located across the street from the UVCC.

Conference Information

BREAKFASTS, LUNCH AND BREAKS

The 2022 IEEE NSREC will provide breakfast and refreshments at breaks during the NSREC Short Course and Technical Sessions. Additionally, lunch will be included on Monday for the Short Course attendees. These meals and refreshments are for *registered conference attendees only.* Please see the schedule for times and locations.

The exhibitors will host a lunch on Wednesday, July 20, in the Exhibit Hall. This lunch is for *registered conference attendees and Exhibit Booth Staffers only.*

BUSINESS CENTER

The UVCC does not have a business center. However, the Provo Marriott and the Hyatt Place Provo have limited-service business centers that can handle computer printing, internet access, and minimal photocopying. These self-service stations are open to hotel guests only, 24 hours a day and 7 days a week. The guest room key cards provide access.

For more extensive business center needs, feel free to contact:

1) The UPS Store, 223 W. Cougar Blvd, Provo Tel: 801-379-6000
2) FedEx Office Print & Ship Center, 1774 N University Pkwy, Ste 30, Provo Tel: 801-377-1791

ROOMS FOR SIDE MEETINGS

A few "side meeting rooms" are available for use by any registered conference attendee at the Provo Marriott on a first-come, first-served basis. *NSREC encourages side meetings to be scheduled at times other than during technical sessions.* Contact **ETCic at 720-733-2003** or send an e-mail to ***etc@etcic.us*** to make side meeting reservations before the conference. To make a side meeting room reservation during the conference, see the NSREC Registration staff in the Hobble Creek 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.

Conference Information

CHILD CARE REIMBURSEMENT

The 2022 Conference is offering child-care reimbursement of up to $400 per family to assist conference attendees who incur additional childcare expenses by attending the conference. This program, funded by the NPSS AdCom, will also be carried out at other NPSS Conferences during 2022. Limited funds are available, and preference will be given to applicants in the early stages of their careers who are IEEE NPSS members. Up to five candidates will be selected.

Eligible applicants:

- Families where both parents are registered attendees at the conference
- Parent (registered attendee) who brings child(ren) to the conference
- Parent (registered attendee) who incurs additional expenses at his or her home location, *above normal child-care expenses,* while attending the conference.

Allowable expenses include:

- Babysitting or child-care expenses at the conference location while the parent(s) attend the conference
- Additional baby sitting or child-care expenses incurred in leaving a child home while parent(s) attend the conference
- Transportation expenses for a child-care provider to care for child(ren) during the conference. Reimbursement is only allowed for an adult or relative that does not share your home residence.

Expenses must be documented by receipts. An expense report, accompanied by receipts, must be received by Matt Gadlage matthew.j.gadlage.civ@us.navy.mil by August 5, 2022. If the report is not received by that date, no reimbursement will be made. All reimbursements will be made after the conference.

To apply, an attendee must register for the conference technical sessions, and then complete the application form to request reimbursement for child care. The application must be received no later than June 1, 2022 by ***kay.c.chesnut@raytheon.com.*** Applicants will be notified whether they qualify for these funds by June 15th 2022. Due to limited funding, it is possible that not all qualified applicants will be eligible for reimbursement. The application and expense form is available at ***www.nsrec.com.***

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 17. After that date, the "Late Registration" rates apply.

Registrations can be submitted using the NSREC website link: ***www.nsrec.com.*** E-mailed or faxed registrations will be accepted with a credit card payment, or you can mail the conference registration form, along with your payment, to ETCic. If your registration form (with payment) does not arrive at ETCic by Monday, July 11, then it would be best to hand-carry the payment to the conference for On-Site registration. Telephone registrations will not be accepted.

ETC Incentives & Conferences (ETCic)
2254 Emerald Drive
Castle Rock, CO 80104
Tel: 720-733-2003
Fax: 720-733-2046
etc@etcic.us

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) cash (on-site only), or 3) MasterCard, VISA, Discover, and American Express credit card.

ON-SITE REGISTRATION LOCATION & TIMES IN PROVO

All conference registration will occur in the Utah Valley Convention Center (UVCC). If you *have not yet registered,* go to "On-Site Registration" in the Hobble Creek Room on the third floor. If you h*ave already registered*, go to "Pre-Registration" in the Silver Creek Room on the third floor.

Registration hours are:

Sunday, July 17	**5:00 PM – 8:00 PM**
Monday, July 18	**7:30 AM – 5:00 PM**
Tuesday, July 19	**7:30 AM – 5:00 PM**
Wednesday, July 20	**7:30 AM – 3:00 PM**
Thursday, July 21	**7:30 AM – 3:00 PM**
Friday, July 22	**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, 2022, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify ETCic by fax at 720-733-2046 or e-mail at ***etc@etcic.us***

Registration and Travel

HOTEL ACCOMMODATIONS:

Host Hotel Option #1

Provo Marriott Hotel & Conference Center
101 West 100 North
Provo, Utah 84601
Tel: 801-377-4700

Photo courtesy of Provo Marriott Hotel & Conference Center

Host Hotel Option #2:

Hyatt Place Provo
180 West 100 North
Provo, Utah 84601
Tel: 801-609-2060

Photo courtesy of Hyatt Place Provo

OPTION #1: One hotel for the 2022 IEEE NSREC is the 4-star **Provo Marriott,** located in the heart of Provo and across the street from the Convention Center. The property features a full-service restaurant, one cocktail lounge, a 24-hour fitness center (complimentary to hotel guests), a business center, room service, lobby ATM, computer room for guest use, complimentary self-parking at their attached garage, a whirlpool, and both indoor and outdoor swimming pools.

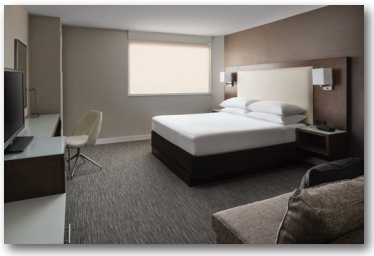


Photo courtesy of Provo Marriott Hotel & Conference Center

The 329 guest rooms are all non-smoking and are comfortably furnished. Each room features large windows with dramatic views, individual climate control, flat-screen TV with video-on-demand & cable, complimentary hi-speed wireless internet, work desk with USB chargers, coffee maker, hairdryer, iron & ironing board, phone with voice mail, one king or two double beds, and room service. A concierge floor is expected to be open by July. . . but not guaranteed. Check-in is 3:00pm or later; check out is before 12:00n.

Provo Marriott Guest room rates for a standard king or double-double are:

NEGOTIATED GROUP RATE:	GOVERNMENT PER DIEM:
$154.00 single/double per night	**$98.00 single/double* per night**

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

HOTEL ACCOMMODATIONS (CONTINUED)

Room taxes currently at 13.32% will be added to all rates listed above.

Based on availability, the guest room rates will be offered **3 days before and 3 days after** the conference. If you want to "arrive early" or "depart late," and the nights you need are NOT shown on the online system, it is suggested that you make your reservation for the maximum number of nights that you can and THEN send a request for the remaining nights that you need to Jeremiah Clark at: ***Jeremiah.clark@marriott.com.*** Be sure to provide Jeremiah with your existing hotel reservation number.

If you prefer, you can also *call Marriott Reservations to confirm your room:* ***Tel. 800-228-9290.*** Ask for the group named IEEE NSREC and then, they can use the applicable room type code, as follows:

IEEIEER – Group rate in run-of-house standard room. No bed preference
IEEIEEA – Group rate with request for king bed in the room
IEEIEEB – Group rate with request for 2 queen beds in the room
IEGIEGR – Government rate in run-of-house standard room

OPTION #2: Another great hotel option would be the 3-star **Hyatt Place Provo** in the heart of town and one block from the Convention Center. This 133-room property is totally non-smoking. Each room features a combination sitting area & bedroom, complete with a pull-out sofa, a mini-frig, single-serve coffee maker, individual climate control, flat-screen HDTV with video-on-demand & cable, complimentary wireless internet, desk with USB chargers, hairdryer, iron & ironing board, phone, and one king or two double beds.

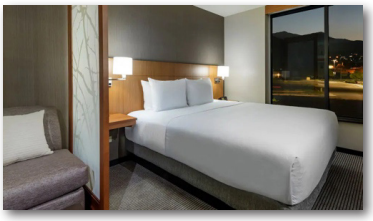


Photo courtesy of Hyatt Place Provo

Additional amenities in the Hyatt Place include an outdoor swimming pool, a small business center with free public computers for guest use, free parking in an open-air lot 1 block away OR $10 per night in their "soon-to-be-open" attached parking garage, 24-hour gym, a 24-hour guest market (snacks & toiletries), an evening bistro, and complimentary *hot breakfast daily*... a great option for families! Check-in is 3:00pm or later; check-out is before 12:00n.

Hyatt Place Provo Guest room rates:

NEGOTIATED GROUP RATE:	GOVERNMENT PER DIEM:
$169.00 single/double per night	**$98.00 single/double* per night**

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

Room taxes currently at 13.32% will be added to all rates listed above.

Based on availability, the guest room rates will be offered **3 days before and 3 days after** the conference. If you want to "arrive early" or "depart late" but the nights that you need are NOT shown on the online system, then it is suggested that you *call the hotel directly to make your reservation:* ***Tel. 801-609-2060.*** Advise them of the applicable group code **G-IEEE** (group rate) or **G-IEE2** (government rate).

Registration and Travel

HOTEL RESERVATIONS

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

Provo Marriott Hotel – Group rate:
https://www.marriott.com/event-reservations/reservation-link.mi?id=1642127556364&key=GRP&app=resvlink

Provo Marriott Hotel - Government rate:
https://www.marriott.com/event-reservations/reservation-link.mi?id=1642130041501&key=GRP&app=resvlink

Hyatt Place Provo – Group rate:
https://www.hyatt.com/en-US/hotel/utah/hyatt-place-provo/pvuzp?corp_id=G-IEEE

Hyatt Place Provo – Government rate:
https://www.hyatt.com/en-US/hotel/utah/hyatt-place-provo/pvuzp?corp_id=G-IEE2

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 Mountain Daylight Time (MDT) on **June 17, 2022.** Once the room block has been filled OR after the cut-off date (whichever comes first!), it is at the hotel's discretion as to whether they can book more rooms and at what room rate will be offered. Early reservations are strongly suggested!

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

AIRPORT AND TRANSPORTATION INFORMATION

Provo Regional Airport (code: **PVU**) is located approximately 4 miles west of the Provo Marriott and Hyatt Place Provo. However, this airport only has small commuter aircraft on Allegiant Air from just a few cities and on limited days during the week, so... it is ***NOT*** likely to be the best option for most NSREC attendees.

The major airport nearby is **Salt Lake City International Airport** (code: **SLC**). The Provo Marriott and Hyatt Place Provo are located about 43 miles south of this airport. Traveling outside of normal commuting hours, the drive typically takes between 45-50 minutes. During heavy commuting times, the drive can take up to 75 minutes.

Airport to Hotel Transportation:
There is no scheduled shuttle service from either of these two airports to downtown Provo, but there are other options.

1) From/to the Provo Regional Airport, the following will supply private taxi service.
   - Travel Car Service **Tel: (801) 854-0000**

2) From/to the SLC Airport, the following will supply private car transportation at a fee.
   - American Limousine **Tel: (801) 400-0777**
     Website: ***https://americanlimousineutah.com/***
   - Easy Taxi Utah **Tel: (801) 874-8793**
     Website: ***https://www.easytaxiorem.com/***

- Travel Car Service **Tel: (801) 854-0000**
  Website: ***https://travelcarservices.com/***
- Uber Website: ***https://www.uber.com/***
- Lyft Website: ***https://www.lyft.com/***

3) From/to the SLC Airport to Provo, there IS public transportation!! The southbound Light Rail service (TRAX) at the airport will connect half-way to Provo to a train called the "Frontrunner".

   To use this option, you should first plan your trip using Utah Transit Authority's (UTA) Trip Planner at the website https://rideuta.com/Rider-Tools/Trip-Planner. You can learn more about specific route information for the Frontrunner at https://www.rideuta.com/Rider-Tools/Schedules-and-Maps/750-FrontRunner. In any case, follow these instructions:

   a) Go to the SLC Airport Light Rail (TRAX) system which is located at the south end of Terminal 1
   b) Buy your Frontrunner ticket at one of the kiosks using the following criteria.
      - Frontrunner
      - One-Way
      - The full fare at approximately $7.00, or a reduced fare for senior citizens or disabled passengers. TRAX is free, so you're only paying for the Frontrunner service.
      - From: North Temple Board Station
      - To: Provo Central (in the "additional stations" section)
   c) Get on the Light Rail 704 Green Line going south
   d) Get off the Light Rail at the North Temple Bridge/Guadalupe Station
   e) Head to the west end of the Station, cross the train tracks, and take the escalator down to North Temple Station
   f) Take Southbound Frontrunner 750
   g) Get off at the Provo Station (the last stop going south). From here, you can either walk less than a mile to the hotel, call Uber or Lyft, OR . . .
   h) Get onto the UVX (Utah Valley Express) bus 830X (free service)
   i) Exit at the Center Street Station
   j) Walk .2 mile (less than 5 minutes) to the Provo Marriott or Hyatt Place Provo

PLEASE NOTE THAT THE FRONTRUNNER DOES NOT OPERATE ON SUNDAYS!!!!

Car Rental:
This is one place where a car rental makes sense!! There are so many places to explore, it's easy to get around, and the host hotels have free (or very inexpensive) parking for hotel guests. Therefore, consider the cost of car rental versus the cost of airport transfers plus any additional transportation you might need during the week. Most major car rental companies are located in the Salt Lake City International Airport at their Gateway Car Rental Center (across the drive from baggage claim). More information can be found at ***https://slcairport.com/parking-and-transportation/rental-cars-2/***

No car rental service is available at the smaller Provo Regional Airport.

Registration and Travel

PARKING AND DRIVING DIRECTIONS

Self-parking at the **Provo Marriott Hotel** is FREE for hotel guests, so this is not a concern when driving your own car or renting one. In addition, the Hyatt Place offers FREE parking at a lot one block from the hotel OR parking at $10 per night at their attached garage. Driving directions from the Salt Lake City Airport are as follows.

Salt Lake City International Airport to Marriott or Hyatt:

- Head northeast on N Terminal Drive
- Turn right towards N 3700 W and then continue onto W Crossbar Rd
- Take the ramp onto Terminal Drive and then follow signs to I-80 E towards Ogden/Provo
- After about 3 miles, take the exit on the left onto I-15 S/I-80 E towards Cheyenne/Las Vegas
- Continue to follow I-15 S for about 24 miles, but be aware of a "fork" where you will then...
- Keep to the left to stay on I-15 S for 18 additional miles
- Take exit 265 to Provo's Center Street
- Turn left on N 500 W
- Turn right onto W 100 N
- In 3.5 blocks, a) **Marriott** will be on the right . . .
- ***OR*** b) in 3 blocks, turn left onto Freedom Blvd (another name for 200 W) to the **Hyatt Place**

Basically, the **UVCC** can be found at the southwest corner of *W 100 N and Freedom Blvd 200 W.* The **Marriott** is on the southeast corner of that intersection, and the **Hyatt Place** is on the northeast corner of that intersection.

If you are not staying at either of the NSREC's host hotels and you need to drive to the **UVCC**, the following are a couple of the free public parking areas nearby:

- Freedom Lot (outdoor parking) at 225 N. Freedom Blvd with 400 parking spaces
- UVCC Lot (outdoor parking) at 250 W. 100 N with 41 parking spaces

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. The Utah Transit Authority (UTA) provides local bus service (including the "Utah Valley Express") throughout Utah County to venture a bit farther from the hotels. There is a UVX stop near the hotel that provides convenient transportation to BYU, Utah Valley University, and other destinations in Utah Valley. It would be helpful to peruse their website and specifically look at their route map on the website:
https://www.rideuta.com/-/media/Files/Rider-Tools/System-Maps/2022/Utah_County_System_Map_2022.ashx

Downtown Provo is laid out on a standard street grid with great logic for street names IF you know the "plan." The main streets are University (or Highway 189) going north/south AND Center Street (state road 114) going east/west. Most of the remaining streets are named according to their distance from these two main streets. For instance, the street called "W 100 N" means that this street is west of University and 1 block north of Center Street. That can be handy to know when exploring the area!

Registration and Travel

TIPS WHEN VISITING PROVO

Altitude: The valley is rich with lakes and rivers, but its altitude of about 4,550′ (1,387 m) above sea level keeps the humidity level relatively low. Drink plenty of water to stay hydrated in this dry and high altitude location.

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. The heat of the day could affect you rather quickly in Provo and the surrounding areas!

Weather: In July, this "semi-arid" climate is typically quite dry with low humidity but high temperatures. However, nights and early mornings can be cool, even in July. Historically, the average high temperature in July is in the low 90's with an average low in the low 60's. July could have some light rain, but it would typically be short-term.

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 Provo area, but there are numerous students out and about at all hours since this is a college town. Let's face it. . . when tourists are not familiar with the area, they don't always pay attention to everything around them. Also, know that driving while talking on a cell phone in Utah is illegal, and they DO issue tickets.

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 15 to 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.

Alcoholic Beverages: Utah is a "liquor control state," which maintains the policy that "moderation" can be best achieved through "control ." The laws are strict regarding where alcoholic beverages can be sold and/or served, to whom they can be sold/served, the quantity that can be served, and more. The DUI alcohol limit, pertaining to a person's maximum blood alcohol level when driving a car or riding a bike, is now the most strict in the country . . . only .05%. For some people, that's only one drink. Do NOT drink and drive! For more information, see: ***https://utah.com/state-liquor-laws***

Utah Valley Savings Passport: Get your Savings Passport ***before the conference*** to unlock discounts that can only be found in Utah Valley. Whether you are a visitor or resident, the Explore Utah Valley Savings Passport will help you find great deals at restaurants, hotels, local businesses, attractions, and more! The Savings Passport is ever-changing, but you'll have access to ongoing and new offers once you have signed up. To learn more, go to the website:
https://www.utahvalley.com/explore-utah-valley-savings-passport/

Industrial Exhibits

Tara Luther
Industrial Exhibits Chair
SkyWater Technology

The **2022 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 2022 NSREC Industrial Exhibits will be first floor of the Utah Valley Convention Center on Tuesday and Wednesday. Breakfast and conference breaks will be hosted in the Exhibit Area on Tuesday and Wednesday for registered attendees, with an Exhibitor Lunch to be held Wednesday. 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:

Tara Luther
SkyWater Technology

Phone: 1-651-492-7086
Email: Tara.Luther@skywatertechnology.com

Or visit the 2022 NSREC Industrial Exhibits web site:
https://www.nsrec.com/industrial-exhibits/

Industrial Exhibits

Please check our web site (***www.nsrec.com***) for a current listing of companies exhibiting at 2022 NSREC.

NSREC
INDUSTRIAL EXHIBITS

UTAH VALLEY
CONVENTION CENTER

EXHIBIT HALL A-B-C

EXHIBIT HALL HOURS

TUESDAY, JULY 19

7:00 AM – 5:30 PM
10:00 AM - 10:30 AM
MORNING BREAK
1:50 PM - 2:30 PM
AFTERNOON BREAK

5:30 PM – 7:00 PM
RECEPTION

WEDNESDAY, JULY 20

7:00 AM – 2:00 PM
10:10 AM - 10:40 AM
MORNING BREAK
12:00 PM - 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.	www.3d-plus.com	501
AEi Systems	www.aeng.com	303
Alpha Data, Inc.	www.alpha-data.com	604
Alphacore, Inc.	www.alphacoreinc.com	611
Analog Devices, Inc.	www.analog.com	305
Apogee Semiconductor	www.apogeesemi.com	402
BAE Systems	https://www.baesystems.com/en-us/productfamily/space-systems	103
BASE Facility	www.cyclotron.lbl.gov	202
Boeing	www.boeing.com	101
CAES	https://caes.com	206/207
Crane Aerospace & Electronics	www.craneae.com	609
Crocker Nuclear Laboratory	http://cyclotron.crocker.ucdavis.edu	106
Data Device Corporation	www.ddc-web.com	309
Defense Microelectronics Activity	www.dmea.osd.mil	404
EMA	www.EMA3D.com	503
EMPC	www.empc.com	308
EPC Space	https://epc.space/	606
FASTRAD®	www.fastrad.net	107
Fifth Gait Technologies	www.5thgait.com	612
Flex Logix	www.flex-logix.com	301
Foss Therapy Services, Inc.	www.fosstherapyservices.net	508
Honeywell	www.honeywell.com	405
IR HiRel, an Infineon Technologies company	www.infineon.com/space	601
J.L. Shepherd & Associates	www.jlshepherd.com	306
Jeffrey Titus, Radiation Test Consultant	https://JLT-RAD-TEST.com	105
JSTF	www.jazztrusted.com	203
Microchip Technology, Inc.	www.microchip.com	510
Micropac	www.micropac.com	605
Micross	www.micross.com	312
MIT Lincoln Laboratory	www.ll.mit.edu	304
Mobile Semiconductor	https://www.mobile-semi.com/	109
NASA NEPP Program	https://nepp.nasa.gov	509
PULSCAN	www.pulscan.com	502
Radiation Test Solutions, Inc.	www.RadiationTestSolutions.com	511/512
RADNEXT & PAC-G	https://radnext.web.cern.ch/	108
Renesas	www.renesas.com/us/en/products/space-harsh-environment	310/311
Robust Chip	www.robustchip.com	507
Sandia National Laboratory	www.sandia.gov	205
SkyWater Technology	www.skywatertechnology.com	506
STMicroelectronics	www.st.com	607/608
Texas Instruments	www.ti.com/space	407/408
Triad Semiconductor, Inc.	www.triadsemi.com	307
Trusted Semiconductor Solutions	http://trustedsemi.com/	201
TTM Technologies	www.ttm.com	102
UNITES Systems	https://unites-systems.com	602
Vanderbilt University	https://www.isde.vanderbilt.edu	610
Vicor Corporation	www.vicorpower.com	104
VORAGO Technologies	www.voragotech.com	403
VPT, Inc.	www.vptpower.com	504/505

2022 IEEE NSREC Short Course and Technical Sessions Registration Form

Registration is available on-line at www.nsrec.com

Name _____
Last Name *First Name* *Middle Initial*

Name to appear on badge _____

Company/Agency _____

Address _____

Address _____

City _____

State/Province _____

Zip or Postal Code _____

Country _____

Telephone Number _____

Fax Number _____

E-mail Address _____

IEEE Membership Number _____

* To obtain the IEEE rates, the IEEE membership number must appear on this form.

SPECIAL FUNCTIONS

☐ I am an IEEE Young Professional and will attend the IEEE Young Professionals Breakfast on Thursday, July 21

☐ I plan to attend the Women in Engineering (WIE) Lunch on Thursday, July 21

REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 17, 2022

	Early	Late	
IEEE Member*			
Short Course	$320	$385	$_____
Technical Sessions	$615	$730	$_____
Non-IEEE Member			
Short Course	$405	$490	$_____
Technical Sessions	$780	$925	$_____
IEEE Life Member*			
Short Course	$150	$385	$_____
Technical Sessions	$175	$730	$_____
IEEE Student Member*			
Short Course	$**	$385	$_____
Technical Sessions	$175	$730	$_____

***SPECIAL DEAL for IEEE Student Members: In 2022, the Short Course is automatically included when you pay the EARLY registration for the Technical Sessions!*

TOTAL AMOUNT ENCLOSED: $_____

PAYMENT OF FEES

☐ Enclosed is a check in **U.S. DOLLARS ONLY**, drawn on or payable through a U.S. bank. Payable to: **IEEE NSREC**

☐ Charge registration fees to my credit card (U.S. dollars):

☐ American Express ☐ Master Card
☐ Visa ☐ Discover

Card No. _____

Expiration Date _____ Security Code _____

Name on card _____

Cardholder Signature _____

Billing address _____

_____

_____

CANCELLATIONS

A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of conference registration fees requested after June 17, 2022, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. You must notify NSREC Registration by e-mail at etc@etcic.us or fax at 720-733-2046 *by no later than June 17, 2022.*

Mail or Fax this form and your remittance to:

IEEE NSREC REGISTRATION
2254 Emerald Drive
Castle Rock, CO 80104

Tel: 720-733-2003 Fax: 720-733-2046

2022 IEEE NSREC Short Course and Technical Sessions Registration Form

PAGE 2 OF ATTENDEE REGISTRATION: Must be completed and returned with Page 1

IEEE Privacy Policy and Event Terms and Conditions: At IEEE, we respect your privacy. We want to ensure that you get the information, content, and experiences that matter most to you. IEEE is committed to protecting the privacy of its members, customers, volunteers, and other contacts. Acceptance of IEEE Policies is required to register for this event. By submitting your registration details, you acknowledge that you have read and are in agreement with the IEEE Privacy Policy
https://www.ieee.org/security-privacy.html ❒ I accept the IEEE Privacy Policy

You have read and are in agreement with the IEEE Event Terms and Conditions:
https://www.ieee.org/conferences/event-terms-and-conditions.html ❒ I accept the IEEE Event Terms and Conditions

The IEEE NSREC must divulge any use of the contact information derived from your registration. These are:

1) Contact data is included in an Attendee Directory provided to all IEEE NSREC conference attendees following the conclusion of the conference.
2) Contact data is used as the IEEE mailing list for the Conference and Workshop proceedings which are sent to all Technical Session attendees.

Please check **YES** if you allow usage of your contact information for items 1 & 2 and **NO** if you do not want your contact data to be used in this way. ❒ **YES** ❒ **NO**

Another level in which data can be used is:

3) IEEE NSREC exhibitors who obtain the Attendee Directory could, potentially, use the Attendee Directory to send marketing materials..
4) The IEEE NSREC utilizes the Attendee Directory contact information to provide future conference information and details to each past registrant using IEEE guidelines.

Please check **YES** if you allow usage of your contact information for items 3 & 4 and **NO** if you do not want your contact data to be used in this way. ❒ **YES** ❒ **NO**

Non-Discrimination Policy

IEEE is committed to the principle that all persons shall have equal access to programs, facilities, services, and employment without regard to personal characteristics not related to ability, performance, or qualifications as determined by IEEE policy and/or applicable laws. For more information on the IEEE policy visit
http://www.ieee.org/about/corporate/governance/p9-26.html?WT.mc_id=hpf_pol

Ethics and Compliance

IEEE strives to achieve the highest standards of integrity and endeavors to conduct business around the world in a responsible and ethical way. It is important that those who act on the organization's behalf ensure IEEE's compliance by adhering to the same standards and expectations. The IEEE code of Conduct describes the commitment of IEEE members and staff to the highest standards of integrity, responsible behavior, and ethical and professional conduct. Find the IEEE Code of Conduct at
https://www.ieee.org/about/ieee_code_of_conduct.pdf

Reports of violations, or concerns regarding potential violations, of IEEE Policies or the IEEE Code of Conduct can be filed anonymously through EthicsPoint at +1 888 359 6323 or by submitting an online report at
https://secure.ethicspoint.com/domain/en/report_custom.asp?clientid=20410

IEEE Event Safety and Conduct Statement

IEEE believes that science, technology, and engineering are fundamental human activities, for which openness, international collaboration, and the free flow of talent and ideas are essential. Its meetings, conferences, and other events seek to enable engaging, thought-provoking conversations that support IEEE's core mission of advancing technology for humanity. Accordingly, IEEE is committed to providing a safe, productive, and welcoming environment to all participants, including staff and vendors, at IEEE-related events. IEEE has no tolerance for discrimination, harassment, or bullying in any form at IEEE-related events. All participants have the right to pursue shared interests without harassment or discrimination in an environment that supports diversity and inclusion. Participants are expected to adhere to these principles and respect the rights of others. IEEE seeks to provide a secure environment at its events. Participants should report any behavior inconsistent with the principles outlined here, to on site staff, security or venue personnel, or to ***eventconduct@ieee.org.***

By checking the box below, I AGREE to follow the IEEE policies as outlined in the NSREC website, including the following--

- *No photos or video/sound recordings will be permitted during the Short Course, Technical Sessions, Data Workshop or Poster Sessions.*
- *Conference attendees will not engage in harassment of any kind, including sexual harassment, or bullying behavior, nor discriminate against any person because of characteristics protected by law. In addition, attendees will not retaliate against any person who reports an act of misconduct, or who reports any violation of the IEEE Code of Ethics or Code of Conduct.*

I will follow the IEEE NSREC policies ❒ **YES** ❒ **NO**

2022 IEEE NSREC
Social Activities Registration Form

Conference Attendee _____
Last Name *First Name I*

Company/Agency _____

Address _____

Address _____

City _____

State/Province _____

Zip or Postal Code _____

Country _____

Telephone Number _____

Fax Number _____

E-mail Address _____

Please register any accompanying guest(s): *List ages only for children who are under 21 years.*

_____ *Name* *Age*
_____ *City, State, Country*

_____ *Name* *Age*
_____ *City, State, Country*

_____ *Name* *Age*
_____ *City, State, Country*

CANCELLATIONS

To encourage advance registration for conference social activities, the NSREC will refund all activity fees for conference attendees and/or their companions who, for any reason, are unable to attend the conference. If your plans change after this form is submitted and you would like to request a refund, you must notify NSREC Registration by e-mail at etc@etcic.us or by fax at 720-733-2046 *by no later than June 5, 2022.*

Mail or Fax this form and your remittance to:

IEEE NSREC REGISTRATION
2254 Emerald Drive
Castle Rock, CO 80104

Tel: 720-733-2003 Fax: 720-733-2046

ACTIVITIES FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 17, 2022. All functions are limited in attendance so early registration is suggested. Children must be accompanied by an adult during all tours and social events.

	Early	Late	Qty	Total Cost
Conference Social – Wadley Farms				
Wednesday, July 20				
Adult (21 yrs +)	$50	$65	____	$_____
Teen (13-20 yrs)	$35	$45	____	$_____
Child (6-12 yrs)	$25	$35	____	$_____
Infant (0-5 yrs)	$0		____	$_____
Companion Function: Thanksgiving Point				
Tuesday, July 19				
Adult/Teen (13 yrs +)	$41	$46	____	$_____
Child (0-12 yrs)	$5	$10	____	$_____
Companion Function: Park City				
Thursday, July 21				
Adult/Teen (15 yrs +)	$24	$29	____	$_____
Child (4-14 yrs)	$9	$14	____	$_____
Infant (0-3 yrs)	$0		____	$_____

TOTAL AMOUNT ENCLOSED: $_____

PAYMENT OF FEES

☐ Enclosed is a check in **U.S. DOLLARS ONLY**, drawn on or payable through a U.S. bank. Payable to: **IEEE NSREC**

☐ Charge registration fees to my credit card (U.S. dollars):

☐ American Express ☐ Master Card
☐ Visa ☐ Discover

Card No. _____

Expiration Date _____ Security Code _____

Name on card _____

Cardholder Signature _____

Billing address _____

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Social Program

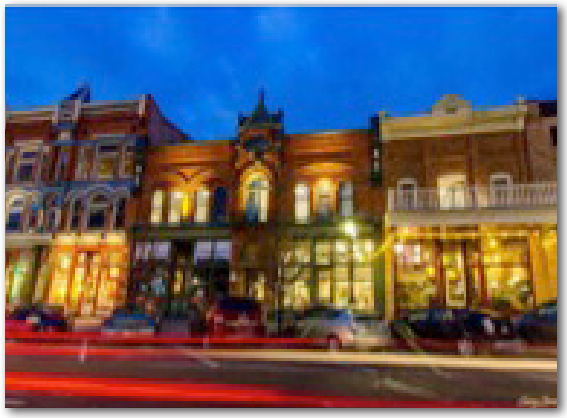
"Welcome to NSREC 2022, Provo, and the UVCC. I am excited for you to attend NSREC in downtown Provo, Utah. The UVCC is the perfect venue for the conference with ample space, easy walking access to a wide variety of restaurants, shopping, cultural icons, and so much more. I hope you enjoy the conference as much as we have enjoyed planning it. And I hope that this location encourages us to all become reacquainted with one another after these last two virtual years and that new professional relationships can be formed. I look forward to seeing you in Provo!"

Daniel Loveless
University of Tennessee at Chattanooga

"Welcome to NSREC 2022 and to Provo, Utah – the place I have called home for the last thirty years. Provo is a great place to enjoy beautiful outdoor scenery, friendly people, and a unique cultural heritage. Provo is a great central location to visit many of the unique sites in the intermountain western United States including majestic mountains, beautiful canyons, fascinating red rock formations, unusual geological sites and interesting cultural attractions. I hope you take some time outside of the conference to enjoy this unique place by visiting nearby sites. I hope you enjoy visiting Utah as much as I enjoy living here. Feel free to contact me if you have any questions about Provo or any of the nearby sites and venues. "

Mike Wirthlin
Brigham Young University

Provo, the heart of the larger Utah Valley, boasts arguably the most dramatic backdrop in the Wasatch Front. Mount Timpanogos, with nearly 5,300 ft (1,614 m) of prominence and an 11,752 ft summit (3,582 m), is an inspiring citadel of solid rock, and is the centerpiece to the Utah Valley stretch of the Wasatch Front. Today, Provo sets itself apart as a place for innovation in technology, health care, education, as well as a place for easy access to Provo Canyon.



Downtown Provo
(Photo courtesy Utah Valley CVB)

The picturesque town of Provo is brimming with culture, history, nature, and wildlife (cougars, most notably). Get an alpine start on a hike to the Mount Timpanogos summit or spend a day floating or rafting down the waters of the Provo River. Whatever your preferences, you will have no trouble finding things to do in Provo.

Provo was settled by members of The Church of Jesus Christ of Latter Day Saints in 1849. It was the first Latter-day Saint colony in Utah outside of the Salt Lake Valley. Conflict between the settlers and the native Ute people led to a defensive fort called Fort Utah. It was built as a stockade with exterior walls that were fourteen feet high. Peace came slowly between the Latter-day Saints and the Ute people, but after the first year, the settlers had to set up homes outside of Fort Utah and quickly began to establish Provo with farms and industrial centers. Provo soon became known as the "Garden City" because of its extensive fruit orchards, trees, and gardens. The Brigham Young Academy was founded in Provo in 1875. This school grew into what is now Brigham Young University (BYU). It is the largest church-affiliated university in the United States. BYU's students quickly outgrew the Brigham Young Academy Building, and the campus moved to its present location. The Academy today stands restored in its original location, but now as a beautiful public city library. Visitors of Provo can see several sites today that have a great historic significance. These locations are landmarks of the community.

The conference committee has designed a social program that will provide you with the rich history of Provo as well as the time to enjoy the breathtaking landscape. The **Excursion to Thanksgiving Point** will allow recreation, education, and peace to come together. It is located twenty minutes south of Salt Lake City, Utah, off Interstate 15, and 20 minutes north of the Provo Marriott. Thanksgiving Point acts as a refuge from everyday life - a unique location showcasing the beauty and majesty of nature in countless ways. Discover the lost world of dinosaurs at the Thanksgiving Point Museum of Ancient Life. Take a stroll through the beautiful 55-acre Ashton Gardens or enjoy a hayride through Farm Country. See over a thousand butterflies from around the world at the Butterfly Biosphere, plus many other insects. Choose from more than 400 interactive experiences at the Museum of Natural Curiosity. Additionally, we will be guiding a **Tour of Park City**, that will begin with a drive to Bridal Veil Falls before stopping for a short tour of Sundance Resort and heading for a scenic drive to Park City. We will arrive to historic Main Street where, after a quick tour, guests will have ample time to enjoy lunch and go shopping or sightseeing on their own. Our social program on Wednesday will take place at the picturesque Wadley Farms.

Social Program

The operational family farm boasts impressive architecture, breathtaking views, and course … a castle! You may enjoy a quiet space in the garden for connecting with your family, friends, and colleagues, or find yourself listening to music, dancing, and more!

SUNDAY, JULY 17, 2022
6:00 PM TO 9:00 PM

REGISTRATION
WELCOME RECEPTION

TIMPANAGOS TERRACE & CASCADE BALLROOM

Join your colleagues for a reception and light snacks on the **Timpanagos Terrace & Cascade Ballroom.** This reception is open to all Short Course and Technical Session attendees and their registered guests as 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 19, 2022,
9:30 AM TO 3:30 PM

TOUR OF THANKSGIVING POINT

On Tuesday morning you will meet the tour coordinator and depart from the Provo Marriott at 9:30 AM to experience the Excursion to Thanksgiving Point. We will begin with a stop at the Gardens Campus for a visit of Ashton Gardens in the morning when it is not too hot. The tour will provide you with an "Explorer Pass" that will also allow a visit to the Museum of Natural Curiosity in this area as well as the other facilities in the afternoon. The motorcoach will move everyone to the Watertower Campus in the afternoon for a visit to the Butterfly Biosphere, the Museum of Ancient Life and Farm Country. This is also where you can find 3 dining options – the Tower Deli, the Trellis Café and the Harvest Restaurant. The motorcoach will return to the Provo Marriott at 3:30 PM.

Ashton Gardens, Courtesy of Thanksgiving Point

Ashton Gardens
The heart of Thanksgiving Point is the magnificent 55-acre Ashton Gardens. Each area in the Garden has an individual identity, like rooms in an estate. Visitors will be enchanted by a Rose Garden, Monet Garden, Italian Garden, Secret Garden, Butterfly Garden, Vista Garden, Parterre Garden, the Largest Man-Made Waterfall and the one-of-a-kind Light of the World Garden. Each spring 300,000 tulips are on display in the annual Tulip Festival. More than 100,000 guests visit the festival each year.

More information: ***https://thanksgivingpoint.org/***

Waterfall Amphitheatre at Ashton Gardens, Courtesy of Thanksgiving Point

The Museum of Natural Curiosity
The Museum of Natural Curiosity occupies a 45,000 square foot building built for families to explore. Inside are 400 interactive exhibits, including four main galleries—Rainforest, Water Works, Kidopolis, and the Discovery Garden.

Social Program

The Museum of Ancient Life

Exhibits at Thanksgiving Point's Museum of Ancient Life include some of the longest and tallest dinosaurs ever discovered. In all, the gigantic dinosaur museum houses more that 50 standing dinosaurs and more than 100 flying reptiles! The museum also features 50 hands-on exhibits for families to enjoy and learn together.

Dinosaurs at the Museum of Ancient Life, Courtesy of Thanksgiving Point

The Butterfly Biosphere

The Butterfly Biosphere at Thanksgiving Point's Water Tower Plaza is an experience unlike anything in the state of Utah! This 40,000 square foot venue is home to over a thousand butterflies from around the globe. In addition to dozens of species of butterflies, it also has 20 species of tarantulas, beetles as big as your fist, and many more creepy crawly friends. Complete the experience by helping release a butterfly into the conservatory!

TUESDAY, JULY 19, 2022, 6:00 PM TO 7:30 PM

INDUSTRIAL EXHIBITS RECEPTION

EXHIBIT HALLS A-B-C, UVCC, 1ST FLOOR

Join us for the 2022 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to Exhibit Halls A, B, and C to visit the booths, enjoy some refreshments and participate in a raffle. *All attendees and registered guests must show their badges to enter the NSREC Industrial Exhibits.*

Social Program

WED. JULY 20, 2022
6:00 PM TO 10:00 PM

CONFERENCE SOCIAL

WADLEY FARMS

Wednesday Social Site, Wadley Farms

Using old world craftsmanship, Wadley Farms offers an ageless stage for any unique event. The main castle and updated barn are the ideal location for the 2022 NSREC Conference Social, with its dramatic arched wood beams and high vaulted ceilings. The adjacent Railroad Building provides a picturesque atmosphere with its sparkling chandeliers and Tuscan style fireplace for an intimate conversation. The site is host to gardens, which feature a wisteria wrapped gazebo, grand rock archways, castle turrets, a cascading fountain, and lush vegetation.

View of the Old Railroad Building at Wadley Farms

Join your colleagues and friends for a buffet, beverages, and entertainment at the castle. Wear casual clothing. The coaches will depart from the Provo Marriott 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 grounds, admire the architecture, or partake in a game. Tickets are not included in the conference registration so be sure to purchase them with your registration.

Wadley Farms Sparkling Grape Juice

For more information on the history of Wadley Farms, see website ***https://www.wadleyfarms.com/our-history/wadleyfarms/lindonutah/weddings/events/familyfarm***

Social Program

THURSDAY, JULY 21, 2022
7:00 AM TO 8:15 AM

IEEE YOUNG PROFESSIONALS BREAKFAST

CASCADE A AND B, UVCC, 3RD FLOOR

IEEE youngprofessionals

A special breakfast will be held in the Cascade A and B, UVCC, 3rd floor for IEEE member attendees who are Young Professionals ***(http://yp.ieee.org/, https://www.facebook.com/ieeeyp)***. This is an excellent opportunity for newer industry members to informally discuss radiation effects and to become better acquainted.

Our guest speaker for the Young Professional breakfast will be Anthony (Tony) Sanders of the Electrical Engineering Division at NASA Goddard Space Flight Center, who will be presenting an entertaining talk entitled *"From High School Intern to Senior Executive."*

Tony Sanders entered the Senior Executive Service on February 28, 2021 as Chief of the Electrical Engineering Division at NASA's Goddard Space Flight Center, providing leadership for end-to-end electrical engineering capabilities to enable NASA science observations from space.

Prior to that, Tony started his career at NASA in 1986 as a high school intern. He served as an electronics technician while a co-op student supporting several branches in Robotics, Power Systems, and Flight Data Processing Devices. Tony spent much of his career working as a design and test engineer specializing in parts and radiation qualification of microelectronics in support of spaceflight missions such as Hubble Space Telescope (HST), Lunar Reconnaissance Orbiter (LRO), Sample Analysis at Mars (SAM) Instrument on Mars Curiosity Rover, and Magnetospheric Multiscale (MMS) mission.

He transitioned into management in 2008 as Associate Branch Head of the Flight Data Systems and Radiation Effects Branch, then served as Assistant Chief (2011) and Associate Chief (2013) in the Electrical Engineering Division. In 2015, Tony served as Associate Chief of the Quality and Reliability Division in the Safety and Mission Assurance (SMA) Directorate where he established Goddard's first Quality Engineering Branch and implemented new commodity risk assessment engineers to meet the Goddard Center Director's reorganization goals and initiatives for SMA.

In 2018, Tony worked at NASA Headquarters in the Office of Safety and Mission Assurance where he was matrixed to the Science Mission Directorate, providing technical authority to over 100 science missions as well as served as senior advisor to the NASA Electronic Parts Manager for the Agency.

Tony holds a B.S. in Electrical and Nuclear Engineering from University of Maryland, College Park and a Certificate in Public Leadership from the Brookings Institute, Washington, DC. He is the recipient of the NASA Honor Award for Group Achievement for Detector Development Improvement for NASA 2018, the Robert H. Goddard (RHG) Award for Mentoring in 2016, RHG Award for Supervisory in 2015, and the Agency NASA Equal Employment Opportunity Medal in 2015. He is a member of the IEEE Nuclear and Plasma Sciences Society, American Institute of Aeronautics and Astronautics (AIAA), and lifetime member of the National Society of Black Engineers.

Social Program

In addition, the Young Professionals breakfast will include individuals representing IEEE, the Nuclear & Plasma Sciences Society (NPSS) Radiation Effects Steering Group, and various NSREC committees for discussions on how to become involved in IEEE NPSS activities. For more information, contact Ted Wilcox, ***ted.wilcox@nasa.gov.***

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

THURSDAY, JULY 21, 2022
9:00 AM TO 3:30 PM

TOUR OF PARK CITY

On Thursday morning you will meet the tour coordinator and depart from the Provo Marriott at 9:00 AM to experience the Tour of Park City, Utah. We will begin with a guided drive to Bridal Veil Falls for a viewing of the waterfall and continue onward for a short stop at Sundance Resort. After a small walking tour and a stop at the gift shop, we will continue the scenic drive to Park City. We will drive to historic Main Street in Park City and provide commentary along the way. We will also drive in the mountains of deer valley to see the resort and some mountain top views. There will be a stop to do some light walking. We will arrive to Main Street around 12:30 PM. After doing a quick driving tour pointing out all the restaurants and shops, you will have two hours to have lunch and do shopping and sightseeing on your own. There are also plenty of bars to grab a drink as well. We will begin our drive directly back to Provo at 2:30 PM.

Downtown Park City, Utah
(photo courtesy of Utah Office of Tourism)'

THURSDAY, JULY 21, 2022
12:00 PM TO 1:15 PM

WOMEN IN ENGINEERING LUNCH

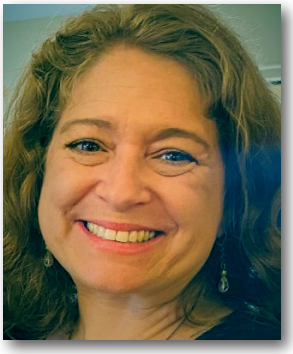
CASCADE A AND B, UVCC, 3RD FLOOR

A special lunch will be held in Cascade Rooms A & B, UVCC, 3rd floor 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 event is on the topic of *"Stress, Conflict, and Burnout"* This interactive talk examines the stress response, explains how stress and conflict are normal and necessary, and explores ways of managing stress and building resiliency in order to alleviate burnout. The workshop includes a self-assessment, mindfulness practice, and assertiveness tools for better conflict communication. Participants will:

- Complete and reflect upon their own work-life stress
- Explore ways to manage the stress and mitigate burnout
- Earn an assertive response to workplace conflict
- Practice a mindful meditation

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

Social Program



Elisa Enriquez, LCSW
Senior Associate Ombuds
Los Alamos National Laboratory (LANL)

elisae@lanl.gov

Elisa Vazquez Enriquez (she/her/hers) is a Senior Associate Ombuds at Los Alamos National Laboratory (LANL). With a background in clinical counseling and as an Employee Assistance Program Counselor, Elisa has been a practicing Ombuds since 2011 and is a certified organizational ombuds practitioner (CO-OP®). Elisa enjoys presenting and teaching conflict resolution and communication skills at LANL, the greater New Mexico community, and at national conferences, such as the annual International Ombuds Association conferences and NM Alternative Dispute Resolution Symposiums. While she develops her own workshops, Elisa is also a certified trainer in Crucial Conversations and in Adult Mental Health First Aid. She recently became a certified coach and trainer for the 4 Stages of Psychological Safety and the Mediation Training Institute Conflict Dynamics Profile.

Elisa is a mom to two teens and enjoys hikes with her husband and her two shelter pups. She also enjoys yoga, singing, and eating gourmet food not cooked by her.

For more information, contact Elizabeth Auden, ***eauden@lanl.gov.***

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 **ETCic** via fax **(720-733-2046)** or e-mail (***etc@etcic.us***) 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. Also be aware that not all areas of the companion events are wheelchair and stroller friendly.

Local Activities

GENERAL INFORMATION

Downtown Provo
(Photo courtesy Utah Valley CVB)

DOWNTOWN PROVO

Come stroll along the beautiful tree lined streets of Downtown Provo on a lazy afternoon of shopping. From Art Galleries, to clothing stores, to bookstores and antique shops, Downtown Provo has a little something for everyone. Explore the eclectic restaurant culture of downtown Provo and grab a show at Velour, or the **Rooftop concert series** over the summers!

Provo's historic downtown is influenced by the local Brigham Young and Utah Valley Universities. The city center has a thriving district where families and business professionals can enjoy their free time. With over 50 independently-owned restaurants featuring local and international cuisine, plus unexpected unique activities and experiences.

Take the Historic Provo Buildings Walking Tour, where historic buildings lock arms around modern structures, a blend of a sublimely walkable, hyperlocal main drag shows a vibrant and fast-growing economy. The wide thoroughfare of the formidable University Avenue intersects with the tree-lined Center Street; were it not for the line of parked contemporary cars you'd think you had stepped back in time gazing on ornamental cornices and decorative facades from another age in architectural design. An unexpected number of those storefronts lure us off the sidewalk with the promise of satiating our **sweet tooth**, from the Kro-Nut, artisan chocolate, handmade ice cream, piña coladas, custom soda shops, and more.

- 50+ Restaurants
- Vintage Boutiques
- Urban Art
- Historic Buildings
- Live Entertainment, Comedy Shows, Virtual Experiences Karaoke, Axe Throwing, and more

Check the NSREC website for a full list of discounts and yelp recommendations for shopping, dining, and local attractions.

Local Activities

BRIGHAM YOUNG UNIVERSITY

Provo is home to **Brigham Young University**, a private research university in Provo, Utah sponsored by The Church of Jesus Christ of Latter-day Saints. BYU is well known for its mature and culturally experienced, multi-lingual student body, its world-class teaching and its majestic mountain location. The 557-acre campus nestled at the base of the Wasatch mountains includes 265 buildings featuring a wide variety of architecture styles. The campus includes several museums (see museum section below for details), beautiful landscapes and a variety of educational activities for campus visitors. A visit to the BYU campus can be made with a short ride on the UVX commuter bus with stops near the conference center and at BYU.

BYU CAMPUS TOURS

Tours of the BYU campus are provided to campus visitors by the office of University Relations (https://ur.byu.edu/campus-tours). Visitors to the University will be taken by tour cart throughout campus by an experienced guide who will present the University's rich heritage and unique educational philosophy.

Photo courtesy usnews.com

BYU ARTS

BYU Arts is the producing and presenting organization for the Brigham Young University College of Fine Arts and Communications. The Division of Arts Production provides marketing and production services for the more than 500 annual performances and events sponsored by the Department of Dance, Department of Theatre Arts, Department of The School of Music, and BRAVO! Professional Performing Arts Series. Performances are staged in the **Harris Fine Arts Center, Marriott Center**, and **Richards Building**. The division also supports the university's performing groups in other venues on campus as well as on tour throughout Utah, the United States, and the world.

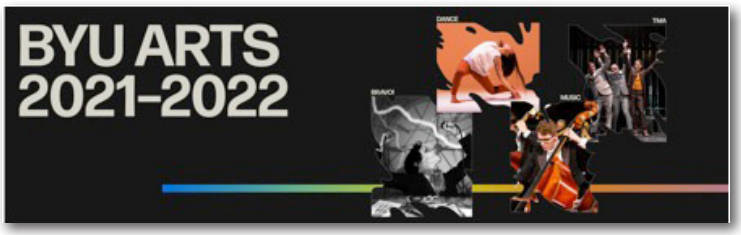


Photo courtesy https://arts.byu.edu/brochure-2022/

BYU ARBORETUM

The **Bertrand F. Harrison Arboretum** is named in honor of the legendary professor who taught botany for 43 years until his retirement in 1974. As the site plaque states, "Professor Harrison and his students transformed these few acres into an area for study, for relaxation, and for reflection." The original trees were planted to approximate the United States geographically, including the giant sequoia, common to the Sierra Nevada of California, and the water-loving bald cypress, typically found in the Gulf region. The amphitheater was donated by the class of 1980 and 1981.

Local Activities

MUSEUMS AND GALLERIES

Utah Valley is ripe with historical museums, nature-centered museums, art museums, and interactive playful museums--there's something for everyone.

BYU MUSEUM OF ART

One of the largest and best-attended art museums in the Mountain West, the BYU Museum of Art, offers a dynamic exhibition schedule that includes displays of its permanent collection, world-class traveling shows, and thought-provoking exhibitions organized by museum curators. One of the museum's most important roles is its contribution to the academic mission of Brigham Young University. From the research and study of the artworks in the permanent collection, to the teaching and learning that occurs in classrooms and galleries, the museum plays an important role in the academic pursuits of many students at BYU. The museum also seeks to connect to broad community audiences through exhibitions and educational programming.

BYU MONTE L. BEAN LIFE SCIENCE MUSEUM

The **Monte L. Bean Life Science Museum** is a dynamic repository and trustee for a remarkable group of biological collections. These collections are used to celebrate the role of Jesus Christ as Creator, while enhancing student learning and mentoring and promoting faculty teaching and research. They also serve as a unique venue for inviting the public and scientific community to explore and contemplate intricate biological relationships and processes.

BYU'S MUSEUM OF PEOPLES AND CULTURES

BYU's **Museum of Peoples and Cultures** researches, preserves, and exhibits artifacts from cultures past and present, housing over 1 million anthropological items from all around the world. The museum began as a repository for the Department of Anthropology, whose expeditions were actively generating collections as early as the 1960s.

THE MUSEUM OF ANCIENT LIFE

Located at **Thanksgiving Point, the Museum of Ancient Life** offers a hands-on trip through an amazingly realistic prehistoric world. Kids can dig up their own fossils, construct a giant dinosaur, or build their own private sand valley (complete with real eroding rivers). For a prehistoric adventure you'll never forget, come and enjoy a day here at the Museum of Ancient Life.

The Museum of Ancient Life exhibits fossil specimens representing every geological period from the Precambrian to modern times. Featuring more than 120 skeletons, 63 interactive exhibits, and hundreds of smaller fossil remains, it ranks as one of the world's largest permanent exhibitions of ancient life.

The Museum of Ancient Life
(https://www.utahvalley.com/listing/museum-of-ancient-life/101/)

Local Activities

SPRINGVILLE MUSEUM OF ART

The Springville Museum of Art is Utah's first museum for the visual fine arts. Dedicated as a "Sanctuary of Beauty and a Temple of Contemplation" by David O. McKay, the Museum houses over 2,500 works. Utah art, twentieth-century Soviet Realist art and American art, comprise the Museum's permanent collection.

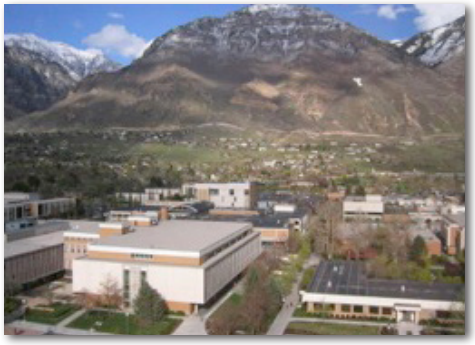
NATURAL HISTORY MUSEUM OF UTAH

The state museum of natural history, located in **Salt Lake City**, provides an introduction to the science on display in Utah's remarkable landscape! With engaging exhibits and more than 5,000 artifacts on display, the Museum features Utah's paleontology discoveries, fascinating gems and minerals found world-wide, preserved artifacts from Utah's prehistoric peoples, and stories told by the five Native nations that lie within the state's boundaries. Journey to the top of a three-story indoor Canyon. Wander through Utah's dinosaurs and animal life. Interact with earthquakes, erosion, and our digital globe to discover how the earth's surface and the Great Salt Lake have changed over time. Hear stories of Utah's native peoples, past and present. Enjoy breath-taking views from our observatory deck. Hike the Bonneville Shoreline trail. Experience natural history as only Utah can reveal it. Conclude your visit by shopping at the Museum Store for unique jewelry, toys, and gift items.

HIKING

Hiking in Utah Valley is one of the best ways to enjoy the outdoors and appreciate the mountains and natural beauty here. There are trails for all people, ranging from easy "walks in the park" to challenging climbs up mountain tops.

- Y MOUNTAIN
  - Distance: 2.4 miles (add about 4 miles to the top of Y Mountain)
  - Trail type: very steep, out-and-back, loose gravel
  - Difficulty level: moderate; kid-friendly
  - Trailhead: Y Mountain Trailhead Rd, Provo
  - *The Y Mountain is on the east portion of BYU, and the first place to look for a good hike. It is also a great place for families to have an outdoor adventure. Hiking the Y is basically a rite of passage for every BYU student, and some have even joked that it is a graduation requirement. It offers beautiful views over Provo and Orem that make the steep hike worth it.*



Y Mountain (https://en.wikipedia.org/wiki/Y_Mountain#/media/File:BYU_East.jpg)

- ROCK CANYON
  - Distance: 5.5 miles
  - Trail type: out-and-back, rocky
  - Difficulty level: moderate to hard
  - Trailhead: Rock Canyon Trailhead Parking, Provo
  - *This popular hike leads you up Rock Canyon, passing unique rock formations, crossing bridges over rivers, and even walking by a few caves, until you reach Rock Canyon Campground. You can also hike to Squaw Peak from here, by turning onto Squaw Peak Trail about halfway through.*

Local Activities

BRIDAL VEIL FALLS

- Distance: <1 mile
- Trail type: out-and-back, paved
- Difficulty level: easy, kid-friendly
- Trailhead: Bridal Veil Falls parking lot
- *This highly popular short path is really more of a walk than a hike, but it is so beautiful we had to put it on here. The path leads to a gorgeous waterfall that is over 600 feet tall and will take your breath away!*

Bridal Veil Falls (https://www.utahvalley.com/blog/post/guide-to-50-best-hikes-in-utah-valley/)

STEWART FALLS

- Distance: 3.5 miles
- Trail type: out-and-back
- Difficulty level: easy
- Trailhead: Aspen Grove or Sundance Resort
- *If you are looking for a more exciting trail to a waterfall than Bridal Veil Falls, take this trail! The waterfall is smaller, but the adventure of getting there makes it so fun.*

TIMPOONEKE TRAIL ("TIMP" HIKE)

- Distance: 15 miles
- Trail type: out-and-back
- Difficulty level: challenging
- Trailhead: Aspen Grove or Timpooneke Trail
- *If you are looking for an epic one-of-a-kind hike, take this trail near the top of one of the highest peaks in Utah on Mount Timpanogos.*

TIMPANOGOS CAVE TRAIL (CANYON NATURE TRAIL)

- Distance: 3.5 miles
- Trail type: out-and-back
- Difficulty level: moderate
- Trailhead: Timpanogos Cave National Monument, American Fork
- *One of the most popular attractions in Utah Valley, this trail leads to Timpanogos Cave. In order to enter the cave, tickets are required, but it is so worth it to see the amazing sites in the cave.*

SQUAW PEAK

- Distance: 7.2 miles
- Trail type: out-and-back
- Difficulty level: difficult
- Trailhead: Timpanogos Cave National Monument, American Fork
- *One of the most popular attractions in Utah Valley, this trail leads to Timpanogos Cave. In order to enter the cave, tickets are required, but it is so worth it to see the amazing sites in the cave.*
- ***Squaw Peak Overlook** is a great place to overlook the valley and can be reached by car on the **Alpine Loop.** As you drive up Provo Canyon about three miles up there is right turn, follow the road and when it forks, continue right. It has a great overlook of the city lights at night.*

MT. NEBO

- *The **Nebo Loop Scenic Drive** offers breathtaking views of the Wasatch Range and 11,877-foot Mt. Nebo, the tallest peak in the county. This route is equipped with several popular hiking/biking trails like the Blackhawk Loop Trail and Loafer Mountain Trail. Devil's Kitchen is a must-see pocket of red-rock hidden among the forests giant conifers.*

More information:
https://www.utahvalley.com/blog/post/guide-to-50-best-hikes-in-utah-valley/

Local Activities

THANKSGIVING POINT

Thanksgiving Point is a unique destination where recreation, education, and peace come together. It is located twenty minutes south of Salt Lake City, Utah, off Interstate 15, and 20 minutes north of the Provo Marriott. Thanksgiving Point acts as a refuge from everyday life - a unique location showcasing the beauty and majesty of nature in countless ways. Discover the lost world of dinosaurs at the Thanksgiving Point Museum of Ancient Life. Take a stroll through the beautiful 55-acre Ashton Gardens or enjoy a hayride through Farm Country. See over a thousand butterflies from around the world at the Butterfly Biosphere, plus many other insects. Choose from more than 400 interactive experiences at the Museum of Natural Curiosity.

THE MUSEUM OF NATURAL CURIOSITY

The Museum of Natural Curiosity occupies a 45,000 square foot building built for families to explore. Inside is 400 interactive exhibits, including four main galleries—Rainforest, Water Works, Kidopolis, and the Discovery Garden.

THE MUSEUM OF ANCIENT LIFE

Exhibits at Thanksgiving Point's Museum of Ancient Life include some of the longest and tallest dinosaurs ever discovered. In all, the gigantic dinosaur museum houses more that 50 standing dinosaurs and more than 100 flying reptiles! The museum also features 50 hands-on exhibits for families to enjoy and learn together.

THE BUTTERFLY BIOSPHERE

The Butterfly Biosphere at Thanksgiving Point's Water Tower Plaza is an experience unlike anything in the state of Utah! This 40,000 square foot venue is home to over a thousand butterflies from around the globe. In addition to dozens of species of butterflies, it also has 20 species of tarantulas, beetles as big as your fist, and many more creepy crawly friends. Complete the experience by helping release a butterfly into the conservatory!

ASHTON GARDENS

The heart of Thanksgiving Point is the magnificent 55-acre Ashton Gardens. Each area in the Garden has an individual identity, like rooms in an estate. Visitors will be enchanted by a Rose Garden, Monet Garden, Italian Garden, Secret Garden, Butterfly Garden, vista Garden, Parterre Garden, the Largest Man-Made Waterfall and the one-of-a-kind Light of the World Garden. Each spring 300,000 tulips are on display in the annual Tulip Festival. More than 100,000 guests visit the festival each year.

More information: **https://thanksgivingpoint.org/**

Thanksgiving Point (https://utah.com/thanksgiving-point)

Local Activities

SCENIC DRIVES

Utah Valley is a great place to take a scenic drive through Utah's mountains. A number of scenic drives are within minutes of the conference venue.

https://www.utahvalley.com/things-to-do/outdoor-recreation/scenic-drives/

THE ALPINE LOOP

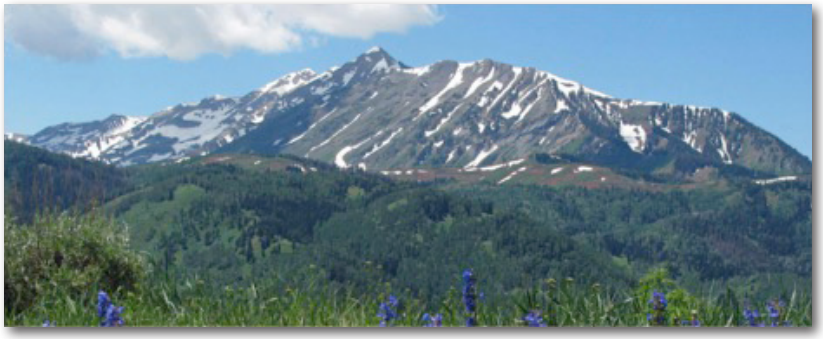
The Alpine Loop Scenic Byway, also known as Utah State Route 92, is a 20-mile thoroughfare that travels through American Fork Canyon and Provo Canyon, passing Sundance Mountain Resort and Aspen Grove. There is so much to do on this loop, including the Timpanogos Cave Trail, Squaw Peak Overlook, and Nebo Loop hikes.

HOBBLE CREEK CANYON

This drive begins in Springville and then loops to Strawberry Reservoir and back to Hwy 89. Southeast of Spanish Fork, this route offers an excellent tour of the Southern Wasatch Range. Along the way are campgrounds, a golf course, picnic areas and a portion of the Great Western Trail. Parts of the route are unpaved and should be traveled cautiously by a four-wheel-drive vehicle.

NEBO LOOP

One of America's National Scenic Byways, this route winds 32 miles up 11,928-foot Mt. Nebo, Utah Valley's highest mountain. Incredible overlooks offer spectacular vistas of communities below.



Mt. Nebo (https://www.utahvalley.com/things-to-do/outdoor-recreation/hiking-and-biking/nebo-loop/)

GOLFING

Utah Valley's golf courses include the nationally-ranked Thanksgiving Point golf course designed by Johnny Miller; it is the largest golf course in the state and was ranked among the top ten new courses in the country by Golf Digest. Hobble Creek golf course in Springville has been rated by Golf Digest magazine at 4.5 stars and is "one of the best values in North America," according to the magazine. Talons Cove Golf Club, located in Saratoga Springs, was the site of the 2005 & 2006 Utah Open.

- Cedar Hills Golf Club, **https://cedarhillsgolfutah.com/**
- Timpanogos Golf Course, **https://www.timpanogosgolf.com/**
- Fox Hollow Golf Club, **https://www.foxhollowutah.com/**
- Gladston Golf Course, **https://gladstan.com/**
- Hobble Creek Golf Course, **https://www.springville.org/golf/**
- The Links at Sleepy Ridge, **https://www.sleepyridgegolf.com/**
- Thanksgiving Point Golf Club, **https://thanksgivingpoint.org/experience/golf-club/**
- The Oaks at Spanish Fork, **https://www.theoaksatsf.com/**
- The Ranches Golf Club, **https://theranchesgolfclub.com/**

Local Activities

SHOPPING

From Art Galleries, to clothing stores, to book stores and antique shops, Provo has a little something for everyone:

- Provo Town Centre: **https://www.provotownecentre.com/**
- University Place Mall: **https://www.universityplaceorem.com/**
- The Shops at Riverwood: **https://shopsatriverwoods.com/**
- The Meadows Shopping Center: **https://www.utahvalley.com/listing/the-meadows/950/**
- Historic Downtown Provo, Center Street
- Outlets at Traverse Mountain: **https://www.outletsattraversemountain.com/**

2022 Conference Committee

General Chair
Thomas L. Turflinger
The Aerospace Corporation
thomas.l.turflinger@aero.org

Technical Program Chair
Pascale Gouker
MIT Lincoln Laboratory
pgouker@ll.mit.edu

Local Arrangements Chair
Daniel Loveless
Univ. of TN – Chattanooga
daniel-loveless@utc.edu

Short Course Chair
Sylvain Girard
University of St Etienne
sylvain.girard@univ-st-etienne.fr

Publicity Chair
Teresa Farris
Archon LLC
Teresa.Farris@Archon-llc.com

Finance Chair
Matthew Gadlage
NAVSEA Crane
Matthew.gadlage@navy.mil

Awards Chair
Sarah Armstrong
NAVSEA Crane
Sarah.armstrong@navy.mil

Industrial Exhibits Chair
Tara Luther
SkyWater Technology
Tara.Luther@SkyWaterTechnology.com

Poster Chair
Jonathan Pellish
NASA Goddard Space Flight Center
jonathan.pellish@nasa.gov

Rad Effects Data Workshop
Zachary Fleetwood
SpaceX
Zachary.Fleetwood@spacex.com

Asst Local Arrangements
Michael Wirthlin
Brigham Young University
wirthlin@byu.edu

Social Media Chair
Adrian Ildefonso
Naval Research Laboratory
adrian.ildefonsorosa@nrl.navy.mil

Web Developer
Greg Allen
NASA Jet Propulsion Lab.
grallen@jpl.nasa.gov

Official Reviewers

Akin Akturk - *Cool CAD Electronics LLC*
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Vanderbilt University
Robert.reed@vanderbilt.edu
(Term expires: 7/24)

Executive Vice-Chair
Kay Chesnut
Raytheon Technologies
kay.c.chesnut@raytheon.com
(Term expires: 7/24)

Past Chair
Janet Barth
NASA Retired Emeritus
jbarth@ieee.org
(Term expires: 7/24)

Senior Member-at-Large
Michael Campola
NASA GSFC
michael.j.campola@nasa.gov
(Term expires: 7/22)

Member-at-Large
Rubén García Alía
CERN
ruben.garcia.alia@cern.ch
(Term expires: 7/23)

Junior Member-at-Large
Mike Tostanoski
Radiation Test Solutions
mtostanoski@radiationtestsolutions.com
(Term expires: 7/24)

Secretary
Arto Javanainen
University of Jyvaskyla
arto.javanainen@jyu.fi
(Term expires: 7/24)

Vice-Chair, Publications
Dan Fleetwood
Vanderbilt University
dan.fleetwood@vanderbilt.edu
(Term expires: 7/24)

Vice-Chair, Exhibits & Publicity
Teresa Farris
Archon LLC
Teresa.Farris@Archon-llc.com
(Term expires: 7/24)

Vice-Chair, Finance/RESG Delegate
Marty Shaneyfelt
Sandia National Labs (Retired)
mrshaney@ieee.org
(Term expires: 7/24)

Special Publication Assignment
Paul Dressendorfer
Sandia National Labs (Retired)
p.dressendorfer@ieee.org

Vice-Chair, 2022 Conference
Thomas Turflinger
The Aerospace Corporation
thomas.l.turflinger@aero.org

Vice-Chair, 2023 Conference
Keith Avery
AFRL/RV
keith.avery.2@us.af.mil

Vice-Chair, 2024 Conference
Heather Quinn
Los Alamos National Laboratory
hquinn@lanl.gov

Vice-Chair, 2025 Conference
Dolores Black
Sandia National Laboratories
dablack@sandia.gov

NPSS Adcom Member
Keith Avery
AFRL/RV
keith.avery.2@us.af.mi.
(Term expires: 12/22)

NPSS Adcom Member
Ken Galloway
Vanderbilt University
kenneth.f.galloway@vanderbilt.edu
(Term expires: 12/23)

Web Developer
Greg Allen
NASA Jet Propulsion Laboratories
grallen@jpl.nasa.gov
(Term expires: 7/24)

RADECS Liaison
Philippe Paillet
CEA/DIF
philippe.paillet@cea.fr
(Term expires: 9/22)

Vice-Chair, Social Media
Adrian Ildefonso
U.S. Naval Research Lab
adrian.ildefonso@ieee.org
(Term expires: 7/23)

ANNOUNCEMENT and FIRST CALL FOR PAPERS

2023 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

Short Course and Radiation Effects Data Workshop

July 24-28, 2023
Sheraton Kansas City Hotel at Crown Center
Kansas City, Missouri

www.nsrec.com

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IEEE/NPSS Radiation Effects Committee

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Keith Avery
Air Force Research Laboratory
keith.avery.2@spaceforce.mil

Technical Program Chair
Jonathan Pellish
NASA Goddard Space Flight Center
jonathan.pellish@nasa.gov

Short Course Chair
Ethan Cannon
The Boeing Company
ethan.cannon@boeing.com

Local Arrangements Chair
Sarah Armstrong
NAVSEA Crane
sarah.e.armstrong12.civ@us.navy.mil

Publicity Chair
Teresa Farris
Archon, LLC
teresa.farris@archon-llc.com

Finance Chair
Nathan Nowlin
Sandia National Laboratories
nnowlin@sandia.gov

Awards Chair
Julien Mekki
CNES
julien.mekki@cnes.fr

Industrial Exhibits Chair
Ken LaBel
SSAI, Inc. / NASA Goddard Space Flight Center
ken.label@nasa.gov

You are cordially invited to attend the 2023 IEEE Nuclear and Space Radiation Effects Conference to be held July 24-28, 2023 at the Sheraton Kansas City Hotel at Crown Center, Kansas City, Missouri. 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 3, 2023

PROCEDURE FOR SUBMITTING SUMMARIES

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file consisting of a cover page and an informative two to four page summary describing results appropriate for 12-minute oral or poster presentation. The cover page must provide an abstract no longer than 35 words, the title, name and company affiliation of the authors, and company address (city, state, country). Identify the author presenting the paper and provide telephone, and email address. The summary must include sufficient detail about the work to permit a meaningful technical review. In the summary, clearly indicate (a) the purpose of your work, (b) significant new results with supporting technical material, and (c) how your work advances the state of the art. Show key references to other related work. The summary must be no less than two and no more than four pages in length, including figures 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.

Summaries must be received by February 3, 2023

Detailed submission and formatting instructions will be available after December 1, 2022 at www.nsrec.com

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 2024). 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.*

KANSAS CITY, MISSOURI

Courtesy of Visit KC

The location for NSREC 2023 will be the Sheraton Kansas City Hotel at Crown Center in the Crown Center complex in Kansas City, Missouri. The home of swing and bebop for some, "The City of Fountains" to others, Kansas City is different things to different people. Music enthusiasts are drawn to the jazz clubs and old haunts of famous musicians such as Charlie Parker and Count Basie. With more fountains than Rome, there are ample opportunities for scenic "strolling from fountain to fountain." Stop along the way to discover interesting neighborhoods and browse through eclectic shops. Families are particularly attracted to the city because of its child-friendly events and venues. Science City features hands-on exhibits, while the zoo houses impressive African and Australian exhibits plus an IMAX Theater. The city's museums cover everything from the history of jazz music to a celebration of African American baseball players and the National World War I Museum and Memorial. Kansas City spans across the Missouri and Kansas state lines and came to prominence as a port for the Missouri and Kansas Rivers. Today, Kansas City is a burgeoning metropolis with activities and attractions for visitors of all ages and interests. Come and join us for NSREC 2023 and experience it for yourself.