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IEEE/NPSS Radiation Effects Committee

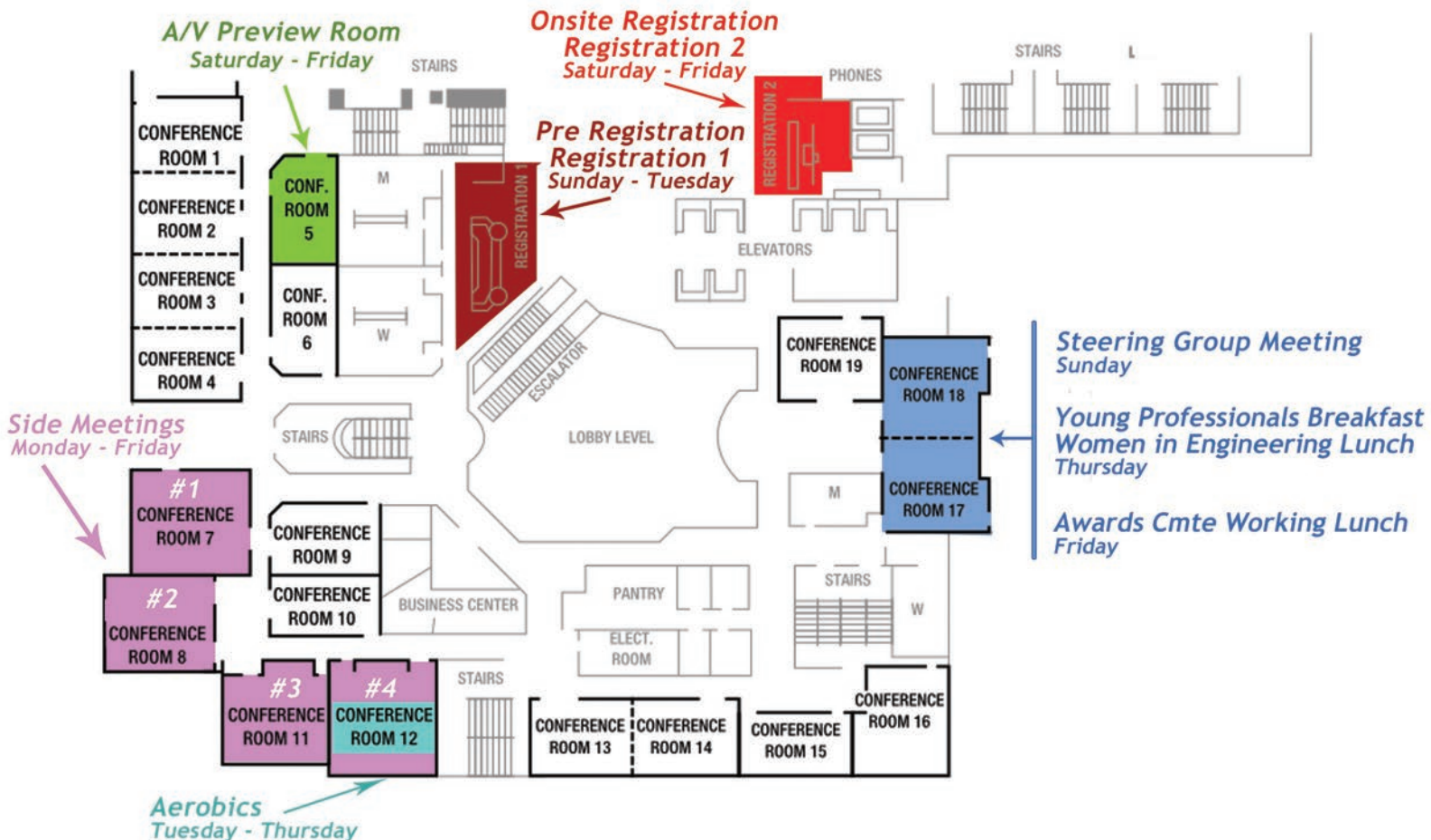
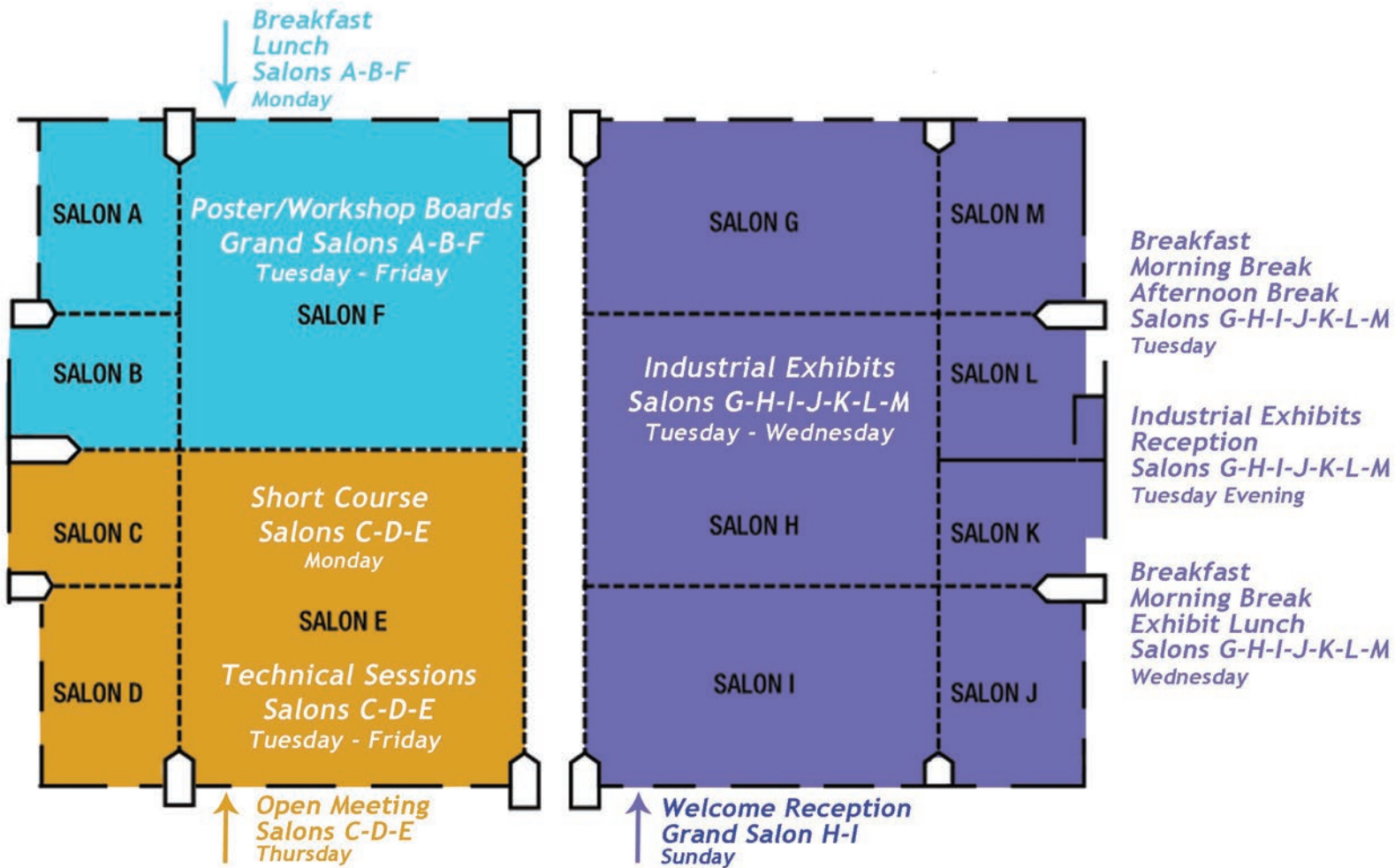
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July 8 - 12, 2019
San Antonio Marriott Rivercenter
San Antonio, TX

IEEE Nuclear and Space
Radiation Effects
Conference

MARRIOTT RIVERCENTER



Schedule

Time	Monday July 8	Tuesday July 9	Wednesday July 10	Thursday July 11	Friday July 12
7:00	[7:00] Breakfast – Salons A-B-F	[7:00] Breakfast – Salons G-M (Exhibits)	[7:00] Breakfast – Salons G-M (Exhibits)	[7:00-8:30] IEEE Young Professionals Breakfast – Conference Rooms 17 & 18 (YP talk begins at 7:30 AM) <i>Ticket Required to Attend</i> — and —	[7:00] Breakfast – Salons A-F (Pre-Function)
7:30					
8:00	[8:00] Short Course Introduction Dr. Steven Moss, Grand Salons C-D-E				
8:10	[8:10] Part I – Basics of Single Event Effect Mechanisms and Predictions				
8:15	Dr. Daisuke Kobayashi				
8:30		[8:20] Opening Remarks/ Awards Presentation Salons C-D-E	[8:20] Invited Talk – Automated Vehicles and the Road Ahead Chris Mentzer Salons C-D-E	[8:30] Invited Talk – Parker Solar Probe: A Mission to Touch the Sun Dr. Jim Kinnison Salons C-D-E	[8:30] Invited Talk – Spanish Exploration and the Beginnings of Texas Natural History Dr. Jesús F. de la Teja Salons C-D-E
9:00		[9:00] Session A – Single Event Effects: Mechanisms and Modeling			
9:30			[9:35] Session F – Basic Mechanisms		
10:00	[9:40] Break – Grand Pre- Function			[9:45] Session H – Photonic Devices and Integrated Circuits	[9:45] Session I – Hardening by Design
10:30	[10:10] Part II – SEE Testing with Broad and Focused Particle Beams Dr. Arto Javanainen	[10:05] Session B – Single Event Effects: Transient Characterization	[10:25] Break – Salons G-M		
11:00		[10:55] Break – Salons G-M	[10:55] Session G – Radiation Effects in Devices and Integrated Circuits	[10:35] Break – Salons A-F Pre- Function Area (Foyer)	[10:35] Break – Salons A-F Pre- Function Area (Foyer)
11:30		[11:25] Session C – Single Event Effects: Devices and Integrated Circuits		[11:05] Session H – (continued)	[11:05] Session J – Hardness Assurance
12:00	[11:40] Short Course Luncheon – Grand Salons A-B-F				
12:30		[12:30] Lunch	[12:30] Exhibitor Lunch – Salons G-M	[12:05] Lunch — and — [12:05] Women in Engineering Lunch – Conference Rooms 17 & 18 <i>Ticket Required to Attend</i>	[12:25] End of Conference
1:00	[1:00] Part III – Photon-Based SEE Testing Part IIIA – Laser-Based Testing for SEE Dr. Dale McMorrow		[1:30] Exhibitor Raffle Drawing		
1:30					
2:00	[2:00] Part IIIB – Current Status and Future Prospects for Pulsed X-Ray SEE Testing Mr. Stephen LaLumondiere		[2:00-4:45] Radiation Effects Data Workshop Salons A-B-F	[1:45-4:30] Poster Session Salons A-B-F	
2:30		[2:20] Session D – Dosimetry			
3:00	[2:50] Break – Grand Pre- Function				
3:30	[3:20] Part IV – SEE Test and Analysis of Complex Devices in Advanced Technologies: From Cells to Systems Mr. Manuel Cabanas-Holmen	[3:10] Break – Salons G-M			
4:00		[3:40] Session E – Space and Terrestrial Environments			
4:30		[4:15] End of Tuesday Sessions			
5:00	[4:50] Wrap-up [5:00] Exam (for students requesting CEU credit only)		[4:45] End of Wednesday Sessions	[4:30] End of Thursday Sessions [4:30 to 6:30] Radiation Effects Committee Annual Open Meeting – Salons C-D-E	
5:30	[5:30] End of Short Course	[5:30 to 7:00] Industrial Exhibits Reception – Salons G-M			
6:00			[6:00 to 10:00] Conference Social – Buckhorn/Texas Ranger Museum (Busses start at 5:30)		
6:30					
7:00					

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Chairman's Invitation



"I am pleased and excited to invite you to attend NSREC 2019 in my hometown of San Antonio, Texas. I and my conference committee have put together a set of exciting and educational technical and social events in order to ensure that your NSREC experience is one to remember. I extend my heartfelt thanks, in advance, to all of the volunteers, authors, exhibitors, supporters, and attendees whose efforts have been directed to ensuring that NSREC 2019 is a resounding success.

¡Bienvenidos a San Antonio!"

John M. Stone
NSREC 2019 General Chair
Southwest Research Institute

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 2019 Nuclear and Space Radiation Effects Conference (NSREC) committee and volunteers, it is my pleasure to invite you to attend the 56th NSREC to be held July 8-12, 2019. The conference will be in my hometown of San Antonio, Texas at the Marriott Rivercenter hotel.

The conference begins Monday, July 8, with a one-day Short Course titled "Predicting, Characterizing, and Mitigating SEE in Advanced Semiconductor Technologies." It is organized by Steve Moss, Aerospace Corporation (retired), and consists of four sections (in five talks) taught by leading experts in their respective fields. The short course is designed to provide a broad overview of Single Event Effects (SEE) topics including an introduction to SEE sources and mechanisms, an overview of established and developing SEE test techniques, and issues therewith, and an introduction to the techniques used and challenges faced in designing for and proving SEE resilience. An extensive set of written notes (provided in a CD or Memory stick) is sure to become a valued technical reference.

The Technical Program will be held from Tuesday, July 9 to Friday, July 12. **Simone Gerardin**, University of Padova, is the Technical Program Chair. He, along with his technical committee, have chosen an outstanding set of contributed papers organized into 10 sessions of oral presentations and a poster session encompassing papers from all 10 sessions. In addition, the technical committee has selected a set of high quality presentations for the Radiation Effects Data Workshop. Workshop posters will present radiation effects data on electronic and photonic devices and systems, and new simulation or test facilities. Finally, Simone has invited three engaging speakers to give general interest presentations from Wednesday through Friday.

The Industrial Exhibit, organized by **Gregg Panning**, Aerospace Corporation, opens Tuesday morning. It will allow one-on-one discussions between conference attendees and exhibitors on the 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 a luncheon for attendees only.

Local Arrangements Chair, **Brian Sierawski**, Vanderbilt University, has organized an outstanding social program. The Conference Social, on Wednesday evening, will provide some of the flavor of San Antonio with western entertainment and a Tex-Mex Buffet at the Buckhorn / Texas Rangers Museum. Two companion tours are also scheduled. The first event, on Tuesday, will include a visit to the Alamo, a narrated riverboat ride through downtown and up the San Antonio River to the Pearl redevelopment for lunch (on your own), and a post lunch visit to the Witte Museum of Natural History. The second event, on Thursday, will include a guided visit to several of the UNESCO World Heritage Site San Antonio Missions, as well as lunch (on your own) at San Antonio's El Mercado (Mexican Market.)

I, along with the committee members mentioned above and the remainder of the NSREC 2019 Conference Committee, including Publicity Chair **Teresa Farris** (Archon-LLC), Finance Chair **Michael Campola** (NASA GSFC), Awards Chair **Christian Poivey** (ESA), Poster Chair **Ethan Cannon** (Boeing), and Radiation Effects Data Workshop Chair **Kirby Kruckmeyer** (Texas Instruments), welcome you to San Antonio, at 301 years old, one of America's most unique cities.

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

We look forward to seeing you in San Antonio this July.

Short Course Program

PREDICTING, CHARACTERIZING, AND MITIGATING SEE IN ADVANCED SEMICONDUCTOR TECHNOLOGIES

**MARRIOTT RIVERCENTER
GRAND SALONS C-D-E – MONDAY, JULY 8, 2019**

- 8:00 AM **SHORT COURSE INTRODUCTION**
Dr. Steven Moss, *The Aerospace Corporation (Rtd)*
- 8:10 AM **PART I – BASICS OF SINGLE EVENT EFFECT MECHANISMS
AND PREDICTIONS**
Dr. Daisuke Kobayashi, *ISAS/JAXA, Japan*
- 9:40 AM **BREAK (Grand Pre-Function)**
- 10:10 AM **PART II – SEE TESTING WITH BROAD AND FOCUSED
PARTICLE BEAMS**
Dr. Arto Javanainen, *University of Jyväskylä, Department of Physics,
Finland*
- 11:40 AM **SHORT COURSE LUNCHEON
(Grand Salons A-B-F)**
- 1:00 PM **PART III – PHOTON-BASED SEE TESTING**
- 1:00 PM **PART IIIA – LASER-BASED TESTING FOR SEE**
Dr. Dale McMorrow, *US Naval Research Laboratory, USA*
- 2:00 PM **PART IIIB – CURRENT STATUS AND FUTURE PROSPECTS
FOR PULSED X-RAY SEE TESTING**
Mr. Stephen LaLumondiere, *The Aerospace Corporation, USA*
- 2:50 PM **BREAK (Grand Pre-Function)**
- 3:20 PM **PART IV – SEE TEST AND ANALYSIS OF COMPLEX DEVICES
IN ADVANCED TECHNOLOGIES: FROM CELLS TO SYSTEMS**
Mr. Manuel Cabanas-Holmen, *Boeing Research and Technology, USA*
- 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 an electronic copy of the 2019 Short Course Notes.

Short Course

COURSE DESCRIPTION

A one-day short course, *"Predicting, Characterizing, and Mitigating SEE in Advanced Semiconductor Technologies,"* will be presented at the 2019 IEEE Nuclear and Space Radiation Effects Conference (NSREC). The course will discuss single event effects (SEE) that occur in components used in space systems. The past four decades have seen our understanding of the range of SEE experienced by space systems expand substantially as more modern devices have been exposed to the space radiation environment. Vulnerabilities of devices today are much more complicated than in the past, and those vulnerabilities continue to threaten space systems as parts are scaled, new materials are used, devices become faster, and new mechanisms are discovered.

This short course is organized into four sections. It includes an up-to-date overview of SEE mechanisms and rates; discussions of various methods to test for SEE and isolate sensitive nodes; and a discussion of SEE in advanced components, and the challenges posed by some of these components for our test methodologies. All of the testing presentations will show case studies, indicate how the techniques are used to isolate susceptible nodes, discuss correlations between particle tests and photon tests, and indicate how the test methodologies point to strategies for mitigation.

This short course is intended for radiation effects engineers and scientists, component specialists, systems designers, and other technical and management personnel who are involved in developing reliable systems to operate in environments susceptible to SEE. It provides a unique opportunity for IEEE NSREC attendees to benefit from the expertise of the instructors, along with a critical review of state-of-the-art knowledge in the field. Electronic copies of detailed course notes will be provided at registration.

CONTINUING EDUCATION UNITS (CEUS)

For those interested in Continuing Education Units (CEUs), an open book exam will be held at the end of the course. The course, endorsed by the IEEE and by the International Association for Continuing Education and Training (IACET), is valued at 0.6 CEUs.

SHORT COURSE CHAIRMAN



Dr. Steven C. Moss
The Aerospace Corporation
(Rtd)
Electronics & Photonics
Laboratory
Short Course Chair

Steven C. Moss is retired from the Electronics & Photonics Laboratory at The Aerospace Corporation in Los Angeles, CA. He received a BS Degree (physics, mathematics) from Arkansas A&M College (1970), an MS Degree (physics) from Purdue University (1972), and a PhD Degree (physics) from North Texas State University (1981). He was a National Research Council Postdoctoral Research Associate at the US Naval Research Laboratory (1981-1982). His research interests include the use of ultrashort optical pulses to simulate the transient effects of ionizing radiation on microelectronic devices, transient photoluminescence from materials and advanced devices, permanent damage produced by radiation effects in microelectronic/optoelectronic devices, and reliability and physics of failure of advanced microelectronic/optoelectronic devices. Dr. Moss is a member of the American Chemical Society, the American Association for the Advancement of Science, the American Association of Physics Teachers, the Materials Research Society, and the SPIE – the International Society for Optics and Photonics. Dr. Moss is a life member of the American Physical Society and the Optical Society of America, and is a Life Senior Member of the IEEE. He is an Associate Editor for the IEEE Transactions on Nuclear Science and serves on the Editorial Board for the MRS Bulletin. He is one of the organizers of the annual Single Event Effects Symposium.

Short Course Monday



Daisuke Kobayashi received the Ph.D. degree from the University of Tokyo, Tokyo, Japan in 2005. He then joined Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Kanagawa, Japan, where he is now Assistant Professor of Spacecraft Engineering. His work is primarily on reliability of semiconductor devices exposed to radiation. He received several awards including 2011 Space Science Award for Young Scientists from the Society for Promotion of Space Science. Dr. Kobayashi held various positions for the previous NSREC including a session chair in 2014. He was as an Associate Editor of IEEE Transactions on Nuclear Science from 2015 to 2017.

BASICS OF SINGLE EVENT EFFECTS MECHANISMS AND PREDICTIONS

Dr. Daisuke Kobayashi
ISAS/JAXA

Dr. Daisuke Kobayashi, ISAS/JAXA, will provide basic knowledge of SEE mechanisms and rates that will underlie this year's short course. More than three decades have passed since the term "single-event" appeared for the first time in the titles of NSREC short course presentations. In 1983, two lecturers used "single-event upsets". Since then this research topic has evolved to be very wide and complex, so that we are now collectively calling the field of investigation "single-event effects." This presentation will be useful, in particular for those who are new to this field, to see how SEE have evolved along with the diversity of processes and circuitry in semiconductor parts and their environments. Parts are now fabricated with various materials, such as tungsten and copper and soon cobalt, with complex circuits like radiation-hardened latches. They must withstand the bombardment of heavy ions, protons, electrons, neutrons, muons, photons, etc. The complexity of the mechanisms and predictions is expanding. This talk will provide a foundation for understanding SEE and a background for the remaining presentations in the short course.

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

- Introduction
 - o An Evolutionary Tree-An Analysis of Course Notes
- Origin of SEE
 - o First Observations
 - o Basics of Mechanisms and Predictions
 - Charge Deposition and Collection Mechanisms
 - Event Rate Predictions
- Evolution of SEE
 - o Evolution Mechanisms-What Causes the Diversity
 - o Non-Destructive SEE
 - SEU-From Single Upsets to Hundreds and More
 - SET-From ns to ps, but still 100 ps?
 - o Destructive SEE
 - SEL-From Significant to Less?
 - SEB/SEGR-From V/cm to K
- Future Perspective
- Summary

Short Course Monday



Arto Javanainen is a Senior Researcher in Physics Department at University of Jyväskylä (JYU), Finland, and also an Adjoint Assistant Professor in Electrical Engineering at Vanderbilt University, TN, USA. He received his PhD in applied nuclear physics with honors from JYU in August 2012. His work in the field of radiation effects was recognized by IEEE's Nuclear and Plasma Physics Society with the Paul Phelps Continuing Education Grant in July 2013. Recent years his work has been primarily focused on SEEs in power electronics, both silicon and silicon carbide based. Additionally, Dr. Javanainen has been involved in various radiation-effects test campaigns, primarily at JYU's RADEF facility. Dr. Javanainen is a member in IEEE, and he has acted as reviewer and session chair in RADECS and NSREC conferences for several years. He has also reviewed papers for journals like IEEE TNS, and Nuclear Instruments and Methods B. He is the deputy coordinator in EU Horizon2020 MSCA Innovative Training Network, RADSAGA.

SEE TESTING WITH BROAD AND FOCUSED PARTICLE BEAMS

Dr. Arto Javanainen

Department of Physics, University of Jyväskylä, Finland

Department of EECS, Vanderbilt University, Nashville, TN, USA

Arto Javanainen, University of Jyväskylä, Department of Physics, will discuss issues related with Single Event Effects testing using accelerated particle beams, both broad and focused. Basic physics mechanisms governing the energy deposition and its relation with particle energy will be reviewed. Basic things to be considered when testing with accelerators are addressed. Some of the common pitfalls to avoid when performing SEE tests at particle accelerators will be identified.

Modern technologies with deep submicron feature sizes and low critical charge may exhibit sensitivity to proton direct ionization that can lead to concerns about their susceptibility to muons, hence increased soft error rates in ground level applications. Also SEEs induced by high energy electrons may be a concern for some applications, like those planned for Jupiter missions. What requirements do these issues set for the facilities and the SEE tests in general?

The presentation will introduce different types of facilities available for SEE testing. A non-exhaustive listing of both the conventional broad and also the focused (milli- and micro-) beam facilities, and their general characteristics will be given.

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

- Introduction
- Particle-matter interactions
 - LET
 - Projected range
 - Nuclear reactions
 - Energy deposition in small volumes
- SEE Testing at facilities
 - Broad beams
 - Focussed beams
- Conclusions

Short Course Monday



Dale McMorrow received the Ph.D. degree in Physical Chemistry from The Florida State University, Tallahassee, FL in 1984, under the direction of Prof. Michael Kasha. After a postdoctoral fellowship at the University of Toronto he joined the technical staff at the Naval Research Laboratory in 1988, where he is currently the Head of the Radiation Effects Section. His recent research interests include the development and application of laser-based methodologies for simulating single-event phenomena in microelectronic devices and circuits, and the use of ultrafast nonlinear-optical spectroscopic techniques to probe the details of intermolecular dynamics of liquids and solutions. He has served as Technical Chair for the Single-Event Effects Symposium, session chair at the IEEE Nuclear and Space Radiation Effects Conference, the Radiation and its Effects on Components and Systems Conference, and the Single-Event Effects Symposium. He is a Fellow of the IEEE and a Senior Member of the Optical Society of America. He has authored or co-authored over 250 papers in refereed journals.

LASER-BASED TESTING FOR SEE

Dr. Dale McMorrow

U. S. Naval Research Laboratory

Dr. Dale McMorrow, U.S. Naval Research Laboratory, will discuss application of pulsed-laser approaches to SEE testing and evaluation. Charge carrier generation induced by pulsed-laser excitation has become an essential tool for the investigation of SEE in micro- and nano-electronic structures. A primary advantage of laser-based approaches lies in their spatial selectivity: the ability to pinpoint and characterize sensitive nodes of circuits without the damage associated with particle-based radiation sources. This talk will address the fundamental physics associated with both linear- and nonlinear-optical approaches for charge generation in semiconductor materials, followed by examples that illustrate various aspects of the approach, including sensitive node identification, radiation hardened circuit verification (RHBD and RHBP), basic mechanisms investigations, model validation and calibration, screening devices for space missions, and fault injection to understand error propagation in complex circuits. Finally, recent advances in putting laser SEE approaches on a more quantitative basis will be discussed, including progress toward correlating pulsed-laser and heavy-ion measurements.

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

- Laser-induced single-event effects
 - Charge generation by optical absorption
 - Charge density profiles for SPA and TPA
 - Top side vs. back side excitation
 - Spatial selectivity
- History and background
 - Single Photon Absorption (SPA)/Beer's Law
 - Two Photon Absorption (TPA)/Nonlinear pulse propagation and carrier generation
- Experimental approach
 - Basic experimental setup
 - Calibration and dosimetry
- Selected examples and case studies
- Recent developments and future considerations

Short Course Monday



Stephen LaLumondiere is a Member of the Technical Staff in the Photonics Technology Department at The Aerospace Corporation. Stephen joined The Aerospace Corporation in 1988, and was a key contributor to the development of Aerospace's pulsed laser test SEE facility, a potential laser-based pulsed x-ray source for laboratory SEE testing and development of the pulsed x-ray SEE test technique. His other interests include development of compact laser communications systems for cubesats and time resolved spectroscopy as a diagnostic for electronic and photonic devices.

THE CURRENT STATUS AND POTENTIAL OF PULSED X-RAYS AS A HIGH-RESOLUTION PROBE FOR SINGLE EVENT EFFECTS TESTING

Mr. Stephen LaLumondiere

The Aerospace Corporation

Mr. Stephen LaLumondiere, The Aerospace Corporation, will describe the application of pulsed x-rays for SEE and TID testing of microelectronic devices. Pulsed x-rays from synchrotron-based light sources have recently been demonstrated as a highly effective tool for SEE testing with potentially unprecedented spatial resolution. This part of the short course will describe the background and rationale for synchrotron based x-ray SEE testing. Other potential sources, and their benefits and limitations will be described. A detailed description of the technique, its challenges and limitations will also be presented. Several case studies of pulsed x-ray SEE testing will be detailed, including SETs in linear bipolar devices, wide bandgap materials and the status of work to correlate x-rays with energetic particle LETs. The impact of the Advanced Photon Source (APS) upgrade on future SEE testing activities will also be discussed.

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

- Introduction
- Relevant x-ray Sources
 - Tabletop Lasers
 - X-ray FELs
 - Synchrotrons
- Synchrotron x-ray testing at the Advanced Photon Source
 - X-ray interactions with materials
 - X-ray focusing techniques
 - Typical beamline setup for SEE testing
 - X-ray Flux calibration
- Case studies
 - SETs in wide bandgap materials
 - SETs in linear bipolar integrated circuits
 - Work on correlation with energetic particles
- Other related research
- Proposal system for accessing synchrotron facilities
- Impact of the APS upgrade on SEE testing activities

Short Course Monday



Manuel Cabanas-Holmen is a principal investigator and project lead at the Solid State Electronics Development group at the Boeing Research & Technology organization. He has 20 years of experience in radiation hardening by design (RHBD), and radiation effects analysis and test. His unique expertise ranges from the design of innovative nanoscale radiation hardened circuits to the development of advanced methods for predicting the single event error rate of complex microprocessors, up to system-level radiation effects analysis of commercial, civil and defense space vehicles and payloads. He has spearheaded the development of novel radiation hardening methodologies for Near-Threshold Computing (NTC) applications in state-of-the-art FinFET technologies. He received the B.S. degree in applied physics, computer engineering and electrical engineering from Pacific Lutheran University, and the M.S. degree in electrical engineering from National Technological University.

SEE TEST AND ANALYSIS OF COMPLEX DEVICES IN ADVANCED TECHNOLOGIES: FROM CELLS TO SYSTEMS

Mr. Manuel Cabanas-Holmen

Boeing Research & Technology

Mr. Manuel Cabanas-Holmen, Boeing Research & Technology, will discuss the challenges of SEE testing modern complex devices in advanced semiconductor processing nodes. In modern technologies, standard and Radiation Hardened by Design (RHBD) logic gates, storage elements and macros exhibit strong angular sensitivity that should guide how we test complex devices to avoid naively optimistic results. Fault tolerant microprocessors often have multiple circuit cells and macros with starkly different angular sensitivity, and it is often necessary to perform extensive SEE test campaigns to acquire the data necessary to estimate their error rate. At-speed SEE testing of high performance mixed signal macros, such as Analog-to-Digital Converters (ADC) with high speed interfaces, requires complex instrumentation with continuous data capture and concurrent error detection algorithms. Frequently, it is preferable to synchronize the ADC data capture with the radiation source for a one-to-one correlation of a laser pulse or ion spill with the resulting effect. Advanced packaging solutions using 2.5D and 3D heterogeneous integration increase the complexity of SEE testing many fold by combining multiple complex devices in a single package, without access to the interfaces within the module. The presentation will conclude with a discussion of the challenges to be faced by those testing advanced technologies for susceptibility to SEE.

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

- Introduction
- Charge Sharing Effects in Complex Devices
 - Charge sharing effects of modern bulk technologies
 - Impacts on radiation hardened cell design
 - Single Event Multiple Transients (SEMT)
- Impact of Angular Sensitivity on Complex Devices
 - Angular sensitivity of modern technologies
 - Estimating error rates of complex devices with multiple circuit cells and macros with different angular sensitivity
- At-Speed SEE Testing of High Performance Mixed Signal Macros
 - SEE testing of mixed signal macros with high speed interfaces
 - Complex instrumentation with continuous data capture and concurrent error detection
- Single Photon Absorption (SPA)/Two Photon Absorption (TPA) Laser and Milli-Beam Testing of Complex Devices
- Advanced Packaging Solutions
 - 2.5D and 3D Heterogeneous Integration
 - SEE Testing of 3D stacked memories
- Conclusions

Technical Program

TECHNICAL INFORMATION



"On behalf of the Technical Program Committee, I would like to invite you to attend the 2019 NSREC Technical Sessions. The chairpersons for these twelve sessions have assembled an exceptional program covering the latest developments in the nuclear and space radiation effects fields. Our sincere thanks goes out to the many authors and reviewers who work so hard to ensure the continued success of this unique technical exchange."

Simone Gerardin, University of Padova
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: Lili Ding, NINT
- **Dosimetry**
Chair: Anatoly Rosenfeld, Wollongong University
- **Hardness Assurance**
Chair: Tom Turflinger, Aerospace Corporation
- **Hardening by Design**
Chair: Jeff Kauppila, Vanderbilt University
- **Radiation Effects in Devices and Integrated Circuits**
Chair: Indranil Chatterjee, Airbus
- **Photonic Devices and Integrated Circuits**
Chair: Vincent Goiffon, ISAE-SUPAERO
- **Single-Event Effects: Mechanisms and Modeling**
Chair: Rubén García Alía, CERN
- **Single-Event Effects: Transient Characterization**
Chair: Zach Fleetwood, SpaceX
- **Single-Event Effects: Devices and Integrated Circuits**
Chair: Balaji Narasimham, Broadcom
- **Space and Terrestrial Environments**
Chair: Giovanni Santin, ESA

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 Salons A,B,F. The formal Poster Session will be held on Thursday from 1:45 – 4:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Ethan Cannon from Boeing.

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 Salons A,B,F. Authors will be available on Wednesday to discuss their work from 2:00 – 4:45 PM.. A workshop record will be mailed to all registered conference attendees. The workshop chair is Kirby Kruckmeyer from Texas Instruments.

INVITED SPEAKERS

There will be three invited talks:

- **Current status and future development of autonomous vehicles**
Chris Mentzer, Southwest Research Institute
- **The history of and future expectations for the Parker Solar Probe Mission**
Jim Kinnison, Johns Hopkins University
- **People and nature in the early history of San Antonio**
Dr. J. F. de la Teja, Regents and University Distinguished Professor Emeritus

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 10, 2019. Detailed instructions for submitting late-news summary are available on the NSREC website at www.nsrec.com.

Session Chairs



Rubén Garcia Alia, CERN
Single-Event Effects:
Mechanisms and
Modeling



Zach Fleetwood, SpaceX
Single-Event Effects:
Transient Characterization



Balaji Narasimham, Broadcom
Single-Event Effects:
Devices and Integrated
Circuits



Anatoly Rosenfeld, Wollongong University
Dosimetry



Giovanni Santin, ESA
Space and Terrestrial
Environments



Lili Ding, NINT
Basic Mechanisms of
Radiation Effects



Indranil Chatterjee, Airbus
Radiation Effects in
Devices and Integrated
Circuits



Vincent Goiffon, ISAE-SUPAERO
Photonic Devices and
Integrated Circuits



Jeff Kauppila, Vanderbilt University
Hardening by Design



Tom Turflinger, Aerospace Corporation
Hardness Assurance

Technical Program Tuesday

SALONS C, D, E

8:20 AM

OPENING REMARKS

John Stone, Southwest Research Institute, General Chairman

8:25 AM

AWARDS PRESENTATION

Janet Barth, Radiation Effects Steering Group, Executive Chair

8:55 AM

TECHNICAL SESSION OPENING REMARKS

Simone Gerardin, University of Padova, Technical Program Chairman

SESSION A

9:00 AM

SINGLE EVENT EFFECTS: MECHANISMS AND MODELING

SESSION INTRODUCTION

Chair: Rubén Garcia Alia, CERN

A-1

9:05 AM

A Chip-level Single Event Latchup (SEL) Estimation Methodology

A. Neale, N. Seifert, Intel Corporation, USA

In this work we discuss an SEL assessment methodology that is truly chip-level. The model is calibrated leveraging SEL test structures that enable direct quantification of SEL rates as a function of layout design styles.

A-2

9:20 AM

Ion-Induced Energy Pulse Mechanism for Single-Event Burnout in High-Voltage SiC Power MOSFETs and Diodes

D. Ball, K. Galloway, R. Johnson, M. Alles, A. Sternberg, B. Sierawski, A. Witulski, R. Reed, R. Schrimpf, Vanderbilt University, USA; J. Hutson, Lipscomb University, USA; J. Lauenstein, NASA GSFC, USA; A. Javanainen, University of Jyväskylä, Finland

Heavy ion data suggest a common mechanism for SEB in SiC power MOSFETs and diodes. TCAD simulations show an ion-induced, highly-localized energy pulse is capable of causing SEB in both types of devices.

A-3

9:35 AM

Thermal Neutron and Fast Neutron-induced SEEs in Microcontrollers with Suspected ^{10}B

E. Auden, H. Quinn, S. Wender, J. O'Donnell, P. Lisowski, J. George, Los Alamos National Laboratory, USA

Soft error rates were measured in microcontrollers suspected to contain boron-10. A strong response to thermal neutrons was observed. Simulations indicate both products from $^{10}\text{B}(\text{n},\alpha)^7\text{Li}$ reactions can cause upsets at the 130-nm and 65-nm nodes.

A-4

9:50 AM

Polarization Dependence of Pulsed Laser Induced SEEs in a FinFET Structure

L. Ryder, K. Ryder, A. Sternberg, J. Kozub, H. Gong, E. Zhang, R. Weller, R. Schrimpf, S. Weiss, R. Reed, Vanderbilt University, USA; D. Linten, J. Mitard, IMEC, Belgium

Pulsed laser induced single event current measurements on FinFETs experimentally show dependence on the polarization of the laser light. This dependence may affect the reproducibility of laser-based measurements.

Technical Program Tuesday

POSTER PAPERS

PA-1 New SEU Modeling Method for Calibrating Target System to Multiple Radiation Particles

P. Caron, C. Inguimbert, L. Artola, ONERA, France; F. Bezerra, R. Ecoffet, CNES, France

This paper proposes a method using electron and proton single event upset sensitivities of a device to predict its sensitivity to heavy ions. The method is described, and comparisons between experimental and simulation results are presented.

PA-2 Statistical Method to Extract Multiple-Cell Upsets of SRAMbased FPGAs

A. Perez-Celis, M. Wirthlin, Brigham Young University, USA

This paper presents a method to extract multiple-cell upsets in the configuration memory of SRAM-based FPGAs with minimal layout information. The results show the distribution of MCUs for three families of Xilinx FPGAs.

PA-3 Analytical Modeling of Single-Event Upsets in Advanced Technologies

R. Harrington, J. Kauppila, M. Alles, D. Ball, B. Bhuvva, L. Massengill, Vanderbilt University, USA

An analytical model for predicting the critical charge of fast-switching memory circuits is presented. Predictions of SRAM critical charge align with SE compact model results calibrated to experimental data in 14/16nm bulk FinFET technology.

PA-4 Correlation of Sensitive Volumes Associated with Ion- and Laser-Induced Charge Collection in an Epitaxial Silicon Diode

K. Ryder, L. Ryder, A. Sternberg, J. Kozub, E. Zhang, R. Weller, R. Schrimpf, S. Weiss, R. Reed, Vanderbilt University, USA; A. Khachatrian, S. Buchmer, D. McMorro, J. Hales, U.S. Naval Research Laboratory, USA; Y. Zhao, L. Wang, C. Wang, Beijing Microelectronics Technology Institute, China

An ion-based sensitive volume is developed for a diode and applied to laser charge generation profiles. While this sensitive volume works well for ions with various LETs, it does not agree with all laser measurements.

PA-5L Single Event Effect Testing with Xe and Pb Ultra High Energy Heavy Ion Beams

M. Kastriotou, P. Fernandez Martinez, R. Garcia Alia, A. Coronetti, G. Lerner, J. Bernhard, A. Gerbershagen, S. Danzeca, H. Wilkens, CERN, Switzerland; C. Cazzaniga, STFC, United Kingdom; M. Tali, CERN/ESA/University of Jyväskylä, Switzerland

An evaluation of Single Event Effect testing with the CERN Ultra High Energy heavy ion beams in terms of parallel board testing, contribution of fragmentation and physical processes is performed through experimental measurements and simulations.

Technical Program Tuesday

SESSION B SINGLE EVENT EFFECTS: TRANSIENT CHARACTERIZATION

10:05 AM SESSION INTRODUCTION

Chair: Zachary Fleetwood, SpaceX

B-1 Comparison of Single-Event Transients in SiGe HBTs on Bulk and Thick-Film SOI

10:10 AM

A. Ildefonso, J. Cressler, G. Tzintzarov, A. Omprakash, D. Nergui, P. Goley, Georgia Institute of Technology, USA; J. Hales, A. Khachatrian, S. Buchner, D. McMorrow, J. Warner, U.S. Naval Research Laboratory, USA

A comparison of heavy-ion-induced single-event transients in SiGe HBTs on bulk and SOI is presented. Laser data and TCAD simulations are used to explain some unexpected results. The implications on ion/laser correlation are discussed.

B-2 New Approach for Pulsed-Laser Single-Event Effects Testing that Mimics Heavy-Ion Charge Deposition Profiles

10:25 AM

J. Hales, D. McMorrow, A. Khachatrian, J. Warner, S. Buchner, U.S. Naval Research Laboratory, USA; A. Ildefonso, T. George, D. Nergui, J. Cressler, Georgia Institute of Technology, USA

A new optical approach for pulsed-laser testing using two-photon absorption produces dosimetry similar to a heavy ion. This approach removes a known impediment to correlating single-event effects produced by laser and heavy-ion irradiation.

B-3 Single-Event Transients in SiGe HBTs Induced by Pulsed XRay Microbeam

10:40 AM

D. Nergui, J. Cressler, A. Ildefonso, G. Tzintzarov, A. Omprakash, Georgia Institute of Technology, USA; Z. Fleetwood, SpaceX, USA; S. Lalumondiere, D. Monahan, J. Bonsall, H. Kettering, Aerospace Corporation, USA

The first experimental study of pulsed X-ray induced single-event transients in SiGe HBTs is presented. Charge collection data from pulsed X-rays are analyzed and compared with those of heavy ions.

POSTER PAPERS

PB-1 Impact of Interface Quality on Single-Event Charge Collection in Rad-hard SOI MOSFETs

A. Tonigan, D. Ball, M. Alles, R. Reed, R. Schrimpf, Vanderbilt University, USA; J. Black, D. Black, J. Trippe, Sandia National Laboratories, USA

Data-calibrated TCAD simulations quantify the impact of isolation interface quality on single-event charge collection in SOI MOSFETs. Sensitivity to surface recombination velocity is reduced at low LETs and with scaling from 350 to 90 nm.

PB-2 Single Event Transient Analysis with Ionizing Radiation Effects Spectroscopy (IRES)

B. Patel, T. Loveless, D. Reising, The University of Tennessee at Chattanooga, USA; L. Massengill, Vanderbilt University, USA

Ionizing radiation effects spectroscopy for SET characterization is demonstrated through simulation and measurements. IRES simplifies the identification of transients through statistical analysis of waveform behavior, allowing for the capture of subtle changes in circuit dynamics.

Technical Program Tuesday

10:55 AM – 11:25 AM
SALONS G-M

BREAK

SESSION C

11:25 AM

SINGLE EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS

SESSION INTRODUCTION

Chair: Balaji Narasimham, Broadcom

C-1

11:30 AM

The Impact of Proton-Induced Single Events on Image Classification in a Neuromorphic Architecture

*R. Brewer, B. Sierawski, M. McCurdy, M. Alles, R. Reed, Vanderbilt University, USA;
S. Moran, J. Cox, S. Iyer, University of California Los Angeles, USA*

Single event upsets are found to change the relative occurrence of false positives/negatives in a neuromorphic architecture engaged in image recognition even when the overall classification accuracy is unaffected.

C-2

11:45 AM

Investigation of Buried-Well Potential Perturbation Effects on SEU in SOI DICE-based Flip-Flop Under Proton Irradiation

*K. Sakamoto, S. Baba, S. Okamoto, H. Shindou, O. Kawasaki, Japan Aerospace Exploration Agency, Japan; D. Kobayashi, K. Hirose, ISAS/JAXA, Japan; T. Makino, QST, Japan;
Y. Mori, D. Matsuura, M. Kusano, T. Narita, S. Ishii, MHI, Japan*

The effects of potential perturbation under the BOX layer are studied in a highenergy proton-SEU test of an SOI DICE-based flip-flop. Their dependence on incident-angle and back-bias is discussed in comparison with non-DICE structure responses.

C-3

12:00 PM

Comparison of the Impact of Thermal and High Energy Neutrons in COTS Devices

D. Oliveira, P. Rech, F. Santos, G. Piscoya, UFRGS, Brazil; C. Cazzaniga, C. Frost, STFC, United Kingdom; R. Baumann, Radiosity Solutions, USA

We compare the impact of high-energy and thermal neutrons on COTS memories and processing devices. Thermal neutrons still pose a risk for COTS reliability and their failure signature is unique from failures caused by high-energy neutrons.

C-4

12:15 PM

Understanding the Key Parameter Dependencies Influencing the Soft-Error Susceptibility of Standard Combinational Logic

N. Pande, S. Kumar, L. Everson, C. Kim, University of Minnesota, USA

This work presents statistical results and detailed analysis on the multitude of design choices affecting soft-error susceptibility of standard combinational logic in advanced CMOS nodes.

POSTER PAPERS

PC-1

Impact of Configuration Scrubbing on Silent Data Corruption in FPGA Cloud Applications

A. Keller, M. Wirthlin, Brigham Young University, USA

Using neutron radiation testing and two different fault injection flows, configuration scrubbing is shown to significantly reduce the occurrence and persistence of silent data corruption in several Stratix V FPGA accelerator applications.

Technical Program Tuesday

PC-2 In-Situ Testing of a Multi-Band Software-Defined Radio Platform in a Mixed-Field Irradiation Environment

J. Budroweit, M. Jaksch, DLR, Germany; S. Mueller, FAU, Germany; R. Garcia Alia, A. Coronetti, CERN, Switzerland; A. Koelpin, BTU, Germany

In this paper a complex automated in-situ test concept for a multi-band software-defined radio platform in a mixed-field radiation environment is presented and selected test results of the system-level evaluation are discussed.

PC-3 The Use of Microprocessor Trace Infrastructures for Radiation-Induced Fault Diagnosis

M. Peña-Fernandez, Arquimea Ingenieria SLU, Spain; A. Lindoso, L. Entrena, M. Garcia-Valderas, Universidad Carlos III, Spain

A methodology is proposed to diagnose radiation-induced faults in a microprocessor using the hardware trace infrastructure. The diagnosis capabilities of this approach are demonstrated for an ARM core under neutron irradiation.

PC-4L Effects of Ion-Induced Electric Fields on Leakage Current Degradation in Silicon Carbide Schottky Power Diodes

R. Johnson, D. Ball, K. Galloway, A. Sternberg, A. Witulski, M. Alles, R. Reed, R. Schrimpf, Vanderbilt University, USA; J. Hutson, Lipscomb University, USA; A. Raman, P. Chakraborty, R. Arslanbekov, CFD Research Corporation, USA; J. Lauenstein, NASA GSFC, USA; A. Javanainen, University of Jyväskylä, Finland

Onset of ion-induced reverse leakage current in SiC Schottky diodes is shown to depend only on material properties, ion LET, and bias across multiple manufacturers. Voltage derating has no effect on leakage current degradation.

12:30 PM – 2:20 PM LUNCH

SESSION D 2:20 PM DOSIMETRY SESSION INTRODUCTION

Chair: Anatoly Rosenfeld, University of Wollongong

D-I SOI Thin Microdosimeters for High LET Single Event Upset Studies in Fe, O, Xe and Cocktail Ion Beam Fields

2:25 PM

B. James, L. Tran, D. Bolst, S. Peracchi, J. Davis, S. Guatelli, A. Rosenfeld, University of Wollongong, Australia; D. Prokopovich, Australia's Nuclear Science and Technology Organisation (ANSTO), Australia; M. Povoli, A. Kok, SINTEF, Norway; N. Mastufuji, National Institute of Radiological Sciences (NIRS), Japan; M. Van Goethem, University of Groningen / KVI-CART, Netherlands Antilles; M. Nancarrow, Australian Institute of Innovative Materials, Australia

Response of silicon-on-insulator microdosimeters was investigated with Fe, O, Xe and cocktail ion beam fields. 5 μm microdosimeters are applicable for single event upset prediction in mixed ion fields with LET up to 8 MeV/ μm .

Technical Program Tuesday

D-2
2:40 PM

A Heavy Ion Detector Based on 3D-NAND Flash Memories

M. Bagatin, S. Gerardin, A. Paccagnella, University of Padova, Italy; S. Beltrami, Micron Technology, Italy; A. Costantino, C. Poivey, G. Santin, V. Ferlet-Cavrois, ESA, Netherlands; C. Cazzaniga, C. Frost, STFC, United Kingdom

The feasibility of a 3D NAND Flash based heavy-ion detector is explored. The possibility of measuring the angle of incidence and the LET of impinging particles through the pattern of threshold voltage shifts is discussed.

D-3
2:55 PM

Simulation and Measurements of Collimator Effects in Proton and Neutron Radiation Testing for Single Event Effects

C. Bélanger-Champagne, E. Blackmore, C. Lindsay, C. Hoehr, M. Trinczek, TRIUMF, Canada

Proton beam profile data from a SRAM-based dosimeter is compared to FLUKA simulations to understand the contributions of secondary neutrons and slit-scattered protons to the flux outside of the nominal irradiation area for SEE testing.

POSTER PAPERS

PD-1

A Solid-State Microdosimeter for Dose and Radiation Quality Monitoring for Astronauts in Space

S. Peracchi, B. James, L. Tran, D. Bolst, A. Rosenfeld, J. Davis, S. Guatelli, M. Petasecca, M. Lerch, University of Wollongong, Australia; D. Prokopovich, Australia Nuclear Science and Technology Organisation (ANSTO), Australia; N. Matsufuji, Heavy Ions Medical Accelerator in Chiba, Japan; A. Kok, M. Povoli, SINTEF, Norway

In this work, we demonstrated the possibility of using a silicon on insulator (SOI) microdosimeter for Q and Hp(10) derivation in a radiation field mimicking galactic cosmic rays outside and inside the International Space Station.

PD-2

Study of the Deposited Energy Spectra in Silicon by High Energy Neutron and Mixed Fields

C. Cazzaniga, C. Frost, STFC, United Kingdom; R. Garcia Alia, M. Kastriotou, M. Cecchetto, P. Fernandez-Martinez, CERN, Switzerland

An experimental and computational study of the energy deposition in a silicon detector allows for the comparison of high-energy spallation facilities dedicated to the irradiation of microelectronics and for the validation of radiation transport models.

PD-3

An Innovative and Flexible Real-Time Dosimeter for Radiation Hardness Assurance Tests

F. Di Capua, P. Casolaro, L. Campajola, University of Napoli Federico II and INFN-Napoli, Italy; G. Breglio, S. Buontempo, F. Fienga, University of Napoli Federico II, Italy; M. Consales, A. Cusano, P. Vaiano, A. Cutolo, University of Sannio, Italy

In this work we propose an innovative method for real-time dosimetry with radiochromic films. This method, based on optoelectronic instrumentation, makes radiochromic film a flexible and accurate dosimetric tool for radiation hardness quality assurance tests.

Technical Program Tuesday

PD-4L Temperature-compensated MOS dosimeter fully integrated in a high-voltage 0.35 μ m CMOS process

S. Carbonetto, M. Echarri, M. Garcia-Inza, A. Faigon, Device Physics-Microelectronics Laboratory, INTECIN, Facultad de Ingeniería, Universidad de Buenos Aires, Argentina; J. Lipovetzky, Low Temperatures Lab., Centro Atómico Bariloche, Comisión Nacional de Energía Atómica, Argentina

We present a differential dosimeter based on the mismatch of two identical FOXFETs. The sensor was fabricated in a high-voltage 0.35 μ m CMOS process, and it was characterized regarding its response to radiation and temperature.

PD-5L A Novel System and Method for Optical Fiber Post-Mortem Dose Measurements

D. Francesca, K. Kandemir, G. Li Vecchi, R. Garcia Alia, Y. Kadi, M. Brugger; CERN, Switzerland

This contribution presents a novel and versatile 'system and method' to perform post-mortem optical attenuation measurements on irradiated optical fibers for radiation dosimetry purposes.

3:10 PM – 3:40 PM
SALONS G-M

BREAK

SESSION E SPACE AND TERRESTRIAL ENVIRONMENTS

3:40 PM SESSION INTRODUCTION

Chair: Giovanni Santin, ESA

E-1 An Update to MOBE-DIC Using Current Monitor Measurements from Galileo

3:45 PM

A. Hands, K. Ryden, University of Surrey, United Kingdom; I. Sandberg, G. Provatas, S. Giamini, A. Tsigkanos, C. Papadimitriou, Space Applications and Research Consultancy (SPARC), Greece; D. Heynderickx, DH Consultancy, Belgium; D. Rodgers, H. Evans, ESA, Netherlands

We use electron flux derived from the "EMU-SURF" current monitor on board a Galileo GNSS constellation satellite to modify and update the Model of Outer Belt Electrons for Dielectric Internal Charging (MOBE-DIC).

E-2 Single Event Effects in Ground Level Infrastructure during Extreme Ground Level Enhancements

4:00 PM

A. Dyer, A. Hands, K. Ryden, C. Dyer, University of Surrey, United Kingdom

Historical extreme space weather event data has been used to derive representative ground level neutron fluxes which have been applied to microelectronic device hard single event effect cross-sections to determine their predicted risk of failure.

Technical Program Tuesday

POSTER PAPERS

PE-1 Preliminary On-Orbit Results from the GOES-16 and GOES-17 Space Environment In-Situ Suite (SEISS) Dosimeters

E. Dawson, T. Nasser, B. Dichter, G. Galica, Assurance Technology Corporation, USA

Preliminary dose results from the GOES-16 and GOES-17 dosimeters are presented, including the period of heightened solar activity in September 2017. The dosimeters comprise part of the Space Environment In-Situ Suite of space weather sensors.

PE-2 Experimental and Numerical Study of Internal Charging on Spacecraft and Risks of Discharge on Floating Metallic Elements

A. Ben Zaid, T. Paulmier, P. Sarrailh, ONERA, France; D. Payan, CNES, France

A SubD-25 pins-connector has been irradiated using electron beams to evaluate the charging kinetics and risks of discharges induced by floating pins. Current and potential have been measured and correlate with simulation performed with SPISIC.

PE-3 Study of Albedo Neutron Fields and their Impacts on SER as Function Facility and Terrestrial Topologies

G. Hubert, L. Artola, ONERA, France

This work investigates experimentally the albedo neutron spectra and their SER impacts on 28- nm technology in using Californium sealed source. Scenes and topologies relatives to facility and terrestrial environment were considered.

4:15 PM END OF TUESDAY SESSIONS

5:30 – 7:00 PM
EXHIBIT RECEPTION

SALONS G-M

Technical Program Wednesday

SALONS C, D, E
INVITED TALK
8:20 - 9:35 AM

Automated Vehicles and the Road Ahead

Chris Mentzer, Assistant Director – R&D, Southwest Research Institute



The subject of automated driving has received international attention over the past several years as a new paradigm in transportation that may change how we live our lives. Companies ranging from existing automotive manufacturers to major technology companies to a variety of startups are all investing heavily into making automated vehicles a reality. Chris Mentzer will review a brief history of automated vehicle development and some of the terminology used in this space. He will also discuss the hardware and techniques currently involved in automated vehicle operation. Ultimately the talk will focus on current challenges in this domain and hurdles the industry has yet to overcome for future adoption.



SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in "the driver's seat"		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	• automatic emergency braking • blind spot warning • lane departure warning	• lane centering OR • adaptive cruise control	• lane centering AND • adaptive cruise control at the same time	• traffic jam chauffeur	• local driverless taxi • pedals/steering wheel may or may not be installed	• same as level 4, but feature can drive everywhere in all conditions

Chris Mentzer was extensively involved in SwRI's Mobile Autonomous Robotics Technology Initiative (MARTI) program. This program created an autonomous vehicle out of a 2006 Ford Explorer with which SwRI was able to demonstrate key technologies improving upon the state-of-the-art in-ground vehicle autonomy. This system has been demonstrated alongside other industry leaders in the field at the Intelligent Transportation Systems (ITS) World Congress in 2008 and the Army's Robotics Rodeo in 2009, 2010, and 2012. Chris performed system integration for the Small Unit Mobility Enhancement Technologies (SUMET) program for ONR and is currently the project manager for the Dismounted Soldier Autonomy Tools (DSAT), and follow-on Robotic Technology Kernel (RTK) programs for the US Army TARDEC. Chris is currently responsible for overseeing the unmanned ground vehicle programs at SwRI, including work in the commercial on-road, off-road and agricultural domains.

SALONS C, D, E
SESSION F
9:35 AM

BASIC MECHANISMS SESSION INTRODUCTION

Chair: Lili Ding, NINT

F-1
9:40 AM

Microdose Reliability

T. Oldham, C. Whitney, C. Arutt, Ball Aerospace, USA

This paper analyzes underlying mechanisms for certain reliability failures in memories exposed to heavy ion irradiation. Although the failures are well-known, they have not generally been recognized as a microdose effect.

Technical Program Wednesday

F-2
9:55 AM **Ionizing Radiation Tolerance of Stacked Si₃N₄-SiO₂ Gate Insulators for Power MOSFETs**

K. Muthuseenu, H. Barnaby, A. Patadia, K. Holbert, A. Privat, Arizona State University, USA

Metal-nitride-oxide-semiconductor capacitors are shown to exhibit a high tolerance to irradiation. Electrical characterization and TCAD simulations are performed to characterize these effects. Thick oxide-nitride layer can be used as gate insulator in power MOSFETs.

F-3
10:10 AM **Total-Ionizing-Effects and Low-Frequency Noise in 16-nm InGaAs FinFETs with HfO₂/Al₂O₃ Dielectrics**

S. Bonaldo, S. Gerardin, A. Paccagnella, DEI - University of Padova, Italy; S. Zhao, A. O'Hara, M. Gorchichko, E. Zhang, S. Pantelides, R. Reed, R. Schrimpf, D. Fleetwood, Vanderbilt University, USA; N. Waldron, N. Collaert, V. Putcha, D. Linten, IMEC, Belgium

Radiation-induced buildup of defects in HfO₂ and Al₂O₃ dielectric layers of InGaAs FinFETs is evaluated under different bias conditions through DC static characterization, noise vs. temperature measurements, and density-functional theory calculations.

POSTER PAPERS

PF-1 **Effects of High-Energy Ion Beams on Double-interface CoFeB/MgO Ultrathin Films**

B. Wang, Z. Wang, K. Cao, S. Yan, Y. Zhang, W. Zhao, Beihang University, China; Y. Zhao, Zheng, Beijing Microelectronics Technology Institute, China; J. Liu, P. Zhai, Chinese Academy of Science, China; G. Guo, China Institute of Atomic Energy, China; H. S. Yuan, Tsinghua University, China

Effects of Ta/proton ions on double-interface CoFeB/MgO films were evaluated. The results indicated that the coercivity after Ta irradiation was decreased. Whereas the films were resistant to proton irradiation. We proposed physical and structural analysis.

PF-2 **Modeling Single-Event Effects in Heterojunction Bipolar Transistors from 14 MeV Neutrons**

M. Jasica, W. Wampler, G. Viskelethy, E. Bielejec, Sandia National Laboratories, USA

Effects from 14 MeV neutron collisions in GaAs are modeled from ionizing and non-ionizing energy loss recoil spectra. Measured inverse gain changes from single displacement cascades were found to agree well with the model.

PF-3 **Total Ionization Dose Effects of N-type Tunnel Field Effect Transistor (TFET) with Ultra-shallow Pocket Junction**

J. Bi, J. Chu, G. Xu, B. Li, K. Xi, M. Liu, IMECAS, China; H. B. Wang, Hohai University, China; S. Majumdar, The ICFI University, India

N-type tunnel transistor with an ultra-shallow N⁺ pocket junction has been fabricated. Total ionizing dose (TID) effects on TFET were investigated by ⁶⁰Co γ-rays. In general, the TFETs exhibit excellent anti-radiation performance up to 1 Mrad(Si).

Technical Program Wednesday

PF-4 Dose Response of MOS Transistors Irradiated at Low Temperatures

J. Dardié, TMI-Orion and IES, France; J. Boch, A. Michez, A. Touboul, J. Vaillé, F. Saigné, IES, France; F. Bezerra, CNES, France; P. Girones, CEA, France; J. Favre, TMI-Orion, France

The effect of dose on MOS transistors is investigated for irradiation performed at low temperatures. Degradation of threshold voltage and drain off-state current is shown and discussed in terms of physical mechanisms.

PF-5L Observation of Radiation Induced Leakage Current Defects in MOS Oxides with Multi-Frequency Electrically Detected Magnetic Resonance

S. Moxim, J. Ashton, P. Lenahan, Penn State University, USA; S. King, Intel Corporation, USA

We report high and low frequency electrically detected magnetic resonance measurements on radiation induced leakage currents in irradiated Si/SiO₂ MOS structures.

10:25 – 10:55 AM
SALONS G-M

BREAK

SESSION G RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS

10:55 AM **SESSION INTRODUCTION**

Chair: Indranil Chatterjee, AIRBUS

G-1 Radiation Induced Variable Retention Time in Dynamic Random Access Memories

11:00 AM

V. Goiffon, T. Bilba, T. Deladerriere, G. Beaugendre, A. Dion, A. Jay, ISAE-SUPAERO, France; A. Le Roch, ISAE-SUPAERO / CNES, France; C. Virmondois, CNES, France; M. Gaillardin, P. Paillet, CEA, France

The variable retention time (VRT) phenomenon is studied in DDR3 DRAMs exposed to ⁶⁰Co and 22 MeV neutrons. This work demonstrates that both, displacement damage dose and TID lead to the creation of VRT cells.

G-2 Word Line Dependent Bit Error in 3-D NAND Flash Under Ionizing Radiation

11:15 AM

P. Kumari, B. Ray, University of Alabama in Huntsville, USA; F. Irom, Jet Propulsion Laboratory, USA

We find the bottom layers of 3-D NAND flash are more vulnerable to ionizing radiation compared to the top layer cells due to non-uniform cell sizes. The result can be utilized for energy-efficient data scrubbing.

G-3 Total-Ionizing-Dose Effects and Low-Frequency Noise in 30-nm Gate-Length Bulk and SOI FinFETs

11:30 AM

M. Gorchichko, H. Gong, S. Zhao, P. Wang, R. Jiang, C. Liang, D. Fleetwood, R. Schrimpf, R. Reed, E. Zhang, Vanderbilt University, USA; Y. Cao, Xidian University, China; D. Yan, Jiangnan University, China; D. Linten, IMEC, Belgium

Total-ionizing-dose effects and low-frequency noise are evaluated in 30-nm gate-length bulk and SOI FinFETs. Minimal threshold voltage shifts are observed at 2 Mrad(SiO₂), but large increases in noise are found.

Technical Program Wednesday

G-4
11:45 AM **Total Ionizing Dose Effects on InGaAs FinFETs with Improved Gate Stack**

S. Zhao, R. Schrimpf, R. Reed, D. Fleetwood, P. Wang, E. Zhang, Vanderbilt University, USA; S. Bonaldo, A. Paccagnella, University of Padova, Italy; N. Waldron, N. Collaert, D. Linten, IMEC, Belgium; S. Gerardin, DEI - Padova University, Italy

Modifications of InGaAs nMOS FinFETs fabrication process show improved radiation response compared to first-generation development-stage devices. Changes to the gate stack, channel length dependence, and gate-bias dependence are discussed.

G-5
12:00 PM **Impact of Total Ionizing Dose on the Threshold Voltage of FOI FinFET with a Property of Tunable Interface Defects**

F. Zhang, B. Li, Q. Zhang, B. Li, L. Wang, Y. Huang, H. Yin, J. Luo, Z. Han, X. Liu, Chinese Academy of Sciences, China

TID effect of FOI FinFET is discussed. ALL-0 state is identified as the worst case up to 870 krad(SiO₂). Radiation damage can be alleviated by tuning the quality and morphology of the fin bottom.

G-6
12:15 PM **TID-Induced Off-State Leakage Current in Radiation-Hardened SOI LDMOS**

S. Lei1, Harbin Institute of Technology, China; L. Wang, C. Sui, W. Cao, Beijing Microelectronics Technology Institute, China; X. Luo, University of Texas at Austin, USA; K. Zhao, X. Zhou, UESTC, China; Y. Li, Beijing University of Technology, China; C. Liu, T. Wang, HIT, China; Y. Zhao, HIT and BMTI, China; K. Galloway, Vanderbilt University, USA

The off-state leakage current (IL) for SOI n-channel lateral power MOSFETs is examined after exposure to TID. Results show that the IL increases with accumulated dose. The mechanisms for IL are identified by TCAD simulation.

POSTER PAPERS

PG-1 **Probing Ion Radiation Effects in Si Crystal by 3D Integrated Resonating Diaphragms**

H. Chen, H. Jia, P. Feng, Case Western Reserve University, USA; M. McCurdy, R. Reed, R. Schrimpf, M. Alles, Vanderbilt University, USA; P. Hung, Aerospace Corporation, USA

Vertically-stacked vibrating Si diaphragms were exposed to 10.25 MeV oxygen ion flux ($5.6 \times 10^{13}/\text{cm}^2$). Different types and magnitudes of radiation effects (ionization, displacement) are simultaneously probed via multimode redshifts (up to 27%) in different layers.

PG-2 **Silicon Carbide (SiC) Nanoelectromechanical Antifuses Operating in Radiation and High-Temperature Environments**

V. Pashaei, H. Chen, P. Feng, Case Western Reserve University, USA; C. Arutt, W. Liao, M. McCurdy, R. Reed, R. Schrimpf, M. Alles, Vanderbilt University, USA

Silicon carbide (SiC) nanoelectromechanical antifuses are exposed to harsh environments, including proton, X-ray irradiations, and high temperature up to 500°C. The antifuses remain robust in these harsh environments.

Technical Program Wednesday

PG-3 Investigation of X-Ray Irradiation Effects on Graphene Nano-Disc Non-Volatile Memory

K. Xi, J. Bi, Y. Xu, Y. Li, X. Zhang, C. Jiangwei, M. Liu, Chinese Academy of Sciences, China; C. Liang, Maxim Integrated Product Inc., USA

Graphene nano-disc non-volatile memory (GND-NVM) is a promising novel device based on two-dimensional materials. This work investigates the X-ray induced total ionizing dose effects on GND-NVM device and the impact of gate bias during irradiation.

12:30 PM – 2:00 PM
SALONS G-M

LUNCH

RADIATION EFFECTS DATA WORKSHOP

2:00 - 4:45 PM
SALONS A, B, F

INTRODUCTION



Chair: Kirby Kruckmeyer, Texas Instruments

DW-1 Guide to the 2018 IEEE Radiation Effects Data Workshop Record

D. Hiemstra, MDA, Canada

The 2018 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

DW-2 Total Dose Performance at High and Low Dose Rate of CMOS, BiCMOS, and Bipolar Low Dropout Voltage Regulators

D. Hiemstra, V. Kirischian, MDA, Canada; X. Li, L. Chen, University of Saskatchewan, Canada

Results of Cobalt-60 irradiation of low dropout voltage regulators at high and low dose rates are presented. Performance in the space radiation environment is discussed.

DW-3 Total Dose Homogeneity of Commercial-off-the-Shelf BiCMOS and Bipolar Voltage References at Low Dose Rate

D. Hiemstra, V. Kirischian, MDA, Canada; S. Shi, Z. Li, L. Chen, University of Saskatchewan, Canada

Total dose homogeneity of BiCMOS and bipolar voltage references at low dose rate is presented. Radiation hardness assurance implications and performance in the space radiation environment are discussed.

Technical Program Wednesday

DW-4 0.040 rad(Si)/s Total Dose Testing of Renesas Parts Proposed for the Europa Clipper Mission

N. Van Vonno, J. Gill, F. Ballou, L. Pearce, W. Newman, Renesas Electronics America, USA

We report results of TID testing carried out by Renesas Electronics America and Jet Propulsion Laboratory for the Europa Clipper program. The program investigated the TID response of seven Intersil part types.

DW-5 A Comparison of 0.040 rad(Si)/s and 0.010 rad(Si)/s Total Dose Results of Renesas Parts Proposed for the Europa Clipper mission

N. Van Vonno, J. Gill, F. Ballou, L. Pearce, W. Newman, Renesas Electronics America, USA

We compare results of TID testing at 0.010 and 0.040 rad(Si)/s carried out by Renesas and Jet Propulsion Laboratory for the Europa Clipper program. We investigated the TID response of seven Intersil part types.

DW-6 Radiation Degradation of Temperature Dependences of Electrical Parameters of Bipolar Operational Amplifiers

A. Bakerenkov, V. Pershenkov, V. Felitsyn, A. Rodin, V. Telets, V. Belyakov, A. Zhukov, N. Glukhov, National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Russian Federation

Radiation-degradation temperature-dependence of electrical parameters of bipolar operational amplifiers was investigated. Results of the research can improve our understanding of physical and circuit radiation effects in bipolar operational amplifiers.

DW-7 Radiation Evaluation of the TPS7H2201-SP Load Switch

J. Cruz-Colon, H. Torres, J. Valle, V. Narayanan, Texas Instruments, USA

Single events effects characterization of the TPS7H2201-SP is discussed. Characterization shows the device is SEL, SEB and SEGR and SEFI free up to $LET_{eff} = 75 \text{ MeVcm}^2/\text{mg}$.

DW-8 Radiation Effects Characterization of TI THS4541 Rail-to-Rail Output 850 MHz Fully Differential Amplifier

V. Narayanan, R. Gooty, J. Cruz-Colon, Z. Kaye, Texas Instruments Inc., USA

THS4541-SP is a rail to rail output 850 MHz fully differential amplifier being released for space applications. It passed total dose of 100 krad under both high and low dose rates and was latch-up immune up to $86 \text{ MeV-cm}^2/\text{mg}$.

DW-9 Radiation Evaluation of the ADS1278-SP Radiation Hardened 24-Bit 8-Ch Simultaneous-Sampling Delta-Sigma ADC

R. Gooty, Texas Instruments Inc., USA

Single event effects characterization results for ADS1278-SP 24-Bit 8-Ch simultaneous-sampling delta-sigma ADC is summarized, showing SEL free up to $LET_{eff} = 69.96 \text{ MeV-cm}^2/\text{mg}$.

Technical Program Wednesday

DW-10 Single-Event Effects Testing for the ADC12DJ3200QML-SP 12-bit, Dual 3.2-GSPS or Single 6.4-GSPS, RF-Sampling, JESD204B, Analog-to-Digital Converter

*K. Lewis, M. Childs, P. Kramer, J. Sandner, M. Guibord, Texas Instruments, USA;
R. Taft, A. Bodem, T. Hoehn, P. Schmitz, V. Nair, F. Savic, Texas Instruments, Germany*

The effects of heavy-ion irradiation on the single-event effect performance of the ADC12DJ3200QML-SP and its JESD204B serialized interface were characterized. The results demonstrate latch-up immunity up to $LET_{eff} = 120 \text{ MeV-cm}^2/\text{mg}$ at $T_J = 125^\circ\text{C}$. Dynamic cross sections are presented.

DW-11 Radiation Effects Characterization of Commercial Multi-Channel Digital to Analog Converters for Spaceflight Applications

A. Daniel, G. Allen, S. Vartanian, NASA - JPL, USA

This paper presents recent heavy ion single-event effects test results for commercial off the shelf multi-channel digital to analog converter devices. Data were taken in FY18 for device evaluation for use in a NASA space observatory mission.

DW-12 Single Event Transient and Single Event Upset Characterization of a Cobham Designed 3.125 Gbps Crosspoint Switch

M. Von Thun, J. Pfeil, T. Engelbart, A. Turnbull, Cobham, USA

Single event transient and single event upset characterization data will be presented for the newly designed and fabricated Cobham radiation-hardened UT65CML8X8FD 3.125 Gbps Crosspoint Switch (XPS).

DW-13 Characterization of the Effects of Proton-Induced Total Ionizing Dose and Displacement Damage on the UCI875 Controller

S. Messenger, M. Mishler, J. Hack, P. Dudek, Northrop Grumman Corporation, USA

This paper explores the combined effects of total ionizing dose and displacement damage caused by 250 MeV protons on the Texas Instruments UCI875 controller. Two fluences, 4×10^{11} and 1×10^{12} protons/cm², were used.

DW-14 Characterization of the Effects of 250 MeV Proton-Induced Total Ionizing Dose and Displacement Damage on the HCPL-625K Optocoupler

S. Messenger, M. Mishler, J. Hack, P. Dudek, Northrop Grumman Corporation, USA

This paper explores the combined effects of total ionizing dose and displacement damage caused by 250 MeV protons on the Broadcom HCPL-625K optocoupler. Proton fluences up to 4×10^{12} were used.

DW-15 TID and SEE Responses of Rad-Hard A/D Converter RHFAD128

G. Chaumont, A. Souflet, C. Prugne, STMicroelectronics, France; F. Malou, CNES, France

This paper reports on the different responses observed during heavy ion irradiation and total ionizing dose tests on a newly developed Rad-Hard, 8-Channel, 50 ksps to 1 Msps, 12-Bit A/D Converter, called RHFAD128.

Technical Program Wednesday

DW-16 Single Event Effects and Total Ionizing Dose Test Results for a Current Mode Controller Evaluated for Use in a Harsh Space Radiation Environment

A. Bozovich, A. Barchowsky, G. Allen, S. Vartanian, D. Nguyen, S. Zajac, B. Kahn, E. Merida, NASA JPL, USA

This paper investigates recent single event effects and total ionizing dose test results for the Analog Devices RH3845 synchronous buck controller. This device is evaluated for use in a harsh space radiation environment.

DW-17 Heavy Ion Single Event Effects Results for PWM5032 Pulse Width Modulator Controller

J. Likar, S. Katz, JHU APL, USA; R. Sulyma, Cobham Advanced Electronic Systems, USA

Heavy ion testing of the PWM5032 PWM Controller resulted in no destructive failures; non-destructive events were observed and characterized.

DW-18 Proton, Gamma and Neutron Irradiation of a 10 V Precision Voltage Reference

R. Dungan, D. Lo, T. Tran, D. Murlin, D. Hamberg, Northrop Grumman Aerospace Systems, USA

Electrical performance data were collected on a 10 V voltage reference from proton, γ -ray, and γ -ray + neutron irradiation. Comparisons are made between the results from the different irradiation methods, and proton-induced SET results are reported.

DW-19 Single Event Dielectric Rupture Characterization of Microchip High Voltage Devices

D. Truyen, S. Furic, E. Leduc, Microchip, France

Experimental results on single-event hard errors (SEDR-SEGR) of high voltage MOS transistors and capacitors are presented. A pre- and post-irradiation characterization has been carried out, and safe operating areas have been established.

DW-20 Glenair Optical 5 Gbps and 10 Gbps Transceiver Radiation Test Summary

R. Logan, E. Chua, R. Wyss, Glenair, USA; J. Schaefer, M. Gruber, I. Troxel, Troxel Aerospace, USA

Radiation data for Glenair's 050-301 5 Gbps and 050-346 quad-channel 10 Gbps optical transceivers are presented including SEL, heavy-ion and proton SEE, and TID data for the 5 Gbps; and SEL and heavy-ion SEE for the 10 Gbps devices.

DW-21 Heavy Ion Single Event Latchup Measurements of a Focal Plane Imager at Room and Cryogenic Temperatures

F. Irom, G. Allen, B. Hancock, G. Mariani, NASA JPL, USA

Heavy ion-induced SEL is characterized in a CMOS focal plane array readout at room temperature and 225 K. The LET threshold at room temperature is between 22-24 MeV-cm²/mg. The part is SEL immune at 225 K.

Technical Program Wednesday

DW-22 Test Results of Proton Single-Event Effects Conducted by the Jet Propulsion Laboratory

G. Allen, F. Irom, S. Vartanian, NASA JPL, USA

This paper reports recent SEE results for a variety of microelectronics that include SRAM, FPGA, Flash memory and a linear regulator. The data were collected to evaluate these devices for possible use in NASA missions.

DW-23 NASA Goddard Space Flight Center's Compendium of Total Ionizing Dose, Displacement Damage Dose, and Single Events Effects Test Results

A. Topper, M. Berg, K. Label, D. Cochran, M. O'Bryan, SSAI, USA; T. Wilcox, M. Casey, M. Campola, R. Ladbury, J. Lauenstein, K. Ryder, NASA GSFC, USA; E. Wyrwas, Lentech, Inc., USA

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

DW-24 Compendium of Recent Radiation Test Results from the Johns Hopkins University Applied Physics Laboratory

C. Pham, JHP/APL, USA

Total ionizing dose, enhanced low dose rate sensitivity, and single event effects test results are presented for a variety of analog, digital, mixed signal, and radio frequency devices.

DW-25 Radiation Effects Testing of Selected Voltage Regulator Microcircuits with Heavy Ions and Protons

R. Koga, Aerospace, USA

We present observations of heavy ion and proton induced radiation effects on selected COTS voltage regulator integrated microcircuits.

DW-26 The Aerospace Corporation's Compendium of Recent Single Event Effect Results

S. Davis, D. Mabry, A. Yarbrough, R. Koga, A. Wright, C. Langford, The Aerospace Corporation, USA; J. George, Los Alamos National Laboratory, USA

Single event effects testing using heavy ions and protons was performed on several commercial components to determine the response of these components to the space radiation environment.

DW-27 Single Event Effect Test Results for Candidate Spacecraft Electronics

T. Maksimenko, V. Anashin, A. Kalashnikova, A. Koziukov, N. Bondarenko, K. Bukhasan, M. Vyrostkov, R. Mangushev, A. Drokin, S. Iakovlev, Institute of Space Device Engineering (Branch of URSC – ISDE), Russian Federation; A. Borisov, A. Kryukov, JSC SPC ElTest, Russian Federation

We present test results on the immunity of a variety of candidate spacecraft ICs and modules to proton and heavy ion induced single event effects. Tested devices include analog devices.

Technical Program Wednesday

DW-28 Heavy Ion Test Results for Frequency Synthesizers

I. Maslennikova, V. Anashin, A. Koziukov, S. Iakovlev, V. Lykov, Institute of Space Device Engineering (Branch of URSC), Russian Federation

This paper presents the single event effect test results obtained at the Roscosmos Test Facilities during test campaigns in 2018 for a number of candidate spacecraft electronics, specifically frequency synthesizers.

DW-29 Single-event Evaluation of Xilinx 16 nm UltraScale+™ High-Bandwidth Memory (HBM) Enabled FPGA

Y. Chen, P. Maillard, J. Barton, E. Crabill, P. Kyu, J. Schmitz, M. Voogel, Xilinx, Inc, USA

Single-event characterization of a Xilinx 16 nm UltraScale+ Virtex HBM-enabled FPGA was performed using both high-energy proton and neutron beams. SEE results for the HBM stack, interface and programmable logic are presented.

DW-30 Recent SEE Results for Snapdragon SOCs

S. Guertin, W. Parker, A. Daniel, P. Adell, NASA JPL, USA

SEE test results are presented for Snapdragon 801 and Snapdragon 835 SOCs.

DW-31 Single Event Upset Characterization of the Cyclone V Field Programmable Gate Array Using Proton Irradiation

Q. Chen, Xi'an Microelectronics Technology Institute, China; L. Chen, University of Saskatchewan, Canada; D. Hiemstra, V. Kirischian, MDA, Canada

Proton induced SEU cross-sections of certain functional blocks of the Cyclone V FPGA are presented. Upset rates in the space radiation environment are estimated.

DW-32 BRE440 Heavy Ion SEE Test Summary

N. Kent, J. Schaf, Moog Broad Reach, USA; I. Troxel, J. Schaefer, M. Gruber, Troxel Aerospace, USA

Heavy-ion SEE results are detailed for the radiation-hardened BRE440, a PowerPC440-based SOC processor fabricated on Honeywell's HX5000 150 nm technology node. Statistically significant data at thirteen LETs highlight strong SEE robustness including temperature and angle effects.

DW-33 ATmegaS128 8-bit Microcontroller Total Ionizing Dose and Single Event Effects

G. Bourg-Cazan, J. Vrignaud, Microchip Technology Nantes, France

ATmegaS128 Radiation Tolerant product capability versus radiation environment is presented. The poster provides TID, heavy ions, protons and neutron results focusing on NVM programming capability versus TID.

DW-34 ATmegaS64M1 8-bit Microcontroller Total Ionizing Dose and Single Event Effects

J. Bernard, J. Vrignaud, Microchip Technology Nantes, France

This document describes the ATmegaS64M1 radiation tolerant product radiation characterization, to fit with New Space requirements. A description of device capability versus radiation environment is presented. The document provides TID, heavy ions, protons and neutron results.

Technical Program Wednesday

DW-35 Stratix 10 FPGA Neutron Radiation Test Results

A. Keller, W. Keller, Brigham Young University, USA

The neutron cross section of SEUs in Stratix 10 FPGA memory was measured to be 3.2 FIT per Mbit for configuration memory (20x less than Stratix V) and 7.1 FIT per Mbit for block memories.

DW-36 Neutron Induced Single Event Upset (SEU) Testing of Commercial Flash Memory Devices

M. Allenspach, J. Bird, M. Peters, M. Tostanoski, K. Hartojo, R. Strayer, Radiation Test Solutions, Inc., USA; T. Deaton, Cobham, USA; T. Fullem, Fluor Marine Propulsion, LLC, USA

Neutron (14 MeV) induced single event effect testing results for a 128-Mbit (S25FL128S) and 256-Mbit (S29GL256P) Flash memory using several bit patterns are presented along with cross section data and soft error rates.

DW-37 Radiation-Induced Errors at Elevated Linear Energy Transfer Levels and Magnetic Error Rate Interactions in Magnetic Tunnel Junctions

R. Katti, Honeywell, USA

Magnetic tunnel junctions subjected to oblique-angle heavy ion irradiation and effective LET exposure to approximately 145 MeV-cm²/mg showed radiation-induced hard-error effects that are mitigated by low magnetic error rates and error correction in memory applications.

DW-38 Total Dose and Heavy Ion Radiation Response of 55 nm Avalanche Technology Spin Transfer Torque MRAM

J. Ingalls, M. Gadlage, J. Wang, D. Bruce, A. Williams, NSWC Crane, USA; R. Ranjan, Avalanche Technology Inc., USA

The total dose and heavy ion radiation responses of 55 nm non-volatile spin transfer torque memory devices from Avalanche Technology are presented, and show these devices to be inherently largely radiation tolerant.

DW-39 SEE Testing of DDR2 Memories

D. Hansen, F. Meraz, P. Pham, D. Smith, R. Hillman, G. Williamson, Data Devices Corp., USA

Single event effect testing was performed on three DDR2 devices. The parts were characterized for a variety of SEE, including multi-bit upsets (MBU) and single event functional interrupts.

DW-40 A SET Study on SRAM Memory

P. Wang, 3D PLUS, France; M. Glorieux, iRoC Technologies, France; C. Boatella Polo, ESA ESTEC TEC-QEC, Netherlands; F. Lochon, HIREX Engineering, France; J. Benedetto, Radiation Assured Devices, USA

We report a MBU-liked-SET during SRAM HI test. Further laser study showed that the root cause is not from the silicon but the floating pads to configure the die. A mitigation was proposed and verified.

Technical Program Wednesday

DW-41 Single Event Effect Characterization of High Density SRAMs in Bulk and SOI Technologies

Y. Yu, X. Wang, H. Luo, Y. Zhi, China Electronic Product Reliability and Environmental Testing Research Institute, China

The single event effect characterization of 32M bulk epitaxial SRAM and 16M SOI SRAM are tested using heavy ion. The estimated on-orbit upset rates are less than 10^{-10} errors/bit-day.

DW-42 Laser-Induced Micro SEL Characterization of SRAM Devices

M. Yingqi, H. Jianwei, S. Shipeng, Z. Xiang, C. Rui, National Space Science Center, Chinese Academy of Sciences, China

This study presents micro single event latch-up characterization of SRAM by 1064 nm laser backside testing. The SEL threshold and the detailed screening of micro SEL features have been investigated by laser automatic scanning experiment.

DW-43 Fast-Neutron Beam Testing at the University of Washington Medical Cyclotron Facility

D. Argento, G. Moffitt, K. Marissa, E. Dorman, R. Emery, UW Medical Center, Radiation Oncology, USA

The team at the UW Medical Cyclotron Facility have developed three distinct fast-neutron spectra for use in radiation effects testing: (1) Mean neutron energy of 22 MeV, with $E_{\max} = 45$ MeV; (2) $E_{\text{mean}} = 10$ MeV, $E_{\max} = 43$ MeV; (3) $E_{\text{mean}} = 8$ MeV, $E_{\max} = 43$ MeV.

DW-44L Radiation Tests of a 500 °C Durable 4H-SiC JFET Integrated Circuit Technology

J. Lauenstein, K. Ryder, E. Wilcox, M. Carts, NASA GSFC, USA; S. Wrbanek, J. Wrbanek, P. Neudeck, R. Buttler, NASA GRC, USA

Silicon carbide junction field effect transistor (JFET) semiconductor integrated circuits capable of prolonged operation in Venus-like surface atmospheric conditions show tolerance to total ionizing dose and single-event effects, further demonstrating their suitability for extreme environments.

DW-45L A summary of Mil Std 750, method 1017 neutron irradiation tests performed on JANSR2N3700, JANSR2N2369, JANSR2N2222 and JANSR2N2907 BJTs

P. Schimel, Microchip, USA

This work will explain the results of neutron interactions on 4 JANSR BJTs. The total integral neutron fluence was stepped at 5 levels between $5_{15}10^{11}$ n/cm² and 10^{14} n/cm². The primary effect was H_{fe} degradation with secondary effects including elevated $V_{ce \text{ sat}}$.

DW-46L Impact of Single Event Effects on Key Electronic Components for COTS-based Satellite systems

R. Monreal, J. Alvarez, J. Hollen, G. Dennis, Southwest Research Institute, USA

Single Event Effect (SEE) testing of key electronic components for COTS-based Space systems is undertaken to understand their SEE sensitivity. Results show how the SEE manifestations, even though capable of interrupting operation, can be tolerable with simple mitigation techniques while deployed in orbit.

Technical Program Wednesday

DW-47L A TID and SEE Characterization of Multi-Terabit COTS 3D NAND Flash

E. Wilcox, M. Campola, NASA GSFC, USA

Single-event effects and total ionizing dose testing is described for a 32-layer NAND flash memory, in both SLC and MLC configurations, with special considerations for unique three-dimensional test results.

DW-48L Single-Event Characterization of the 16 nm FinFET Xilinx UltraScale+™ RFSoc Field-Programmable Gate Array under Proton Irradiation

P. Davis, L. David, M. Learn, D. Thorpe, Sandia National Labs, USA

This study examines the single-event upset and single-event latch-up susceptibility of the Xilinx 16nm FinFET Zynq UltraScale+ RFSoc FPGA in proton irradiation. Results for SEU in configuration memory, BlockRAM memory, and device SEL are given.

DW-49L Proton Characterization of RTG4 Flash-Based FPGA for LEO Environment

N. Rezzak, J. Wang, F. Hawley, H. Esmat, Microchip, USA

The single-event response of the RTG4 flash-based FPGA is characterized using 64 and 200 MeV proton sources. STMRFF, SRAMs, PLL, SERDES, FDDR, POR and in-beam reprogramming results are presented.

DW-50L Heavy Ion SEE Testing of Microchip Integrated Motor Controller LX7720

M. Sureau, N. Rezzak, Microchip, USA

The Heavy Ion SEE testing results of the Microchip radiation hardened analog mixed-signal motor controller IC, the LX7720, are presented, including the complete SEL data and SET/SEU for all blocks.

DW-51L Degradation Measurement of Kinect Sensor Under Fast Neutron Beamline

Z. Khanam, S. Saha, B. Aslam, X. Zhai, S. Ehsan, K. McDonald-Maier, University of Essex, United Kingdom; C. Cazzaniga, C. Frost, Rutherford Appleton Laboratory, United Kingdom; R. Stolkin, University of Birmingham, United Kingdom

The neutron-induced degradation of depth images acquired using a Kinect sensor is investigated through the standard metrics. The evaluated metrics indicate saturation of degradation after several hours of exposure, which is recovered through annealing.

4:45 PM END OF WEDNESDAY SESSIONS

6:00 PM - 10:00 PM
(Busses Start at 5:30 PM)

CONFERENCE SOCIAL
BUCKHORN/TEXAS RANGERS MUSEUM

Technical Program Thursday

CONFERENCE ROOMS
17 & 18
7:00 - 8:30 AM

SALONS C, D, E
INVITED TALK
8:30 - 9:45 AM

BREAKFAST WITH YOUNG PROFESSIONALS PRESENTATION (Ticket Required to Attend)

Parker Solar Probe: A Mission to Touch the Sun

Dr. Jim Kinnison, PSP Mission System Engineer, The Johns Hopkins University Applied Physics Laboratory



Sixty years in preparation, Parker Solar Probe launched on August 12, 2018 and a short three months later, reached the innermost regions of the heliosphere to sample the Sun's corona at 0.17 AU. Traveling through a region of space never before explored, this innovative mission must survive solar illumination about 450 times that seen in Earth orbit, an energetic and dynamic solar plasma, and hypervelocity dust impacts at speeds up to 300 km/s. Parker Solar Probe will continue deeper into the corona over the next seven years to make in situ measurements of the Sun's corona and solar wind to push the boundaries of our understanding of the Sun and its effect on the Earth. Jim will discuss the science of Parker Solar Probe, the engineering that allows the spacecraft to survive this extreme environment, and the first results from the mission.



Throughout his career, Jim Kinnison has focused on the intersection of space systems engineering and the practical aspects of surviving extreme environments. Beginning in 1987 at The Johns Hopkins University Applied Physics Laboratory, Jim became a leader in space radiation effects, working on a number of spacecraft such as MESSENGER, NEAR, and New Horizons to develop robust systems to accomplish cutting edge science. In 2007, while completing his PhD from Clemson University, he began an 11-year journey leading the Parker Solar Probe technical team as Mission System Engineer from initial concept, through design and build of the spacecraft, to launch and early operations.



SALONS C, D, E
SESSION H
9:45 AM

PHOTONIC DEVICES AND INTEGRATED CIRCUITS **SESSION INTRODUCTION**

Chair: Vincent Goiffon, ISAE-SUPAERO

H-1
9:50 AM

Electronic-to-Photonic Single-Event Transient Propagation in a Segmented Mach-Zehnder Modulator in a Si/SiGe Integrated Photonics Platform

G. Tzintzarov, J. Cressler, A. Ildefonso, P. Goley, M. Frounchi, J. Campbell, Georgia Institute of Technology, USA; A. Khachatryan, S. Buchner, D. Mcmorrow, J. Warner, Naval Research Laboratory, USA; M. Kaynak, L. Zimmermann, IHP, Germany

The propagation of single-event transients from the electronic to the photonic domain was studied using pulsed laser measurements and simulations. Implications for photonics communication systems are presented.

Technical Program Thursday

H-2 **10:05 AM** **Comparison of X-ray and Electron Radiation Effects on Dark Current Non-Uniformity and Fluctuations in CMOS Image Sensors**

A. Le Roch, ISAE-SUPAERO and CNES, France; V. Goiffon, P. Magnan, ISAE-SUPAERO, France; C. Virmondois, J. Belloir, CNES, France; P. Paillet, CEA DAM, France; J. Warner, Naval Research Laboratory, USA

X-ray and electron irradiation induced dark current distributions and random telegraph signal are investigated in Pinned Photodiode (PPD) CMOS Image Sensors. The analyses provide new insights on TID induced dark current sources in PPD CIS.

H-3 **10:20 AM** **Pre- and Post-Annealing Discrete Switching Fluctuations of Dark Count Rate in Two Proton-Irradiated CMOS SPAD Structures**

F. Di Capua, M. Campajola, Università di Napoli Federico II and INFN, Italy; D. Fiore, Università della Calabria, Italy; E. Sarnelli, C. Nappi, CNR - SPIN, Italy

In this work we studied the random telegraph signals of two SPAD layouts after proton irradiation. Measurements of RTS time constants vs. temperature and isochronal annealing at different temperature steps allow insight into RTS origin.

10:35 – 11:05 AM
SALONS A-F PRE-FUNCTION
AREA (FOYER)

BREAK

H-4 **11:05 AM** **In Situ Deep-level Transient Spectroscopy and Dark Current Measurements of Proton-Irradiated $\text{In}_{0.54}\text{Ga}_{0.46}\text{As}$ Photodiodes**

G. Nelson, S. Hubbard, G. Ouin, S. Polly, Rochester Institute of Technology, USA; K. Wynne, A. Haberl, W. Lanford, University at Albany, USA; R. Lowell, Dynamic Radiation Solutions, USA

InGaAs photodiodes were irradiated at low temperature and the defect profile was extracted before room-temperature annealing could occur. No low-temperature-only traps were found, but annealing of the dominant mid-gap trap began as low as 150 K.

H-5 **11:20 AM** **Radiation Effects on WDM and DWDM Architectures of Pre-Amplifier and Boost-Amplifier**

A. Ladaci, Den-SERVICE d'Etudes Analytiques et de Réactivité des Surfaces (SEARS), CEA, Université Paris-Saclay, France; M. Aubry, CNES / iXblue / Laboratoire Hubert Curien / Politecnico di Bari, France; S. Girard, E. Marin, B. Sane, Y. Ouerdane, A. Boukenter, Université de Saint Etienne, France; L. Mescia, Politecnico di Bari, Italy; A. Laurent, T. Robin, B. Cadier, iXblue, France; M. Boutillier, J. Mekki, CNES, France

We investigated the radiation effects on WDM and DWDM architectures of pre-amplifier and boost-amplifier. The radiation-hardened and normal active fibers will be compared. The gain degradation is very limited for amplifiers made with radiation-hardened fiber.

Technical Program Thursday

H-6 11:35 AM **Radiation-Response of Distributed Feedback (DFB) Bragg Gratings for Space Applications**

A. Morana, E. Marin, S. Girard, A. Boukenter, Y. Ouerdane, Laboratory Hubert Curien, France; L. Lablonde, E. Pinsard, G. Melin, T. Robin, iXBlue Photonics, France

The radiation-response of DFB Bragg gratings was studied up to the total ionizing dose of 1 kGy. The ultra-narrow pass-band peaks are almost not influenced by radiation, independently of the radiation-response of the Bragg gratings.

H-7 11:50 AM **Transient and Steady State Radiation Response of Phosphosilicate Optical Fibers: Influence of H₂**

S. Girard, V. De Michele, A. Alessi, A. Boukenter, Y. Ouerdane, E. Marin, A. Morana, Université de Saint Etienne, France; C. Marcandella, M. Gaillardin, P. Paillet, CEA DAM, France; D. Di Francesca, CERN, Switzerland; S. Agnello, M. Cannas, Università di Palermo, Italy

The response of a phosphorus-doped multimode optical fiber is investigated under both transient and steady state irradiations. We also evaluate the influence of a hydrogen pre-loading on the fiber radiation induced attenuation levels and kinetics.

POSTER PAPERS

PH-1 **Response of Waveguide-Integrated Germanium-on-Silicon p-i-n Photodiodes to Neutron Displacement Damage**

P. Goley, M. Frounchi, G. Tzintzarov, J. Cressler, Georgia Institute of Technology, USA; N. Dodds, N. Nowlin, Sandia National Laboratories, USA

Waveguide-integrated p-i-n germanium-on-silicon photodiodes, from a commercial silicon-based integrated photonics platform, were exposed to fast neutron irradiation. The devices are experimentally shown to be highly resilient to displacement damage.

PH-2 **Proton Radiation Effects on InGaAs/InP SPADs**

A. Tosi, F. Signorelli, M. Sanzaro, Politecnico di Milano, Italy; A. Giudice, Micro Photon Device Srl, Italy; M. Bagatin, S. Gerardin, DEI - Padova University and INFN-PD, Italy & Istituto Nazionale di Fisica Nucleare, Italy; M. Zahidy, University of Padova, Italy; G. Vallone, P. Villorosi, University of Padova, Italy & Istituto Nazionale di Fisica Nucleare, Italy

We present an experimental study of proton radiation effects on the performance of InGaAs/InP Single Photon Avalanche Diodes, used in space communications and remote sensing applications, where single-photon detectors for the near-infrared wavelengths are required.

PH-3 **Comparison of 1D and 3D Electric Field Enhancement Analytical Models to Calculate the Dark Current Non-Uniformity**

K. Lemiere, C. Inguibert, T. Nuns, ONERA, France

A three-dimensional electric field enhancement model is proposed for our Monte Carlo tool used to calculate the dark current non-uniformity, in order to better estimate the hot pixels number in the distribution tail.

Technical Program Thursday

PH-4 Performances of Radiation-Hardened Single-Ended Raman Distributed Temperature Sensors Using COTS Fibers

A. Morana, S. Girard, E. Marin, A. Alessi, A. Boukenter, Y. Ouerdane¹, Laboratoire Hubert Curien, France; A. Cebollada, A. Champavere, Viavi Solutions, France; G. Mélin, T. Robin, iXBlue Photonics, France

We investigate the performances of a radiation-hardened single-ended Raman Distributed Temperature Sensor by combining it with commercial fibers. Such a RDTS presents several advantages with respect to a classical single-ended or a double ended sensor.

PH-5 Proton Irradiation Effect on High Efficient Organic-Inorganic Metal Halide Perovskite Solar Cell

X. Zhang, L. Wang, B. Li, J. Gao, B. Li, M. Liu, Y. Huang, J. Luo, Z. Han, X. Liu, Chinese Academy of Sciences, China; C. Liang, H. Zhang, C. Ji, F. Sun, Beijing Jiaotong University, China; J. Yang, X. Li, Harbin Institute of Technology, China

Through 50 keV proton irradiation, the tolerance of perovskite solar cell and the internal physical mechanism after irradiation were studied in detail by various optical testing methods.

CONFERENCE ROOMS
17 & 18
12:05 - 1:45 PM

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

POSTER SESSION
1:45 - 4:30 PM
SALONS A, B, F

INTRODUCTION



Chair: Ethan Cannon, Boeing

4:30 PM **END OF THURSDAY SESSIONS**

4:30 - 6:30 PM
SALONS C, D, E

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

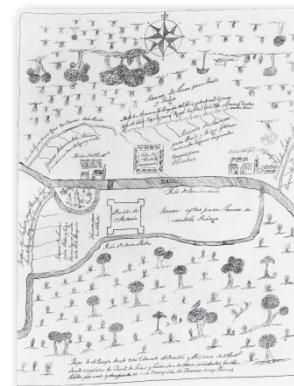
Technical Program Friday

SALONS C, D, E
INVITED TALK
8:30 - 9:45 AM

Spanish Exploration and the Beginnings of Texas Natural History *Dr. Jesús F. de la Teja, Chief Executive Officer, Texas State Historical Association*



Spanish exploration of what is now Texas began in earnest in the late 17th century. Expeditions often were led by Franciscan missionaries looking for new opportunities to convert the native population to Christianity. They often were also the result of military efforts to repel imperial rivals. Aside from the rich record of the Indian peoples of the region, the journals and diaries of expeditions across the Rio Grande have left us valuable information regarding a natural environment long since replaced by towns and cities, highways and railroad tracks, farms and ranches. This talk uses expedition journals and diaries to provide a sense of that long lost Texas and describe how Spanish colonial frontiersmen began the process of environmental transformation in the San Antonio area.



Caption (translation): Map of the place where the presidio and missions of San Antonio are located, where the province of Texas begins, and showing the extent of the surrounding woods. It is an area of very flat land. Original in the Archivo General de la Nación de México.

Jesús F. de la Teja is Regents' Professor Emeritus at Texas State University, where he taught history, and served as department chairman and as director of the Center for the Study of the Southwest. He obtained the Ph.D. in Latin American history from the University of Texas at Austin, and between 1985 and 1991 he worked in the Archives and Records Division of the General Land Office. He has published extensively on Spanish, Mexican, and Republic-era Texas, including *Faces of Béxar: Early San Antonio and Texas* (2016) and has served as book review editor for the *Southwestern Historical Quarterly*. He was the inaugural State Historian of Texas (2007-2009), is a Fellow of the Texas State Historical Association and of the Texas Catholic Historical Society, and is a member of the Texas Institute of Letters and the Philosophical Society of Texas. He currently serves as CEO of the Texas State Historical Association.

SALONS C, D, E
SESSION I
9:45 AM

HARDENING BY DESIGN **SESSION INTRODUCTION**

Chair: Jeffrey Kauppila, Vanderbilt University

I-I
9:50 AM

DFF Layout Variations in CMOS SOI – Analysis of Hardening by Design Options

J. Black, D. Black, N. Domme, P. Dodd, P. Griffin, R. Nowlin, J. Trippe, J. Salas, Sandia National Laboratories, USA; R. Reed, R. Weller, A. Tonigan, R. Schrimpf, Vanderbilt University, USA

Four DFF layouts were created from the same schematic in Sandia National Laboratories' CMOS7 SOI process. SEU modeling and testing showed improved response with an increase in drain size and the use of shallow drain.

Technical Program Friday

I-2
10:05 AM **Improving the Reliability of TMR with Non-Triplicated I/O on SRAM FPGAs**

M. Cannon, A. Keller, H. Rowberry, C. Thurlow, A. Pérez-Celis, M. Wirthlin, Brigham Young University, USA

This work examines the trade-offs between common-IO and triplicated-IO TMR systems and demonstrates several mitigation techniques that improve the neutron cross-section from 2x to 26x with minimum additional resource utilization.

I-3
10:20 AM **Applying Compiler-Automated Software Fault Tolerance to Multiple Processor Platforms**

J. Benjamin, M. Wirthlin, J. Goeders, Brigham Young University, USA; H. Quinn, Los Alamos National Lab, USA

We present experimental data demonstrating our fully automated, compiler-based tool to add fault mitigation to user code, with neutron beam testing on RISC-V, ARM A9 and ARM A53 platforms.

POSTER PAPERS

PI-1 **A Radiation-Tolerant D Flip-Flop Designed for Low-Voltage Applications**

G. Poe, J. Kauppila, B. Bhuvva, L. Massengill, Vanderbilt University, USA; D. Ball, K. Warren, T. Haeffner, Institute for Space and Defense Electronics, USA

A low-voltage robust D flip-flop is presented that targets a middle ground in radiation hardness and electrical performance between existing DICE flip-flop designs and unhardened commercial flip-flop designs.

PI-2 **RHBD Sub-Sampling Phase-Locked Loop in 32 nm PD-SOI**

E. Richards, J. Kauppila, T. Haeffner, W. Holman, L. Massengill, Vanderbilt University, USA; T. Loveless, University of Tennessee at Chattanooga, USA

This work presents a RHBD 15 GHz quadrature phase-locked loop in a 32nm SOI technology. Component and loop level hardening techniques are integrated into a sub-sampling architecture for robust noise and radiation performance.

PI-3 **A SET-tolerant High-frequency Multi-biased Multiphase Voltage-Controlled Oscillator for Phase Interpolator-based Clock and Data Recovery**

H. Yuan, B. Liang, J. Chen, Y. Chi, Y. Guo, National University of Defense Technology, China; T. Liu, B. Ye, Heavy Ion Research Facility at Lanzhou, China; G. Guo, China Institute of Atomic Energy, China; Y. Ma, Chinese Academy of Sciences, China

A high-frequency multi-biased multiphase voltage-controlled oscillator applied to clock and data recovery is proposed. The operating frequency of the Voltage-Controlled Oscillator ranges from 2.1 GHz to 5.5 GHz. Ion experiments show SET tolerance under LETs of 83.7 MeVcm²/mg.

Technical Program Friday

PI-4 Using SEU Mitigation Techniques to Improve SER Performance of FPGA-based Networking Systems

H. Rowberry, A. Keller, M. Wirthlin, Brigham Young University, USA

Terrestrial radiation causes failures in FPGA-based networking systems. In neutron radiation testing, an example system demonstrates a 5.1x improvement in reliability using TMR and demonstrates a 6.6x improvement in detectability using duplication with compare.

PI-5 High Total Ionizing Dose Effects on a Column Parallel Radiation Hardened Single-Slope-Analog-to-Digital Converter

S. Rizzolo, V. Goiffon, F. Corbière, S. Rolando, P. Magnan, ISAE SUPAERO, Université de Toulouse France; P. Paillet, C. Marcandella, CEA, DAM, DIF, France; M. Van Uffelen, L. Mont Casellas, Fusion for Energy (F4E), Spain; R. Scott, Oxford Technologies Ltd. (OTL), United Kingdom; W. De Cock, SCK-CEN, Belgium

TID effects on 26-to-95 column-parallel-10-bit-single-slope-ADCs up to 100 Mrad(SiO₂) are investigated on several manufacturing lots. Input range degradation and random digital failures are reported despite the use of RHBD techniques. Remaining issues root causes are discussed.

10:35 - 11:05 AM
SALONS A-F PRE-FUNCTION
AREA (FOYER)

BREAK

SESSION J 11:05 AM

HARDNESS ASSURANCE SESSION INTRODUCTION

Chair: Thomas Turflinger, Aerospace Corporation

J-1 11:10 AM

Risk Methodology for SEE Caused by Proton-Induced Fission of High-Z Materials in Microelectronics Packaging

R. Ladbury, NASA GSFC, USA

Proton-induced fission of high-Z materials can produce high fluxes of high-LET ions in microelectronics. We develop methods to evaluate risks for a range of destructive and nondestructive SEE modes caused by this threat.

J-2 11:25 AM

Data Retention Voltage Based Analysis of Systematic Variations in SRAM SEU Hardness: A Possible Solution to Synergetic Effects of TID

D. Kobayashi, K. Hirose, ISAS/JAXA and Univ. of Tokyo, Japan; K. Sakamoto, S. Okamoto, S. Baba, H. Shindou, O. Kawasaki, R&D/JAXA, Japan; T. Makino, T. Ohshima, QST, Japan; Y. Mori, D. Matsuura, M. Kusano, T. Narita, S. Ishii, MHI Ltd., Japan

SEU cross-section is known to acquire post-silicon variation by TID. This issue is studied through a voltage parameter easily available in SRAMs. Results show its potential to predict and cancel out the variations in flight.

Technical Program Friday

J-3
11:40 AM **Single Event Latchup Sensitive Volume Model for a 180-nm SRAM Test Structure**

P. Wang, A. Sternberg, B. Sierawski, E. Zhang, D. Fleetwood, R. Reed, R. Schrimpf, Vanderbilt University, USA; N. Dodds, G. Vizkelethy, Sandia National Laboratories, USA; S. Jordan, Jazz Semiconductor Trusted Foundry, USA

New ion-induced latchup data and previous laser-induced latchup data facilitates the definition of a multiple, nested sensitive-volume model using the Monte Carlo Radiative Energy Deposition tool. Hardness assurance implications are discussed.

J-4
11:55 PM **Energy-Dependent Effective Cross Sections of Neutron Interactions with Semiconductor Devices**

S. Wender, J. O'Donnell, L. Zavorka, Los Alamos National Laboratory, USA; B. Bhuvva, Vanderbilt University, USA

We have developed a technique to measure the neutron beam attenuation through a stack of PCBs. This will allow test engineers to correct inaccuracies in the failure-in-time (FIT) rate measurements during SEU tests.

J-5
12:10 PM **Evaluating Elevated Temperature DRAM Stuck Bit Sensitivity at Room Temperature**

S. Guertin, W. Parker, D. Nguyen, G. Allen, D. Sheldon, Jet Propulsion Laboratory, USA; S. Delaney, San Diego State University, USA; P. Blaisdell-Pijuan, Princeton University, USA; J. Vanacore, California Polytechnic State University, USA

High temperature measurements anneal stuck bits in test devices, invalidating results. Impact is exacerbated in low- to moderate-temperature, high-dose missions. A low-temperature method is presented for mission estimates.

POSTER PAPERS

PJ-1 **Silicon Carbide Power MOSFETs Under Neutron Irradiation: Failure In Time Demonstration and Long Term Reliability Degradation Evaluation**

K. Niskanen, A. Michez, F. Wrobel, J. Boch, V. Pouget, F. Saigne, University of Montpellier, France; A. Touboul, R. Germanicus, ENSICAEN-CRISMAT Laboratory, France; P. Girones, CEA, France; S. Morand, O. Crepel, C. Weulersse, C. Binois, Airbus, France

Silicon carbide power MOSFET sensitivity to single event effects under neutron irradiation was studied. Time dependent dielectric breakdown of the gate oxide was also investigated. Lower charge to breakdown values were observed for irradiated devices.

PJ-2 **Application of Bayesian Methodology to Radiation Hardness Assurance and Spacecraft Reliability**

A. Coburger, J. Likar, C. Smith, JHU APL, USA

Bayesian methods offer opportunities to reduce conservatism and uncertainties in RHA and reliability calculations. Methods are demonstrated using RLAT data and a LEO reference mission.

Technical Program Friday

PJ-3 Design-of-Experiments and Monte-Carlo Methods in Upset Rate-Calculations

D. Hansen, Data Devices Corp., USA

This paper reports on the calculation of upset rates in geosynchronous orbit using design of experiments and Monte-Carlo approaches to the parameters available in CREME96. The implications for data collection are discussed.

PJ-4L Direct Ionization Impact on Accelerator Mixed-Field Soft Error Rate

R. Garcia Alia, M. Brugger, M. Cecchetto, F. Cerutti, S. Danzeca, P. Fernandez Martinez, S. Gilardoni, A. Infantino, M. Kastriotou, N. Kerboub, G. Lerner, V. Wyrwoll, CERN, Switzerland; M. Tali, CERN/ESA/University of Jyväskylä, Switzerland; V. Ferlet Cavois, C. Boatella-Polo, ESA, Netherlands; A. Javanainen, H. Kettunen, University of Jyväskylä, Finland; R. Gaillard, Consultant, France; F. Wrobel, University of Montpellier 2, France

The impact of charged particle direct ionization on the mixed-field accelerator soft-error rate is evaluated through experimental measurements and Monte Carlo simulations, showing that present technologies are at the limit of direct ionization dominance.

PJ-5L Inclusion of Radiation Environment Variability for Reliability Estimates for SiC Power MOSFETs

R. Austin, B. Sierawski, R. Reed, R. Schrimpf, K. Galloway, D. Ball, A. Witulski, Vanderbilt University, USA

Variability of the solar energetic particle environment is investigated for single-event-burnout reliability of silicon-carbide power metal-oxide-semiconductor field effect transistors. A probabilistic assessment of failure evaluates the benefits of de-rating voltage, shielding, and mission length.

12:25 PM END OF CONFERENCE



*Janet Barth
Executive Chairman*



*Robert Reed
Executive Vice-Chair*

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 in our community. The REC 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, and 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 in the year following the conference, subject to an additional review. A data workshop is also held each year at the NSREC. The REC oversees publication of a special Data Workshop issue of papers presented at the conference. The Data Workshop is published in the fall of the year that the conference is held.

NSREC 2019 will be held in San Antonio, Texas, July 8-12, 2019 at the Marriott Rivercenter. John Stone of Southwest Research Institute is the Conference Chair. Supporters of the 2019 NSREC include The Aerospace Corporation, BAE Systems; Boeing; Cobham; Harris; IR HiRel Products, an Infineon Technologies Company; Intersil Space Products; Jet Propulsion Laboratory; Southwest Research Institute and VPT. We thank our supporters for their significant and continuing commitments to the conference and welcome other organizations to consider becoming supporters of the IEEE NSREC.

NSREC 2020 will be held in Santa Fe, New Mexico, July 20-24, 2020 at the Hilton Buffalo Thunder Resort. Hugh Barnaby, Arizona State University, is the 2020 NSREC Chair. Steve McClure, JPL, is the Chair of NSREC 2021, which will be held in Ottawa, Ontario Canada.

Papers presented at the 2019 NSREC are eligible for publication in the January 2020 issue of the IEEE Transactions on Nuclear Science. Authors must upload their papers prior to the conference for consideration for publication in the January 2020 TNS Special Issue. Detailed instructions can be found at www.nsrec.com.

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

IEEE FELLOWS

A distinguished member of the international radiation effects community was elevated to the grade of IEEE Fellow on January 1, 2019.

Dale McMorro*w*, *NRL*, “for contributions to laser-based methodologies for simulating single-event effects in digital devices”.

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 2020), 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 the Friday before the Conference (July 5, 2019). 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 2019 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

Ivan Sanchez Esqueda, Associate Editor, USC ISI
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Philippe Paillet, Associate Editor, CEA
Email: philippe.paillet@cea.fr

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. Full membership in IEEE costs \$203. 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 on Thursday of 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, published in January of the year following the conference, 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 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 2019 *IEEE Radiation Effects Data Workshop Record* and the January 2020 special NSREC issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee. A CD or USB flash drive containing the *NSREC Short Course Notes (2019)* will be given to short course attendees.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

**THURSDAY, JULY 11
4:30 – 6:30 PM
GRAND SALONS C-D-E,
MARRIOTT RIVERCENTER**

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 11 from 4:30-6:30pm, in the Grand Salons C-D-E, Marriott Rivercenter. All conference attendees and registered guests are encouraged to attend.

During the meeting we will discuss the 2019 conference and future IEEE Nuclear and Space Radiation Effects Conferences. There will also be an election for the Junior Member-at-Large on the Radiation Effects Steering Group. Nominations will be taken from the floor. All IEEE NPSS members present are eligible to vote. Refreshments will be provided.

2018 OUTSTANDING CONFERENCE PAPER AWARD

Optimizing Optical Parameters to Facilitate Correlation of Laser- and Heavy-Ion-Induced Single-Event Transients in SiGe HBTs

A. Ildefonso, Z. E. Fleetwood, G. N. Tzintzarov, J. M. Hales, D. Nergui, M. Frounchi, A. Khachatrian, S. P. Buchner, D. McMorro, J. H. Warner, J. Harms, A. Erickson, K. Voss, V. Ferlet-Cavrois, and J. D. Cressler

2018 OUTSTANDING CONFERENCE MERITORIOUS PAPER AWARD

Directional Dependence of Co-60 Irradiation on the Total Dose Response of Flash Memories

M. J. Gadlage, D. I. Bruce, J. D. Ingalls, D. P. Bossev, M. McKinney and M. J. Kay

Awards

2018 OUTSTANDING STUDENT PAPER AWARD

Optimizing Optical Parameters to Facilitate Correlation of Laser- and Heavy-Ion-Induced Single-Event Transients in SiGe HBTs

A. Ildefonso, Z. E. Fleetwood, G. N. Tzintzarov, J. M. Hales, D. Nergui, M. Frounchi, A. Khachatryan, S. P. Buchner, D. McMorrow, J. H. Warner, J. Harms, A. Erickson, K. Voss, V. Ferlet-Cavrois, and J. D. Cressler

2018 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

NASA Goddard Space Flight Center's Compendium of Recent Single Event Effects Results

M. V. O'Bryan, E. P. Wilcox, C. M. Szabo, M. D. Berg, K. A. LaBel, M. J. Campola, M. C. Casey, J.-M. Lauenstein, J. A. Pellish, D. Chen, and E. J. Wyrwas

2018 RADIATION EFFECTS AWARD

Dr. Rocky Koga, The Aerospace Corporation, received the 2018 IEEE/NPSS Radiation Effects Award for sustained contributions to the field of single-event testing for microelectronics.

2019 RADIATION EFFECTS AWARDS

The winners of the 2019 Radiation Effects and Radiation Effects Early Achievement Awards will be announced Tuesday morning, July 9. 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.

Nominations are currently being accepted for the 2020 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 2020 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 2020 IEEE NSREC, Santa Fe, New Mexico in July 2020. Nomination forms are available electronically in PDF Format or in Microsoft Word format at <http://ieee-npss.org/technical-committees/radiation-effects/>. Forms should be sent to Julien Mekki, Member-at-Large, CNES, for the Radiation Effects Steering Group. Julien can be reached at Julien.mekki@cnes.fr.

Conference Information

CONFERENCE LOCATION

The river that fostered the creation of San Antonio was first visited by Spanish explorers on the feast day of St. Anthony of Padua in 1691 and named appropriately "San Antonio". Twenty-seven years later, in 1718, a Spanish expedition of missionaries and explorers established the Presidio of Bejar at San Pedro Springs and the mission San Antonio de Valero, later known as the Alamo, "about three-fourths of a league down the creek from the presidio." San Antonio de Valero was the first of five missions established over the next 13 years. This site along the San Antonio River was a stopping place in the Texas wilderness between the Rio Grande and the missions of East Texas. The mission and village thrived and grew to become the 7th most-inhabited city in the U.S. Fortunately, the charm of this historical city was not lost over time!



Photo Courtesy of Marriott

The Alamo still stands as the most famous historical landmark of Texas. It's located only a few short blocks from the Riverwalk, the most famous entertainment zone. Just across the Riverwalk is El Mercado Market Square, the largest Mexican cultural market in the country. NSREC's host hotel for the week is the beautiful San Antonio Marriott Rivercenter Hotel, located in the heart of it all!

BREAKFASTS, LUNCH AND BREAKS

The 2019 IEEE NSREC will provide breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. For those attending the Short Course on Monday, a lunch will be provided. These meals and refreshments are for **registered conference attendees only**. Please see the schedule for times and locations.

BUSINESS CENTER

The Marriott has contracted the UPS Store to operate a full-service business center that can handle faxing, photocopying, computer printer access, laminating, graphic design, equipment rental and shipping/ receiving. Located on the third floor, near the meeting rooms, they are open Monday through Thursday from 6:30am-7:30pm, Friday from 6:30am-6:00pm, and Saturday/Sunday from 7:30am-4:00pm. Costs associated with the UPS Store may be paid by credit card or cash. **Tel: 210-554-6208 E-mail: store6130@theupsstore.com**

ROOMS FOR SIDE MEETINGS

Limited meeting rooms are available for use by any registered conference attendee at the 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 Registration Desk 2 in the hotel.

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.

Conference Information

CHILD CARE REIMBURSEMENT

The 2019 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 2019. 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 the conference finance chair within two weeks of the end of the conference (July 26, 2019). 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, 2019. Applicants will be notified whether they qualify for these funds within two weeks after the deadline. Due to limited funding, it is likely that not all qualified applicants will be eligible for reimbursement. The application form is available on the website for the 2019 NSREC.

<https://ieee-npss.org/awards/conference-awards/>

Registration and Travel

CONFERENCE REGISTRATION

NSREC encourages Pre-Registration and offers a lower registration rate ("Early Registration") if the payment is received by no later than Friday, June 07. After that date, the "Late Registration" rates will apply.

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

Registrations can be submitted by using the link at the NSREC website:

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 Friday, June 28, 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

ON-SITE REGISTRATION LOCATION

All conference registration will take place on Level Three of the Marriott Rivercenter in Registration Desks 1 and 2.

If you have *already registered*, go to "**Pre-Registration**" at Registration Desk 1.

If you have *not yet registered*, go to "**On-Site Registration**" at Registration Desk 2.

ON-SITE REGISTRATION HOURS

Sunday, July 7	5:00 PM – 8:00 PM
Monday, July 8	7:30 AM – 5:00 PM
Tuesday, July 9	7:30 AM – 5:00 PM
Wednesday, July 10	7:30 AM – 3:00 PM
Thursday, July 11	7:30 AM – 3:00 PM
Friday, July 12	7:30 AM – 10:00 AM

CONFERENCE CANCELLATION POLICY

A \$50 processing fee will be withheld from all conference refunds. Due to advance financial commitments, refunds of registration fees requested after June 7, 2019, 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

HOST HOTEL INFORMATION

MARRIOTT RIVERCENTER

101 BOWIE STREET

SAN ANTONIO, TX 78205

TEL: 210-223-1000

The host hotel for the 2019 IEEE NSREC is the 4-star **San Antonio Marriott Rivercenter Hotel**, conveniently located in the heart of downtown San Antonio and adjacent to the famous Riverwalk. This 38-story tower is attached to the Rivercenter Shopping Mall, which includes over 100 shops, restaurants, cafes and theaters. Venture just a few steps further and you're amidst the famous Riverwalk where you're surrounded by even more shops, restaurants, historic sites, galleries, museums, etc.– all along a meandering river. There certainly will be no lack of cultural and entertaining activities within a short, and very scenic, walk!

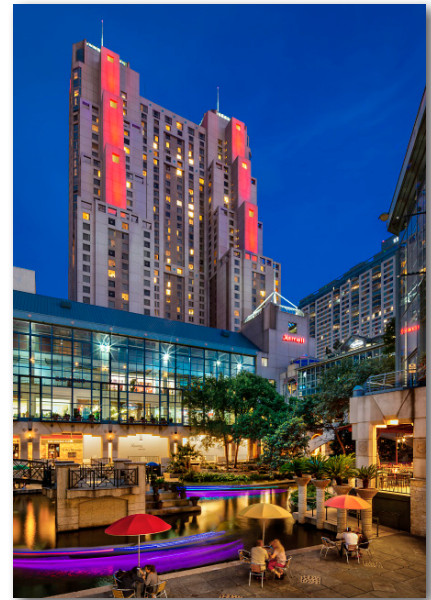


Photo Courtesy of Marriott



Photos Courtesy of Marriott

Marriott hotel amenities include one restaurant, one cocktail lounge, 24-hour health club (complimentary to hotel guests), indoor/outdoor pool, sauna, concierge, business center, wireless internet (public areas), lobby ATM, parking garage, and Starbucks. The 1001 guest rooms are comfortably furnished in typical Marriott contemporary design, with a Southwest flair. All rooms are non-smoking and feature large windows with dramatic views, individual climate control, flat-screen TV with video-on-demand & cable, wireless internet (free for conference attendees), work desk, coffee maker, mini-frig, hairdryer, iron & ironing board, 2-line phones with voice mail, one king or two double plush beds, mirrored closets with a safe, and room service.

Guest room rates for a standard king or double-double are as follows:

NEGOTIATED GROUP RATE:
\$169.00 single/double per night

GOVERNMENT PER DIEM:
\$126.00 single/double* per night

*To be eligible for the government rate, guests must provide current government or military ID. Contractors who request the government per diem must have a letter specifying that they are traveling on a government contract and they must have an employee ID for that company.

There is no additional charge for children 18 years of age and under when sharing a room with an adult and utilizing existing beds. A charge of \$20.00 + tax per night will be added for each third and fourth adult in the room (19 years of age and older.) Room taxes of 16.75% + 1.25% as a tourism public improvement fund will be added to all rates listed above.

Based on availability, the conference room rates will be offered 3 days before and 3 days after the conference.

Registration and Travel

HOTEL RESERVATIONS

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

Group block:

<https://book.passkey.com/gt/217312428?gtid=cecb5075ad2bee19ee67a761cb81ac4b>

Government block:

<https://book.passkey.com/gt/217319374?gtid=ea15a394bbb2a5d37a9d046f64f3555f>

Enter your arrival and departure dates and then follow the prompts.

Reservations can also be made by calling Marriott Reservations toll-free at 800-648-4462 within the U.S. and Canada. To get the special rates, advise the agent of the following group name: "IEEE NSREC". Both the group rate and U.S. government rate will be listed under this name.

All rooms require a credit card to guarantee the reservation. The cut-off for IEEE NSREC reservations is at 11:00 PM Central Daylight Time (CST) on **June 07, 2019**. Once the room block has been filled OR after the cut-off date (whichever comes first!), guest rooms will be confirmed on a space or rate available basis. 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.

Any cancellation must be made by no later than 6:00pm on the day prior to your scheduled arrival. If the cancellation is made by that time, then no penalty will be assessed.

AIRPORT AND TRANSPORTATION INFORMATION

San Antonio International Airport (code: SAT) Is located about 8 miles North of the Marriott Rivercenter. The route is mostly highway with moderate traffic at times other than "rush hour". Taxis to the Marriott are based on time and distance and will normally cost between \$25.00 - \$30.00 one way.

Airport Shuttle:

There is no "scheduled" shuttle service from the San Antonio International Airport directly to the Marriott, but there are other options.

Super Shuttle offers "shared transfer service" and "non-stop ride service" from the airport to the Marriott. The per person rate to downtown hotels is \$15 one way and \$28 roundtrip for shared service in which there may be multiple stops between the airport and the Marriott. The rate is much higher for "guaranteed non-stop" service. Ticket counters are located in the baggage claim area of both Terminal A & B and are open from 9:00am – 1:00am, with an "after hours" number available, if needed. Advance reservations are suggested.

Super Shuttle airport hours: operating 24/7

Tollfree Reservations: 1-800-258-3826

Website: www.supershuttle.com/locations/sanantonio-sat/

Registration and Travel

Car Rental:

A car is probably not necessary but . . . there are many places to explore outside the city so it makes sense to consider your total travel plans and include the cost of car rental and parking versus the cost of airport transfers and having to use public transportation. All major car rental companies are located at the San Antonio International Airport but additionally, Hertz has a car rental station at the Marriott Rivercenter. This is particularly helpful if you need a vehicle for only a portion of the week.

PARKING AND DRIVING DIRECTIONS

If you make your Marriott room reservation within the NSREC room block, then the hotel contract allows for a 50% discount off the daily valet and self-parking rates in effect at the time of your stay. Currently, the Marriott's daily valet parking is at \$43 per night with in/out privileges and the self-parking rate is \$37 per day with in/out privileges. You must register your car at the front desk during check-in in order to get the discount.

San Antonio International Airport to Marriott Rivercenter: If you choose to rent a car and drive from the airport, the following are the driving directions.

- Exiting the airport, head West on Airport Boulevard
- Slight left at McAllister Freeway
- Continue onto Timm Street
- Use the ramp on the left onto US 281 South for approximately 5.9 miles.
- Take Exit 141A (Commerce Street) and turn right at the light, towards downtown.
- Go about 1 block; hotel is on the right at the corner of Bowie and Commerce.

GETTING AROUND TOWN

Public transportation in San Antonio is excellent and is the recommended mode of transport...aside from walking.

SAN ANTONIO PUBLIC TRANSPORTATION

VIA Metropolitan Transit (VIA) operates bus routes throughout the city, along with a small streetcar service downtown. The Marriott Rivercenter is near multiple bus stops and from those locations, you can get almost anywhere in the city!! User-friendly ticket kiosks and the VIAgomobile app provide route maps, rates and tickets.

<http://www.viainfo.net>

Registration and Travel

GO RIO SAN ANTONIO CRUISES AND WATER TAXIS

Colorful barges ride the river through downtown with drivers who narrate the sites-to-be-seen on their 35-minute tour. Tickets can be purchased online or at their docks. Additionally, small versions of these barges, water taxis, are available for simply transiting from place to place, as long as those places are on the water. Look for the “GO River Shuttle” signs along the Riverwalk and along Museum Reach. Website: <https://www.goriocruiises.com/>

CITY SIGHTSEEING DOUBLE-DECKER BUSES

This option allows you to “jump-off” at any stop and then “jump back on” to continue the route of the city. You can reach almost all major San Antonio sites and you’ll do it at your leisure. Tickets can be purchased in advance or you can pay on board. Website: <https://www.citysightseeingsanantonio.com/>

WALKING

Many restaurants, shopping centers, and attractions are within walking distance of the Marriott. After all, you’ll be in the heart of the famous Riverwalk! This is truly an easily walkable city with something new to discover at every turn.

Industrial Exhibits



Gregg Panning
Industrial Exhibits Chair
The Aerospace Corporation

The **2019 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 **2019 NSREC Industrial Exhibits** will be in the Grand Salons G-H-I-J-K-L-M of the Marriott Rivercenter 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:

Gregg Panning
The Aerospace Corporation

Phone: 1-571-524-9663
Email: gregg.s.panning@aero.org

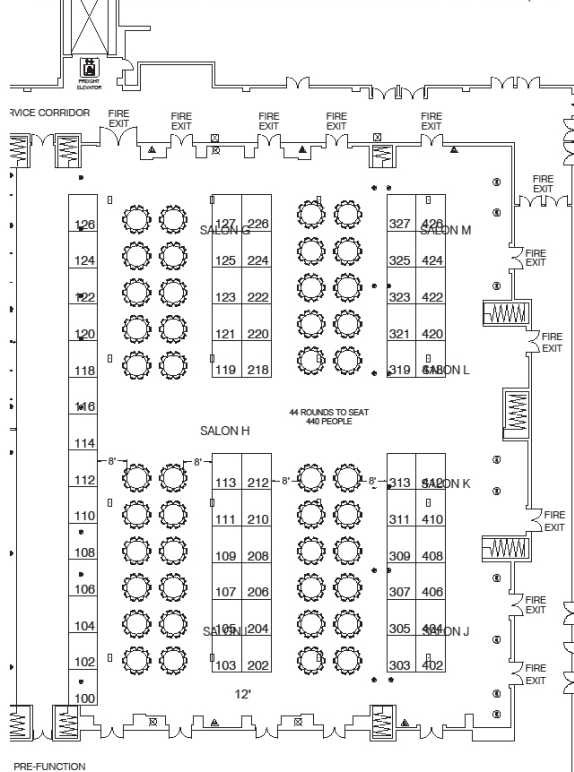
Or visit the 2019 NSREC Industrial Exhibits web site:

<http://www.nsrec.com/industrial-exhibits.html>

NUCLEAR & SPACE RADIATION EFFECTS CONFERENCE

JULY 8-12, 2019

SAN ANTONIO MARRIOTT RIVERCENTER - SALON G-M - SAN ANTONIO, TX



Industrial Exhibits

Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2019 NSREC.

NSREC INDUSTRIAL EXHIBITS

MARRIOTT RIVERCENTER

GRAND SALONS G-H-I-J-K-L-M

EXHIBIT HALL HOURS

TUESDAY, JULY 9

7:00 AM – 5:30 PM

10:55-11:25 AM MORNING BREAK

3:10-3:40 PM AFTERNOON BREAK

5:30 PM – 7:00 PM

RECEPTION

WEDNESDAY, JULY 10

7:00 AM – 2:00 PM

10:25-10:55 AM MORNING BREAK

12:30-2:00 PM LUNCH

1:30 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	206
Advantest	www.cts-advantest.com	325
Alpha Data	www.alpha-data.com	103
Alphacore, Inc.	www.alphacoreinc.com	406
Analog Devices	www.analog.com	226
Apogee Semiconductor	www.apogeesemi.com	418
BAE Systems	www.baesystems.com	218
Boeing Research & Technology	www.boeing.com	321
Cobham Semiconductor Solutions	www.Cobham.com/HiRel	119-121
Crane Electronics, Inc.	www.craneae.com	408
Crocker Nuclear Lab	http://crocker.ucdavis.edu	404
Cypress Semiconductor / DPACI	www.cypress.com & www.dpaci.com	107
Data Device Corporation (DDC)	www.ddc-web.com	319
EMPC	www.empc.com	220
FASTRAD®	www.fastrad.net	123
Foss Therapy Services	www.fosstherapyservices.net	426
Freebird Semiconductor Corporation	www.freebirdsemi.com	222
Glenair, Inc.	www.glenair.com	210
Honeywell	www.honeywellmicroelectronics.com	208
Intersil Space Products	www.renesas.com	114-116
IR HiRel Products, An Infineon Technologies Company	www.infineon.com/IRHIREL	118
iXblue	www.photonics.ixblue.com	224
J.L. Shepherd & Associates	www.jlshepherd.com/	309
Lawrence Berkeley National Laboratory	http://cyclotron.lbl.gov	327
Los Alamos National Laboratory	www.lanl.gov	422
Microchip Technology	www.microchip.com	102
Micropac Industries, Inc.	www.micropac.com	110
Micross	www.micross.com	402
MIT Lincoln Laboratory	www.ll.mit.edu	323
NASA NEPP	http://nepp.nasa.gov/	212
National Reconnaissance Office	https://acq.westfields.net	112
Northrop Grumman Corporation	http://www.northropgrumman.com	122
ON Semiconductor	www.onsemi.com	313
Phoenix, LLC	www.phoenixwi.com	108
Pulscan	www.pulscan.com	120
Radiation Test Solutions, Inc.	www.radiationtestsolutions.com	105
Robust Chip	www.robustchip.com	420
Sandia National Laboratories	www.sandia.gov	303
Silvaco, Inc.	www.silvaco.com	109
SkyWater Technology Foundry	www.skywatertechnology.com	412
Southwest Research Institute	www.spaceavionics.swri.org	125-127
STMicroelectronics, Inc.	www.st.com	410
Texas A&M Cyclotron Institute	http://cyclotron.tamu.edu/ref	311
Texas Instruments	www.ti.com	202-204
University of Washington Medical Cyclotron Facility	https://radiationoncology.uw.edu/ research/cyclotron	307
Vanderbilt University / ISDE	www.isde.vanderbilt.edu	424
VORAGO Technologies	www.voragotech.com	104
VPT, Inc.	www.vptpower.com	111-113
Xilinx	www.xilinx.com	305

2019 IEEE NSREC Technical Sessions and Short Course Registration Form



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 _____

* For IEEE member or student 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 11

☐ I plan to attend the Women in Engineering (WIE) Lunch on Thursday, July 11

REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 7, 2019

	Early	Late	
IEEE Member *			
Short Course	\$310	\$375	\$ _____
Technical Sessions	\$590	\$700	\$ _____

Non-IEEE Member			
Short Course	\$390	\$470	\$ _____
Technical Sessions	\$750	\$890	\$ _____

IEEE Student (or Life Member) *			
Short Course	\$145	\$375	\$ _____
Technical Sessions	\$170	\$700	\$ _____

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 _____

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

2019 IEEE NSREC Technical Sessions and Short Course Registration Form



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 registered attendees.
- 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 these purposes and **NO** if you do not want your contact data to be used in any way.

☐ **YES** ☐ **NO**

Event Conduct and Safety:

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**

CANCELLATIONS

A \$50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of conference registration fees requested after June 7, 2019, 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 7, 2019.

Mail or Fax this form and your remittance to:

IEEE NSREC REGISTRATION

P.O. Box 398

Castle Rock, CO 80104

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

2019 IEEE NSREC Activities Registration Form



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 _____

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 15, 2019.

Mail or Fax this form and your remittance to:

**IEEE NSREC REGISTRATION
P.O. Box 398
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 7, 2019. We strongly encourage early registration; the number of tickets available for each event is limited. Children must be accompanied by an adult during all tours and social events.

	Early	Late	Number Attending	Total Cost
Conference Social – Buckhorn and Texas Ranger Museum, Wednesday, July 10				
Adult (21 yrs +)	\$50.00	\$65.00	_____	\$_____
Teen (13-20 yrs)	\$35.00	\$45.00	_____	\$_____
Child (6-12 yrs)	\$25.00	\$35.00	_____	\$_____
Infant (0-5 yrs)	\$0.00	\$0.00	_____	\$_____

Highlights of San Antonio Tuesday, July 9				
Adult (15 yrs +)	\$35.00	\$40.00	_____	\$_____
Child (4-14 yrs)	\$23.00	\$28.00	_____	\$_____
Infant (0-3 yrs)	\$0.00	\$0.00	_____	\$_____

San Antonio Missions Thursday, July 11				
Adult (15 yrs +)	\$32.00	\$37.00	_____	\$_____
Child (4-14 yrs)	\$15.00	\$20.00	_____	\$_____
Infant (0-3 yrs)	\$0.00	\$0.00	_____	\$_____

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 _____

Social Program



"Welcome to NSREC 2019, San Antonio, and the Marriott Rivercenter. I am excited for you to attend NSREC in downtown San Antonio. The Marriott Rivercenter is a great venue for the conference with 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."

Brian Sierawski
Vanderbilt University

Few destinations provide a sense of place like San Antonio. Here, the bell towers of Spanish colonial missions have greeted mornings for almost 300 years. Mexican, European and Western cultures blend into a unique personality.

San Antonio has been a part of colonial Spain, the Republic of Mexico, the Republic of Texas, and since 1845, the United States. Relics and tales from this iconic past linger along the city streets. Originally colonized by Spain, San Antonio has five beautifully preserved Spanish colonial missions including The Alamo, the location of a famed battle for Texas independence. La Villita Historic Arts Village, a small village that housed Spanish soldiers stationed at The Alamo, is full of life and commerce. Commerce also thrives a few blocks away at Market Square. Known as the largest Mexican market north of the Rio Grande, Market Square is filled with local and imported pieces of art, pottery, jewelry and textiles.



*The Torch of Friendship symbolizing the relationship between the U.S. and Mexico
(Photo Courtesy of visitsanantonio.com, Bob Howen)*

Little known about the regions in and around San Antonio is that many German settlers called this area home. At one point, street signs were written in three languages: English, German and Spanish. German influence can be seen in the lavish homes of the historic King William District; as well as many restaurants and delis that offer visitors traditional German fare. The Hill Country surrounding San Antonio is adorned with small German towns evident through their names, Fredericksburg, New Braunfels, Boerne... In these towns an old version of the German language still lives, untouched by the hands of time that has evolved the language of Germany itself.

Much of the city's unforgettable landscape has grown along the banks of the River Walk where stone paths run aside the San Antonio River. Here you will find miles of meandering paths along the banks of the San Antonio River connecting a Texas-sized sampling of hotels, restaurants, shops, historic landmarks, museums and more. Visitors and locals dine aboard river cruisers and the sounds of mariachis echo from the stone bridges above. This is the river that originally inspired the settlement of San Antonio, and it still flourishes today as the city's center. The 15-mile River Walk also links Spanish Colonial Missions (a World Heritage Site, along with the Alamo), museums, public art and the Pearl, a former brewery reborn into an eclectic mix of shops, restaurants and entertainment.

Famed for Tex-Mex, San Antonio is gaining attention for Tex-Next as the nation's next big culinary destination. From notable restaurants to the Culinary Institute of America, there's something to satiate every palate. Plus, over 50 golf courses and theme parks like SeaWorld San Antonio and Six Flags Fiesta Texas make the city a wonderful place for families.

The conference committee has designed a social program that will provide you with the rich history of San Antonio. The Highlights of San Antonio tour on Tuesday features a guided riverboat tour with excursions to the Pearl District and Witte Museum of Nature, Science, and Culture. The Missions tour on Thursday will

Social Program

explore the physical remains of complexes built in the early eighteenth century illustrating the Spanish Crown's efforts to colonize, evangelize and defend the northern frontier of New Spain. Our social event on Wednesday will include a Tex-Mex buffet and admission to the Buckhorn and Texas Ranger Museums featuring hundreds of authentic Texas Ranger artifacts.



San Antonio River Walk

(Photo Courtesy of visitsanantonio.com, Stuart Dee)

San Antonio weather in early July is warm, with the average high during the NSREC week likely to reach 94°F (34°C) during the day, and the average nighttime low dropping to 75°F (24°C). We can expect very little rain, humidity peaks in the early morning and then drops to 50% by mid-afternoon. Dress along the River Walk is mostly casual and you will want shorts and light shirts for excursions. You may want a light jacket when shopping in businesses with strong A/C systems. There are a lot of enjoyable attractions along the river, and you will want to do a lot of walking. Some of these areas include steps and bridges so include comfortable shoes.

**SUNDAY, JULY 7
6:00 PM TO 9:00 PM**

**REGISTRATION
WELCOME RECEPTION**

Join your colleagues for a reception and light snacks in Salon I. 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 9
9:25 AM TO 3:45 PM**

**HIGHLIGHTS OF SAN
ANTONIO TOUR**

On Tuesday morning you will meet the tour coordinator and depart from the Lobby Level of the Marriott Rivercenter at 9:25 AM to experience the highlights of San Antonio.

Our tour will begin with a narrated walk-about inside the walls of **The Alamo**. Franciscan missionaries established this site as Mission San Antonio de Valero in 1718. This Spanish mission complex was the first of the San Antonio missions



Alamo Front Lawn (Photo Courtesy of visitsanantonio.com)

founded to convert the local American Indians to Christianity. The mission eventually became a community of Spanish, Mexican, and American Indian Catholics. After it was secularized at the end of the 18th century, and during Mexican struggle for independence from Spain, the building fell into disuse. During the Texas Revolution, a small garrison of Texan soldiers defended The Alamo against the Mexican army, and their defeat and deaths became a rallying cry for Texas independence. Today the Alamo, a National Historic Landmark, is located in the heart of downtown San Antonio and remains an important part of Texas history.

Social Program



*Pearl District
(Photo Courtesy of
visitsanantonio.com,
Nick Simonite)*

As we depart from the Alamo, a private narrated riverboat will float to the **Pearl District** for lunch on your own and shopping. Located just north of downtown San Antonio, Pearl provides a unique experience as a top culinary and cultural destination. The mixed-use space features retail, dining, picturesque green spaces, award-winning Hotel Emma, and the third campus of The Culinary Institute of America. As a former brewery operating from 1883 to 2001, Pearl reflects a vivid past while embracing the future. A fan favorite, Pearl is bursting with food and drink options, boutique shopping, festive seasonal events, and loads of local flavor.



*Pearl District
(Photo Courtesy of visitsanantonio.com, Nick Simonite)*

After lunch, you will take a quick bus ride to the **Witte Museum**, San Antonio's premiere museum of South Texas history, culture and natural science. Located on the banks of the San Antonio River, the Witte offers permanent exhibits that include dinosaur skeletons, cave drawings, wildlife dioramas and several historic homes. Changing galleries include Texas artists, textiles and showcase exhibits. A recent \$100 million renovation to the Smithsonian-affiliated museum include major expansions to popular attractions and collections as well as completely new labs, exhibits and galleries.



Witte Museum (Photo Courtesy of Witte Museum)

**TUESDAY, JULY 9
5:30 PM TO 7:00 PM**

SALON I

**INDUSTRIAL EXHIBITS
RECEPTION**

Join us for the 2019 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to Salon I to visit the booths, enjoy some refreshments and participate in a raffle. *All attendees and registered guest must show their badges in order to enter the NSREC Industrial Exhibits.*



Social Program

**WEDNESDAY, JULY 10
6:00 PM TO 10:00 PM**

CONFERENCE SOCIAL

BUCKHORN/TEXAS RANGERS MUSEUM

BUSSES START AT 5:30 PM



*Buckhorn Museum
(Photo Courtesy of
visitsanantonio.com)*

Ingrained in the history and identity of Texas are the great cattle drives which began in the 1860's. Cowboys and vaqueros drove longhorn along a trail from San Antonio, Texas to Abilene, Kansas. In 1881, Albert Friedrich decided to open up a saloon on the ol' dusty trail. After finding that folks didn't have much money, he began accepting horns and antlers in exchange for a drink. His collection helped keep the business open during Prohibition and has since become a top attraction. It is where Teddy Roosevelt recruited Rough Riders and Pancho Villa is rumored to have planned the Mexican Revolution. Many of the original furnishings still grace today's Buckhorn Saloon, including the back-bar which was hand-crafted of marble and cherry wood.

The attached Texas Ranger Museum features hundreds of authentic Texas Ranger artifacts including automatic handguns, shotguns, badges and more. The museum also features a recreation of San Antonio at the turn of the century in Ranger Town. The town includes a replica Buckhorn Saloon, a jail cell, blacksmith and a replica of the 1934 Ford V8 Deluxe—the famous Bonnie & Clyde getaway car.

Join your colleagues and friends for a Tex-Mex buffet, open bar, and entertainment at the Buckhorn. Wear casual clothing. Cocktails begin at 6:00 PM and dinner from 6:30 – 8:00 PM. While you are catching up with old friends and meeting new ones, explore the museums and experience the old west. Tickets are not included in the conference registration so be sure to purchase them with your registration.

The Buckhorn is a short, 10 minute walk at street or river level. For those who prefer not to walk, a shuttle will be available on the Lobby Level beginning at 5:30 PM to transport attendees between the Marriott Rivercenter and Buckhorn.



*Buckhorn Museum Ranger Town
(Photo Courtesy of visitsanantonio.com)*



*Buckhorn Museum (Photo Courtesy of
visitsanantonio.com)*

Social Program

THURSDAY, JULY 11
7:00 AM – 8:30 AM

CONFERENCE ROOMS
17 & 18

IEEE YOUNG
PROFESSIONALS
BREAKFAST



A special breakfast will be held in the Conference Rooms 17 & 18 for IEEE member attendees who are Young Professionals (<http://yp.ieee.org/>, <https://www.facebook.com/ieeeyyp>). 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 Dr. Heather Quinn of Los Alamos National Laboratory, who will be presenting an entertaining talk entitled *"Life is long, so wear your seat belt: lessons in career and life resilience."*



Heather Quinn received a B.A. degree in mathematics and physics from Knox College in 1992, and M.F.A. in poetry from Emerson College, and M.S. and Ph.D. in electrical engineering from Northeastern in 2000 and 2004, respectively. Before graduating with her Ph.D., she worked her way through both of her master's degrees and her Ph.D. while working in investment banking, a dot com disaster, a public health firm that changed her life, and an FDA-approved conveyor belt factory. She has worked at Los Alamos National Laboratory since 2004, where she was a post-doctoral fellow until 2006 and a member of the technical staff since then. Her research has focused on software/hardware co-design issues with integrating FPGAs into traditional computation systems, fault-tolerant space-based FPGA computation and radiation testing of next-generation electronics. She has authored or co-authored over 70 book chapters, journal papers and conference papers. She has authored works that have received awards at the conferences Autotestcon 2008, NSREC 2012, and NSREC 2013. She was local chair for NSREC 2015 and technical program chair for NSREC 2017. Dr. Quinn is an associate editor of the IEEE Transactions on Nuclear Science. She is currently the Section Chair for the Los Alamos and Northern New Mexico IEEE chapter. She lives in Los Alamos, NM with her spouse, Zack Baker, and her previously owned cat, Chairman Meow. Her greatest accomplishment so far is remaining married while completing 30 days of radiation testing per year.

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 Anthony Sanders, [**anthony.b.sanders@nasa.gov**](mailto:anthony.b.sanders@nasa.gov).

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

Social Program

**THURSDAY, JULY 11
9:25 AM TO 3:00 PM**

MISSIONS TOUR

On Thursday morning you will meet the tour coordinator and depart from the Lobby Level of the Marriott Rivercenter at 9:25 AM to visit the Missions National Historical Park. A bus will provide transportation between sites.

Along with the Alamo, the park was named the first World Heritage Site in Texas by the United Nations Organization for Education, Science and Culture (UNESCO), and includes the city's four southernmost Spanish colonial missions – Concepción, San José, San Juan and Espada. In the 18th century, Spanish priests established these five Catholic missions along the San Antonio River to serve as the center of an ethnically

diverse society.

Today, the missions – walled compounds encompassing a church and buildings where the priests and local Native Americans lived – represent the largest concentration of Spanish colonial missions in North America.



*Mission Concepción
(Photo Courtesy of visitsanantonio.com, Bob Howen)*



*San José Rose Window
(Photo Courtesy of visitsanantonio.com)*

Our first stop will be known as the “Queen of the Missions”. Established in 1720, **San José y San Miguel de Aguayo** is the largest mission in San Antonio. Spanish designers built the mission using Texas limestone and brightly colored stucco. At its height, it provided sanctuary and a social and cultural community for more than 300 Indians. In 2011, it underwent a \$2.2 million renovation to refinish interior domes, walls and the altar backdrop. When visiting the church, be sure to look for flying buttresses, carvings, quatrefoil patterns, polychromatic plaster and the famed “Rose Window,” a superb example of Spanish Colonial ornamentation.

Dedicated in 1755, the church at **Mission Nuestra Señora de la Purísima Concepción de Acuña** remains true to its original design, look and feel. In fact, the church stands as the oldest unrestored stone church in the United States. Exterior paintings have faded, but if you peek inside, you can still see original frescos in some of the church rooms.

The bus will drop you off at **El Mercado** for lunch on your own. The “El Mercado” and the “Farmer’s Market Plaza” boast more than 100 locally owned shops and stalls. Enjoy the sights and flavors of old Mexico and find authentic Talavera pottery, exotic curios and handcrafted works of art.



*Pinatas in Market Square
(Photo Courtesy of visitsanantonio.com)*

Social Program

Our last stop will bring us to the southernmost mission in the park, **Mission Espada**. Established in 1731, Espada boasts the best-preserved segment of the area's original irrigation system that was used to bring water to the fields. In 1826, a fire destroyed most of the mission buildings, with only the chapel, granary, and two of the compound walls remaining. Today, part of the original irrigation system still operates: the Espada aqueduct and dam. Take note of the unusual door and stone archway – they make for great photos!

**THURSDAY, JULY 11
12:05 PM TO 1:45 PM**

**CONFERENCE ROOMS
17 & 18**

**WOMEN IN ENGINEERING
LUNCH**



A special lunch will be held in Conference Rooms 17 & 18 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 *"Rising Above Every Day Challenges in Work and Life."* This lunch will also include a panel of radiation effects researchers, Melanie Berg, SPACER2, Kay Chesnut, Raytheon, Jean-Marie

Lauenstein, NASA GSFC, Jonny Pellish, NASA GSFC, and Nadia Rezzak, Microchip, answering questions and discussing topics of interest to women in science and engineering, such as

- Balancing work and life while working as a scientist or engineer,
- Meeting the challenges of being a female engineer and scientist with grace, and
- Boosting your confidence to mitigate the imposter syndrome.

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

Heather Quinn received a B.A. degree in mathematics and physics from Knox College in 1992, and M.F.A in poetry from Emerson College, and M.S. and Ph.D. in electrical engineering from Northeastern in 2000 and 2004, respectively. Before graduating with her Ph.D., she worked her way through both of her master's degrees and her Ph.D. while working in investment banking, a dot com disaster, a public health firm that changed her life, and an FDA-approved conveyor belt factory. She has worked at Los Alamos National Laboratory since 2004, where she was a post-doctoral fellow until 2006 and a member of the technical staff since then. Her research has focused on software/hardware co-design issues with integrating FPGAs into traditional computation systems, fault-tolerant space-based FPGA computation and radiation testing of next-generation electronics. She has authored or co-authored over 70 book chapters, journal papers and conference papers. She has authored works that have received awards at the conferences Autotestcon 2008, NSREC 2012, and NSREC 2013. She was local chair for NSREC 2015 and technical program chair for NSREC 2017. Dr. Quinn is an associate editor of the IEEE Transactions on Nuclear Science. She is currently the Section Chair for the Los Alamos and Northern New Mexico IEEE chapter. She lives in Los Alamos, NM with her spouse, Zack Baker, and her previously owned cat, Chairman Meow. Her greatest accomplishment so far is remaining married while completing 30 days of radiation testing per year.



Social Program

AEROBICS AND STRETCHING

Dave Bushmire, our nationally certified fitness instructor, will be inserting a thirty minute full body stretching session to his aerobics class. The class will begin with thirty minutes of low impact aerobics followed by a stretching session designed to increase your flexibility and range of motion, decrease joint pain, back pain and chance of falling, while reducing stress, depression and fatigue. You will learn a set of stretches that can be done daily to enjoy an active and happy life style. As in prior conferences, the classes will be held from 6:00 to 7:00 AM on Tuesday, Wednesday and Thursday in Conference Room 12.

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 June 22.

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



*Rio San Antonio Cruises
(Photo courtesy of visitsanantonio.com)*

SAN ANTONIO RIVER WALK

For many, San Antonio is the Paseo del Rio, an urban masterpiece better known as the **River Walk**. These cobble- and flagstone paths border the San Antonio River, as it winds through culture-rich downtown. The River Walk has multiple personalities—quiet and park-like in some stretches, while other areas are full of activity with European-style sidewalk cafes, specialty boutiques, art galleries, nightclubs and gleaming high-rise hotels. Under the Mission Reach project, the river reclaimed eight miles worth of waterways in 2013. The River Walk now links Brackenridge Park on the north end with Mission Espada to the south. **Rio San Antonio Cruises**, the river's floating transportation system, provides a novel method of sightseeing and people watching in downtown San Antonio. Groups can dine aboard open-air cruisers as they drift along the scenic waterway, while river taxis deliver visitors to restaurants, hotels, the Henry B. Gonzalez Convention Center and **The Shops at Rivercenter**—a dazzling three-level, glass shopping, dining and entertainment complex. A number of restaurants in the area provide discounts for showing your conference badge.

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

THE SAGA

The Saga is a world-class video art installation on the façade of San Fernando Cathedral, the oldest operating sanctuary in North America. It showcases a breathtaking visual journey through the history of San Antonio. Created by renowned French artist Xavier de Richemont, The Saga is his first outdoor art installation in the U.S. Ongoing free shows are held each Tuesday, Friday, Saturday & Sunday at 9:00pm, 9:30pm, 10:00pm.



The Saga at San Fernando Cathedral (Photo Courtesy visitsanantonio.com)

Local Activities

BRACKENRIDGE

Brackenridge Park, a 343-acre refuge in the heart of the city, provides a full day of family fun. Play a round of golf at Texas' most historic course. Feed ducks and picnic along the adjacent San Antonio River. Refresh with a stroll on the walking trails or catch a ride on the park's miniature train, the Brackenridge Eagle. Here you'll also

find the **San Antonio Zoo**, the third largest in the nation with a collection of more than 3,500 animals representing 750 different species from around the globe. It is also the only zoo in the country to exhibit endangered Whooping cranes.

The **Japanese Tea Garden** features a lush year-round garden and a floral display with shaded walkways, stone bridges, a 60-foot waterfall and ponds filled with Koi.



Japanese Tea Garden (Photo Courtesy of visitsanantonio.com)

MUSEUMS

The **Briscoe Western Art Museum** acts as an artistic hub for Western American culture and lifestyles. Along with the sculpture garden, the museum's historic building and location along the San Antonio river offers visitors an attractive campus for exploration. Exhibitions and events include "Women of the West" film series, a public art exhibition and sale, and a Native American portfolio.

The **McNay Art Museum** is set in a Mediterranean-style mansion and has wide-ranging collections, including post-impressionist and modern pieces, theater-centered works, medieval offerings, Native American art and more. The Jane and Arthur Stieren Center for Exhibitions designed by renowned architect Jean-Paul Viguier increased the McNay's original size by 45,000 square feet, allowing for more of their highly regarded collection to be displayed. Many visitors are finding this addition to be a work of art itself with walls of green stone reminiscent of San Antonio's deep green foliage, a theater paneled in wood derived from a single pear tree and aluminum accents inspired by logs floating down a river.

The **San Antonio Museum of Art** is housed in a castle-like building that was formerly the Lone Star Brewery. This museum is noted for its antiquities collections and the 30,000 square-foot Nelson A. Rockefeller Center for Latin American Art—the largest repository of its kind. The Lenora and Walter F. Brown Asian Art Wing offers 15,000 square feet of galleries dedicated to the museum's Asian art collection that spans nearly 6,000 years of history.



Sunfish Art installation outside San Antonio Museum of Art (Photo Courtesy of visitsanantonio.com, Al Rendon)

Local Activities

The **Institute of Texan Cultures**, located in HemisFair Park, chronicles more than 25 ethnic groups that made the Lone Star State what it is today. Their stories are told through words, photos and fascinating displays that include eclectic items such as a Native American teepee, an old-time barbershop, a frontier dentist's office, a town square band gazebo, an African-American sharecropper's house and even a working post office.

Centro de Artes is located in historic El Mercado Market Square, the largest Mexican market in the country. Centro de Artes tells the story of Latinos in America (past and present), while also showcasing exhibits related to Latino food, culture, history, and lifestyle with a focus on South Texas.

HISTORIC ART DISTRICTS

Eclectic art districts adorn city streets with legendary histories and cultural offerings. Two must sees for art lovers are **La Villita Historic Arts Village** and **Market Square**. La Villita, "the little village," was one of San Antonio's original settlements. It became a hub of Texas revolutionary activity in 1835 and 1836. Today, La Villita is a haven for artists and craftsmen selling jewelry, stained glass and other handcrafts, as well as fashions from Mexico and Guatemala. Dating to 1840, Market Square (El Mercado), the largest Mexican marketplace north of the Rio Grande, is a festive combination of Tex-Mex cuisine, music, entertainment, products ranging from pearls to piñatas, and the anchor Centro de Artes.

On the southern tip of downtown, **Southtown** is a trendy arts community flourishing with individuality. This rare neighborhood is composed of historic houses, converted warehouses, artists' lofts, shops, galleries and restaurants. Just south of downtown, the **King William Historic District** reflects San Antonio's German heritage in a gracious residential area settled in the late 1800s. These beautiful mansions are considered to comprise one of San Antonio's most treasured neighborhoods. Among them are the Steves Homestead mansion and Villa Finale which are open to the public.

Nearby **South Flores Street** includes many up-and-coming restaurants, artistic spaces and socialization opportunities. This new and trendy area also includes the Southtown Arts District, which is home to unique art galleries, creative services, museums, studios and more. Here, various art forms are displayed and performed at many of the museums in this district. This area is considered to host the majority of the city's creative culture.



La Villita (Photo courtesy of visitsanantonio.com, Richard Nowitz)

Local Activities

FAMILY ACTIVITIES

Families may want to start their exploration of the city at **The DoSeum**, where kids are encouraged to explore a miniature version of a city evocative of San Antonio with attractions like a veterinarian office, a taco truck and an H-E-B, a local grocery store. Kids of all ages will want to experience the excitement of **The Magik Children's Theatre**, a professional theater in the heart of downtown, and the nearby **Yanaguana Garden** at HemisFair Park. Another favorite is the **Tower of the Americas**, which offers a spectacular view of San Antonio from 750 feet above the ground. Just blocks away, **Louis Tussaud's Plaza Wax Museum** houses more than 225 life-like characters in four themed sections—Hollywood, Horrors, History and Religion. Next door, the world's largest **Ripley's Believe It or Not! Odditorium** is located in San Antonio's historic Alamo Plaza, right across from The Alamo and next to the famed River Walk. Proving that truth can be stranger than fiction, Ripley's is known for providing exhibits that showcase the ultimate in odd and bizarre like a two-trunked elephant, a 512-pound iron meteorite and locks of Marilyn Monroe's hair, among other oddities. The **Guinness World Records Museum** is a state-of-the-art, interactive experience that brings the world famous book to life.

GOLF

Hit the links in the Texas Hill Country at **TPC San Antonio**, part of the prestigious TPC Network of Clubs. With 36 holes of championship Golf, the **AT&T Oaks Course** is home to the PGA TOUR's Valero Texas Open while the **AT&T Canyons Course** hosted the city's Champions Tour event from 2011 to 2015. The **AT&T Oaks Course** provides golfers a traditional design, lined by Oak trees with deep, cavernous bunkers being the dominant feature. The **AT&T Canyons Course** allows golfers to experience a Hill Country layout, with dramatic elevation changes and breathtaking views of the adjoining nature preserve.

La Cantera Resort and Spa is home to the **Resort Course**, the fifteen-year PGA stop and the **Palmer Course**, designed by the legendary Arnold Palmer. Both courses wind through the Hill Country and provide stunning views and dramatic water features. **The Hill Country Golf Club**, located on the grounds of the **Hyatt Regency Hill Country Resort and Spa**, offers twenty-seven holes on two hundred acres of wide-ranging terrain.



Palmer Golf Course (Photo courtesy visitsanantonio.com)

The **Alamo City Golf Trail** offers golfers premier courses at affordable price points including: Historic Brackenridge Park, the original home to the PGA Tour in San Antonio and the first golf course inducted into the Texas Golf Hall of Fame.

Let **Olympia Hills Golf Course** take your breath away with holes that feature elevation changes of 50 feet or more. Tee off surrounded by some of the largest, most picturesque live oaks in the San Antonio area, then enjoy the natural hills and stunning green course.

Local Activities

Recognized as the “7th Most Unique Golf Course in the U.S.,” the **Quarry Golf Course** makes for a golfer’s paradise in the heart of the city. The course’s front nine plays in a links-style format and features rolling hills, native grasses and immaculate greens, while the back nine lays out in a 100-year-old quarry pit.

DAY TRIPS

There are several items within easy driving distance of San Antonio that may be of interest to guests who wish to take a road trip.

SHOPPING

San Marcos, TX is home to two outlet malls (**Tanger Factory Outlet Center and Premium outlets**) which together comprise 350 stores and an excess of 1,000,000 square feet of floor space. The malls are located on the southern edge of San Marcos which is a 45 minute drive up Interstate Highway 35 from San Antonio. There are numerous places to eat at the malls. For those who want to eat in a more picturesque environment, a stop in the New Braunfels suburb of Gruene, TX for an afternoon meal at the **Grist Mill restaurant** located in the remains of a Cotton gin overlooking the Guadalupe River may be just the thing. Closer to San Antonio are the **Shops at La Cantera**, an upscale outdoor mall in the northern suburbs of San Antonio, near Loop 1604 and I-10, which is anchored by Dillard’s, Macy’s, Neiman Marcus, and Nordstrom, and North Star Mall, which is located near 281 N and Loop 410 and is anchored by Dillard’s, JCPenney, Macy’s, and Saks Fifth Avenue. Shops also abound in the downtown area with one of the most interesting being **Garcia Art Glass** which has a small shop and glassblowing facility at 715 S. Alamo within walking distance of our hotel.

MUSEUMS AND HISTORIC SITES

In addition to the selection of museums and Historic sites in San Antonio itself, there are two or three within a 1.5 hour drive of San Antonio that may be of interest. A moderate drive up IH-10 and Hwy 87 in the small town of Fredericksburg TX, the birthplace of WWII Admiral of the Fleet Chester W. Nimitz, you will find the **National Museum of the Pacific War**, a well-rated, 6 acre site with significant displays focusing on WWII battles in the Pacific. The town of **Fredericksburg** itself provides an opportunity for lunch and browsing in a town that still shows the characteristics of its German settlers. East of Fredericksburg on Hwy 290, past a number of peach orchards and wineries, you will find the **Lyndon B. Johnson State and National Historic Park** and the **Sauer-Beckman living history farm**. The Park consists of two units, one near the Pedernales River crossing which contains the LBJ ranch and living history farm and another in the small town of Johnson City that contains LBJ’s boyhood home. The University of Texas in Austin is home to the **LBJ Presidential Library and Museum**.

SIX FLAGS AND SEA WORLD

San Antonio is the picture-perfect setting for great family vacations. Enjoy Texas-sized fun at **SeaWorld San Antonio**, one of the world’s largest marine life park, and **Six Flags Fiesta Texas**, the town built just for fun. SeaWorld San Antonio combines fun with education and appreciation for some of the ocean’s most fascinating creatures through shows, educational exhibits and rides. Explore Aquatica, a water park designed as a South Seas oasis with all the amenities of a beachside resort, including terraced pools, a giant wave pool, meandering crystal-blue rivers, sandy beaches and private cabanas. Aquatica boasts unique attractions such as up-close stingray encounters and a “weightless” family raft ride that’s a first for North America.

Local Activities

Just down the road, Six Flags Fiesta Texas is a non-stop celebration of San Antonio and South Texas. It's designed around four themed areas: The Mexican town of Los Festivales; the German village of Spassburg; the 1920's cowboy boomtown of Crackaxle Canyon; and the small Texas town of Rockville which includes a '50s-'60s seaside boardwalk. Themes are carried out by entertaining musical shows and exciting rides including water rides and massive steel roller coasters.

In addition to the water parks at SeaWorld of Texas and Six Flags Fiesta Texas, there are two other waterparks in the San Antonio area. **Splashtown San Antonio** is located on IH-35 just north of downtown San Antonio (Exit 160), while **Schlitterbahn Waterpark New Braunfels** is situated along the Landa River 30 miles north of San Antonio in the German settled town of New Braunfels. Finally, for those who like a natural float setting, the Guadalupe River between New Braunfels and the Canyon lake dam is home to a number of outfitters who can provide tubes and canoes for a river adventure underneath towering cypress and live oak trees.

UNDERGROUND ADVENTURES

The hill country of south central Texas area is underlain by a vast collection of Karst limestone formations which yield several stunning Caves. A short drive West on IH 10, south of the town of Boerne TX, is **Cascade caverns**, while closer to town, north on IH 35 outside the town of Garden Ridge TX, is the **Natural Bridge Caverns and Wildlife Ranch** which provides both above ground and below ground attractions. Close by Natural Bridge Caverns is **Bracken Cave**, the home to the largest collection of Mexican free-tailed bats in the World. Bracken Cave is private, but there are occasional evening tours to view the bat flights. You can also observe up to 50,000 Mexican free-tailed bats fly during the summer months from under the I-35 bridge where it cross the San Antonio river near Camden and Newell streets on the Museum Reach section of the Riverwalk. For more information on observing bat flights in Texas, see the Texas Parks and Wildlife web site.

Whether you stay in San Antonio or explore the Texas Hill Country around it, you are sure to have a good time.

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ANNOUNCEMENT and FIRST CALL FOR PAPERS



2020 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE Short Course and Radiation Effects Data Workshop

July 20-24, 2020

Hilton Buffalo Thunder
Santa Fe, New Mexico

www.nsrec.com

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You are cordially invited to attend the 2020 IEEE Nuclear and Space Radiation Effects Conference to be held July 20-24, 2020 at the Hilton Buffalo Thunder, in Santa Fe, New Mexico. 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 with current relevance offered on July 20, 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

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
- 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 Charging
- Predicting and Verifying Soft Error Rates (SER)

Hardness Assurance Technologies, Modeling, and Testing

- New Modeling and Testing Techniques, Guidelines, and Hardness Assurance Methodologies
- Unique Radiation Exposure Facilities or Novel Instrumentation Methods
- Dosimetry

New Developments of Interest to the Radiation Effects Community

PAPER SUMMARY DEADLINE: FEBRUARY 7, 2020

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.
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.

**Summaries must be received by
February 7, 2020**

**Detailed submission and
formatting instructions
will be available after
December 1, 2019
at www.nsrec.com**

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 2021). 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 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*.

SANTA FE, NEW MEXICO (NORTHERN NEW MEXICO)

The Hilton Buffalo Thunder is located just outside downtown Santa Fe and provides access to many beautiful and historical Northern New Mexico attractions including the High Road Trip to Taos, Bandelier National Monument, Jemez Mountains, and many other world-renowned attractions. There is a rich and inspiring history in Northern New Mexico with influences from Hispanic, Anglo, and Native American cultures that are apparent in everything from the architecture to the food to the art. Santa Fe is known as a center for arts and culture and ranks as the country's third largest art market. You will find nearly 300 art galleries and the 3rd largest State Museum system in the country featuring culture, history, and traditions of the Southwest. Treat yourself to the colorful markets and experience why Santa Fe has been considered a hub for trading for hundreds of years. With a backdrop of the Sangre de Cristo Mountains, Santa Fe is also the home of the world-class Santa Fe Opera.

Santa Fe was nationally recognized by several organizations in 2018. This comprised of recognitions as one of the top 15 cities in the US by 2018 Travel+ Leisure World's Best Awards and was one of the top 30 US cities to visit in 2018 according to Trip Advisor. Santa Fe has also earned a stellar reputation with food-lovers ranging from local New Mexican flavors to authentic world cuisines in recent years. The Santa Fe Margarita Trail Tour was recently recognized as one of the 10 Best Food and Drink Trails to Explore according to Pop Sugar.



Photo courtesy of Hotel Buffalo Thunder

For the outdoor enthusiast, Northern New Mexico provides hiking and biking year-around amongst beautiful backdrops and historical sites. The great outdoors and open sky also allow everyone to relax and enjoy activities such as golf, white-water river rafting, horseback riding, and fly-fishing. Remember, we are going to be at an elevation of 7,000 feet and likely in sunny weather.

Please join us at the Hilton Santa Fe Buffalo Thunder for NSREC 2020 and enjoy everything Northern New Mexico has to offer.

SAN ANTONIO DOWNTOWN AREA





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