2016 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

July 11 – 15, 2016

The DoubleTree Hotel
and
Oregon Convention Center

Portland, Oregon

Sponsored by:

IEEE/NPSS Radiation Effects Committee

Supported by:

Atmel

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Boeing

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Honeywell

International Rectifier HiRel Products, Inc.

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VPT Rad

IEEE

NSREC

Photo courtesy of Travel Portland

Conference Facilities

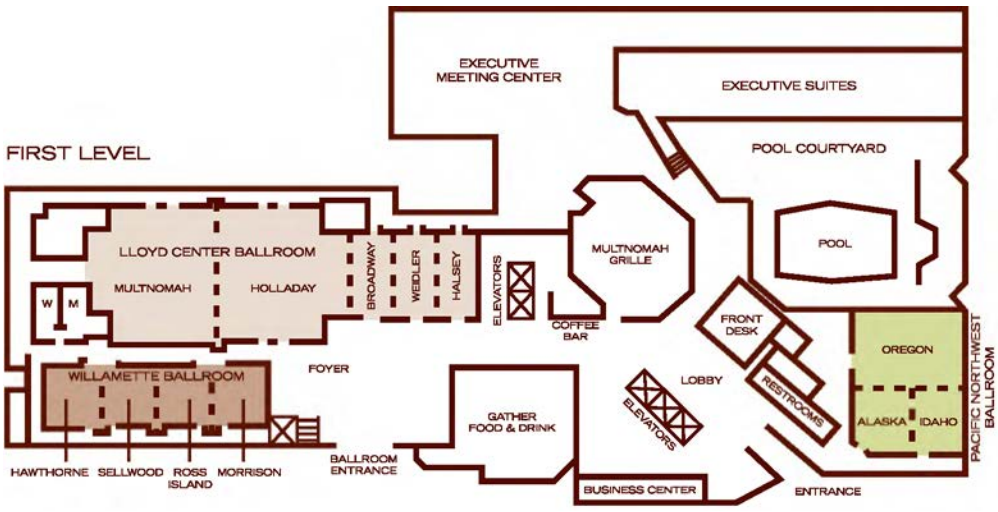
DOUBLETREE HOTEL

REGISTRATION
Ross Island/Morrison
(Sunday Only)

WELCOME RECEPTION
Multnomah/Holladay
(Sunday Only)

BREAKFASTS
Multnomah/Holladay

AEROBICS
Oregon Room



DOUBLETREE TO OREGON CONVENTION CENTER (OCC)
< 10 Minute walk or MAX train

OREGON CONVENTION CENTER (OCC)

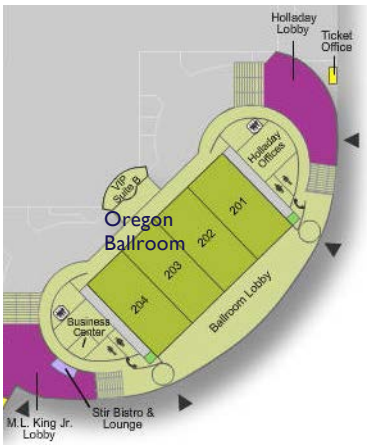
LEVEL 2 (Street Level)

PRE-REGISTRATION
Oregon Ballroom Lobby *(Monday – Tuesday)*

SHORT COURSE AND TECHNICAL SESSIONS
Oregon Ballroom 201-202

SHORT COURSE LUNCH
Oregon Ballroom 203-204

POSTERS AND DATA WORKSHOP
Oregon Ballroom 203-204



LEVEL 1 (Lower Level)

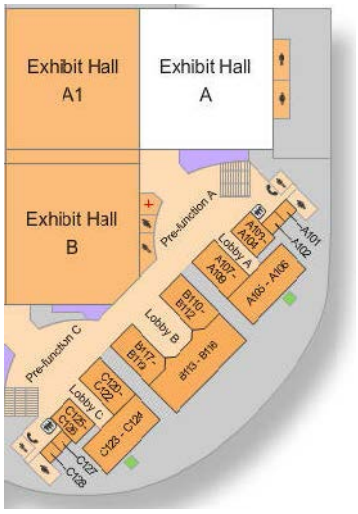
ON-SITE REGISTRATION
Room A103 *(Monday – Friday)*

INDUSTRIAL EXHIBITS AND LUNCH *(Tuesday/Wednesday)*
Exhibit Hall A

INDUSTRIAL EXHIBITS RECEPTION
Exhibit Hall A

YOUNG PROFESSIONALS BREAKFAST AND WIE LUNCH
Room A106

A/V PREVIEW
Room A104



Schedule

Time	Monday July 11	Tuesday July 12	Wednesday July 13	Thursday July 14	Friday July 15
7:00	[7:00] Continental Breakfast – DoubleTree, Multnomah/Holladay (Allow 15 minutes to walk to the OCC.)	[7:00] Continental Breakfast – DoubleTree, Multnomah/Holladay (Allow 15 minutes to walk to the OCC.)	[7:15] Continental Breakfast – DoubleTree, Multnomah/Holladay (Allow 15 minutes to walk to the OCC.) — and — [7:15] IEEE Young Professionals Breakfast – OCC, Room A106 (YP talk begins at 7:30 AM.)	[7:15] Continental Breakfast – DoubleTree, Multnomah/Holladay (Allow 15 minutes to walk to the OCC.)	[7:15] Continental Breakfast – DoubleTree, Multnomah/Holladay (Allow 15 minutes to walk to the OCC.)
7:30					
8:00	[8:00] **Short Course Introduction** Ken Rodbell OCC, Oregon Ballroom 201-202				
8:10	[8:10] **Part 1 – Device Scaling** Jerome Mitard				
8:15					
8:30		[8:30] **Conference Opening** OCC, Oregon Ballroom 201-202	[8:45] **Invited Talk – Where's the Spruce Goose?** Colonel Larry Wood OCC, Oregon Ballroom 201-202	[8:45] **Invited Talk – VLSI Technology Reliability Beyond the 'Golden Age' of Moore's Law** Jeffrey Hicks OCC, Oregon Ballroom 201-202	[8:45] **Invited Talk – Cascadia Subduction Zone - Are We Ready for the Big One?** Scott Burns OCC, Oregon Ballroom 201-202
9:00		[9:10] **Session A – Photonic Devices and Integrated Circuits**			
9:30	[9:40] Break – OCC, Oregon Ballroom 203-204				
10:00	[10:10] **Part 2 – Space Radiation Environment** Paul O'Brien	[10:15] Break – Industrial Exhibits area / OCC, Exhibit Hall A	[10:00] Break – Industrial Exhibits area / OCC, Exhibit Hall A	[10:00] Break – OCC, Oregon Ballroom 203-204	[10:00] Break – OCC, Oregon Ballroom 203-204
10:30		[10:40] **Session A –** *(continued)*	[10:25] **Session E – Hardness Assurance**	[10:25] **Session G – Single Event Effects: Mechanisms And Modeling**	[10:25] **Session I – Dosimetry**
11:00					
11:30	[11:40] Short Course Lunch – OCC, Oregon Ballroom 203-204	[11:40] Lunch in Industrial Exhibits area / OCC, Exhibit Hall A			[11:30] **Session J – Space and Terrestrial Environments**
12:00			[12:00] Lunch in Industrial Exhibits area / OCC, Exhibit Hall A	[12:00] Lunch — and — [12:00] Women in Engineering Lunch – OCC, Room A106	[12:20] End of Conference
12:30					
1:00		[1:10] **Session B – Single Event Effects: Transient Characterization**			
1:30	[1:20] **Part 3 – Environment & Devices, SER - "Modeling Neutrons & Heavy Ion SER from Planar CMOS to FinFETs"** Klas Lilja		[1:30] **Session F – Hardening by Design**	[1:30] **Session H – Single Event Effects: Devices and Integrated Circuits**	
2:00		[2:00] **Session C – Basic Mechanisms of Radiation Effects**			
2:30			[2:20] **Radiation Effects Data Workshop** OCC, Oregon Ballroom 203-204		
3:00	[2:50] Break – OCC, Oregon Ballroom 203-204			[2:50] **Poster Session** OCC, Oregon Ballroom 203-204	
3:30	[3:20] **Part 4 – Environment & Devices, SEE - "Single Event Modeling For Rad-Hard-By-Design Flows"** Jeff Kauppila	[3:20] Break – Industrial Exhibits area / OCC, Exhibit Hall A			
4:00		[3:45] **Session D – Radiation Effects in Devices and Integrated Circuits**			
4:30					
5:00	[4:50] Wrap-up [5:00] Exam (for students requesting CEU credit only)	[5:20] End of Sessions	[4:45] End of Sessions [5:15 to 10:15] Conference Social **Dining with Trees at the World Forestry Center** (Last bus leaves at 6:00 PM. Or, ride the train.)	[5:30] End of Sessions [5:30 to 7:15] Radiation Effects Committee Annual Open Meeting – OCC, Oregon Ballroom 201-202	
5:30	[5:30] End of Short Course	[5:30 to 7:00] Industrial Exhibits Reception – OCC, Exhibit Hall A			
6:00					
6:30					
7:00					

Contents

Chairman's Invitation **1**
Short Course Program **2**
Short Course **3**
Course Description 3
Part 1 – Device Scaling 4
Part 2 – Space Radiation Environment 5
Part 3 – Environment & Devices, SER - "Modeling Neutrons & Heavy Ion SER, from Planar CMOS to FinFETs" 6
Part 4 – Environment & Devices, SEE - "Single Event Modeling for Rad-Hard-By-Design Flows" 7
Technical Program **8**
Technical Information 8
Invited Speakers 8
Late-News Papers 8
Tuesday, July 12 9
Session A - Photonic Devices and Integrated Circuits 9
Session B - Single Event Effects: Transient Characterization 11
Session C - Basic Mechanisms of Radiation Effects 13
Session D - Radiation Effects in Devices and Integrated Circuits 16
Wednesday, July 13 19
Invited Talk - Where's the Spruce Goose? 19
Session E - Hardness Assurance 19
Session F - Hardening by Design 22
Radiation Effects Data Workshop 24
Thursday, July 14 34
Invited Talk - VLSI Technology Reliability Beyond the 'Golden Age' of Moore's Law 34
Session G - Single Event Effects: Mechanisms and Modeling 34
Session H - Single Event Effects: Devices and Integrated Circuits 37
Poster Session 40
Friday, July 15 41
Invited Talk - Cascadia Subduction Zone - Are We Ready for the Big One? 41
Session I - Dosimetry 41
Session J - Space and Terrestrial Environments 43
RESG NEWS **45**
Awards **48**
2015 NSREC Awards 48
2016 Radiation Effects Award 48
Conference Information **49**
Breakfasts, Lunch and Breaks 49
Business Center 49
Rooms for Side Meetings 50
Child Care Reimbursement 50
Registration and Travel **51**
Conference Registration 51
On-Site Registration Hours 51
Conference Cancellation Policy 51
Hotel Reservations and Information 52
Airport and Transportation Information 53
Parking and Driving Directions 54
Getting Around Town 54
Industrial Exhibits **55**
2016 IEEE NSREC Technical Sessions and Short Course Registration Form **57**
2016 IEEE NSREC Activities Registration Form **58**
Social Program **59**
Industrial Exhibits Reception 60
Dining with Trees at the World Forestry Center - Conference Social 61
Local Activities **65**
Weather and Clothing 70
2016 Conference Committee **71**
Official Reviewers **72**
Radiation Effects Steering Group **73**
2017 Announcement and First Call for Papers **74**

Chairman's Invitation

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 2016 Nuclear and Space Radiation Effects Conference (NSREC) committee, it is my pleasure to invite you to attend the 53rd NSREC to be held July 11 – 15, 2016.

The conference will be in Portland at the Oregon Convention Center, and the conference hotel is the Portland Doubletree Hotel. The conference begins Monday, July 11, with a one-day Short Course titled "Techniques for SEE Modeling and Mitigation". It is organized by Ken Rodbell of IBM and consists of four sections taught by leading experts in their respective fields. The first part of the course will provide an introduction to CMOS device scaling and space radiation environments. These two courses will be followed by two talks focusing on issues related to single event effects. It will provide introductory material for those new to the field, as well as advanced concepts and emerging issues for those that are more experienced.

The Technical Program is from Tuesday, July 12 to Friday, July 15. Philippe Paillet of CEA is the Technical Program Chair. He, along with his technical committee, has 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. This is an additional poster session describing radiation effects data on electronic and photonic devices and systems, and new simulation or test facilities. Finally, Philippe has invited three entertaining speakers to give general interest presentations from Wednesday to Friday.

The Industrial Exhibit, organized by Keith Avery of AFRL, 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. Attendees and guests are invited to a cocktail reception in the exhibit hall on Tuesday evening. The exhibit will conclude following a luncheon for attendees on Wednesday in the exhibit hall.

Local Arrangements Chair Steve McClure of JPL has organized an outstanding social program. The Conference Social on Wednesday evening, at the World Forestry Center, will highlight the program. Two companion tours are also scheduled. The first, on Tuesday, will be a tour of the Best of Portland, which includes a visit to the International Rose Test Garden, the oldest of its kind. The second, on Thursday, will be a visit to the Oregon Museum of Science and Industry, followed by a ride on the Portland Aerial Tram.

The NSREC 2016 conference committee, including Publicity Chair Teresa Farris (Cobham), Finance Chairs Rob Waters (NRL) and Brian Sierawski (Vanderbilt University), and Awards Chair Vincent Pouget (IES-CNRS), welcomes you to one of America's most endearing cities.

We look forward to seeing you in Portland this July!

"I would like to invite you to attend this year's conference in Portland. The conference committee has put together excellent technical and social programs. I would like to thank all the volunteers, authors, exhibitors, supporters, reviewers, and attendees for your hard work on making NSREC 2016 possible."

Robert A Reed
Vanderbilt University
NSREC 2016 General Chairman

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

Short Course Program

TECHNIQUES FOR SEE MODELING AND MITIGATION

OREGON CONVENTION CENTER
OREGON BALLROOM 201-202 – MONDAY, JULY 11

8:00 AM	**SHORT COURSE INTRODUCTION** Ken Rodbell, *IBM*
8:10 AM	**PART 1 — DEVICE SCALING** Jerome Mitard, *IMEC*
9:40 AM	**BREAK (Oregon Ballroom 203-204)**
10:10 AM	**PART 2 — SPACE RADIATION ENVIRONMENT** Paul O'Brien, *The Aerospace Corporation*
11:40 AM	**SHORT COURSE LUNCHEON** **(Oregon Ballroom 203-204)**
1:20 PM	**PART 3 — ENVIRONMENT & DEVICES, SER - "MODELING NEUTRONS & HEAVY ION SER, FROM PLANAR CMOS TO FINFETS"** Klas Lilja, *Robust Chip Inc.*
2:50 PM	**BREAK (Oregon Ballroom 203-204)**
3:20 PM	**PART 4 — ENVIRONMENT & DEVICES, SEE - "SINGLE EVENT MODELING FOR RAD-HARD-BY-DESIGN FLOWS"** Jeff Kauppila, *Vanderbilt University Institute for Space and Defense Electronics*
4:50 PM	**WRAP-UP**
5:00 PM	**EXAM (only for students requesting CEU credit)**
5:30 PM	**END OF SHORT COURSE**

Each short course attendee will receive both a CD and a thumb drive for the 2016 Short Course Notes

Short Course

COURSE DESCRIPTION

A one day Short Course "Techniques For SEE Modeling and Mitigation" will be presented at the 2016 IEEE Nuclear and Space Radiation Effects Conference (NSREC). This course will provide an introduction into the many issues involved in modeling and mitigating radiation-induced single event effects (SEE) in terrestrial and space environments, with an emphasis on Soft Error Rate (SER) and Single Event Transient (SET) reliability. The course will be beneficial to those new to the field, by introducing the basic concepts before discussing advanced and emerging issues. It will also benefit those already experienced in the field through the introduction of novel CMOS devices and an update on space radiation environment modeling and SEE modeling and mitigation techniques.

The Short course is organized into four sections, beginning with an overview of CMOS device scaling, from Bulk and SOI planar, to FinFET transistors, and the advantages that some of these advanced technology nodes may have in a space radiation environment. The second section deals with an overview of the the space radiation environment, specifically for near-Earth missions, and the many radiation sources that one needs to take into account. The third and fourth sections take an in depth look at the specific radiation environment on SER (third section) and SEE (fourth section) from a modeling perspective. In section three, modeling of the device and circuit-cell SER in neutron and in heavy ion environments will be explored, from a general framework to that required for advanced SOI CMOS devices (including FinFETs). Finally, in section four the single event modeling issues required for radiation hardness by design (RHBD) will be discussed with an emphasis on the typical tools found in ASIC design flows.

The course is intended for designers, radiation engineers, component specialists, and other technical and management personnel who are involved in developing reliable systems designed to operate in radiation environments. The course provides a unique opportunity to NSREC attendees to benefit from the expertise of the instructors, as well as the in-depth coverage and application-oriented perspective provided by the Short Course format. Electronic copies of in-depth notes will be provided at registration.

CONTINUING EDUCATION UNITS (CEUS)

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

SHORT COURSE CHAIRMAN

Ken Rodbell, IBM
Short Course Chairman

Ken Rodbell is a Principal Research Staff Member and manages Soft Error Rate (SER) research at the IBM Thomas J. Watson Research Center in Yorktown Heights, NY. He received his B.S. (1982), M.S. (1983) and Ph.D. (1986) in Materials Science and Engineering, with a minor in statistics, from Rensselaer Polytechnic Institute. His technical interests have focused on Si based electronic materials; including thin film metallurgy, crystallographic texture, electromigration, and radiation induced soft errors in semiconductor devices (including the first definitive paper characterizing low energy proton induced fails in 65 nm SOI and the use of stacked latches to reduce SER in 32 nm SOI). He has co-authored more than 80 issued U.S. patents. He was one of a team recognized as the New York State 2006 Inventor of the Year for a Cu plating technology patent. Ken is a Senior Member of the IEEE.

Jerome Mitard received the Ph.D. degree in microelectronic engineering from the Polytechnic University School of Marseille, France, in 2003. For three years, he acted as an STMicroelectronics assignee with CEA-LETI, Grenoble, France, where he was deeply involved in the electrical characterization of hafnium-based dielectrics with metal gate for sub-70 nm complementary metal–oxide–semiconductor (CMOS) technologies. After his Ph.D. in microelectronics at Micro and Nanotechnologies Campus Center, Grenoble, France, he joined the IMEC R&D center in Belgium, as a device researcher working on high-mobility devices for sub-10nm FinFET technology. He is currently team leader in charge of the Platform Device Research at IMEC.

DEVICE SCALING

Jerome Mitard
IMEC

Dr. Jerome Mitard, from IMEC R&D center, will present a short course on advanced technology options required to achieve high speed operation and multiple functions of circuits designed for various terrestrial or spatial applications. This short course will be split into three parts going from general device scaling considerations down to a specific case study in which the impact of space radiation is addressed. Novel architectures like FinFET and gate-all-around combined with high-mobility channels will be extensively discussed since they offer a promising path to continue the device scaling while improving the intrinsic device performance further. Lastly, a deep dive into the development of strained Ge pFETs will close this course, showing how this development can serve the interest of the space radiation effects community.

Introduction

- Can the device scaling serve the development of space technologies?
- Transistor scaling : Transistor scaling “to infinity ... and beyond” ?
- How do we support Moore’s law nowadays?
- Changing materials
- Changing device architectures
- What’s beyond CMOS?
- Case study: strained Ge pFinETs. From TCAD simulations to state-of-the-art high-mobility devices.

Conclusions

Paul O'Brien is a Research Scientist in the Space Sciences Department at The Aerospace Corporation, where he has been since 2002. He conducts scientific research into the Earth's radiation belts and magnetosphere. He also develops space environment models and tools for satellite design, situational awareness, and anomaly resolution. He has a B.A. degree from Rice University in Physics and Classics, and M.S. and Ph.D. degrees from UCLA in Geophysics and Space Physics.

SPACE RADIATION ENVIRONMENT

Paul O'Brien
The Aerospace Corporation

Paul O'Brien, The Aerospace Corporation, will present a short course on the space radiation environment, with emphasis on topics relevant to space system design and operation for near-Earth missions. We begin with an overview of the radiation environment and its effects, followed by a brief description of how designers and operators approach the problems caused by that environment. We survey energetic plasma, trapped electrons, trapped protons, solar energetic particles, and galactic cosmic rays. For each topic we describe the location, phenomenology, effects, design specification approaches, operational considerations, and areas of active research. We also discuss small sensors designed to provide situational awareness and support further improvement of design specifications. We show that new orbits, new materials, and new technologies drive a need for continued improvement in models and sensors to support space system design and operation.

Overview of particle populations
- Energetic plasma
- Trapped electrons
- Trapped protons
- Solar energetic particles
- Galactic cosmic rays

A new perspective on sensors
- Why fly sensors?
- What sensors to fly

Design margin
- Sources of excess margin
- Strategies for reducing excess margin
- Closing the loop with flight data

Klas Lilja is the founder and CEO of Robust Chip Inc. (RCI), a company specialized in analysis of radiation effects in electronics and design of radiation hard electronics. He received M.Sc. and Ph. D. degrees from Chalmers Technical University, Sweden, and the Swiss Federal Institute of Technology (ETH), Switzerland, in 1986 and 1992 respectively, and has over 25 years of experience in the area design, simulation and radiation hardening of electronic devices and circuits. Prior to founding RCI, Klas was VP Engineering at ISE and Head of TCAD at Avant! Corporation (both companies are now part of Synopsis). As founder of RCI, he has led the development of RCI's unique software tools and break-through technology for radiation hardened electronics, and developed the company into a worldwide leader in this field. Klas holds more than 10 issued and pending patents on RCI's new technology, as well as several other patents in the area of semiconductor devices and semiconductor simulation.

ENVIRONMENT & DEVICES, SER - "MODELING NEUTRONS & HEAVY ION SER, FROM PLANAR CMOS TO FINFETS"

Klas Lilja
Robust Chip Inc.

Dr. Klas Lilja, Robust Chip Inc., will discuss methods, techniques, and tools for single event error rate prediction. This short course will focus primarily on the device and circuit-cell, and will review various approaches to SER prediction, ranging from the classic RPP (sensitive volume) method to the most accurate state-of-the-art techniques. This class will give an overview of the tools and modeling techniques involved, including particle Monte Carlo and device- and circuit simulation, describe cross-section and error rate calculation, and show how different radiation environments are handled in the predictions.

The advantages and short-comings of the various error rate prediction methods for application in today's most advanced FinFET and SOI technologies will be discussed, as well as their application in the process of optimizing and hardening a design in these technologies. Based on application examples, the key information that a designer can get from SER prediction, the expected accuracy of the information, and how it can be used in hardening of the design, will be discussed. Finally, a brief overview of how the cell level SER information supports full chip/system SER analysis, prediction, and potential hardening, will be given.

Introduction to Single Event Effects

Review of SER prediction methods

Modeling techniques for SER prediction

- From energy deposition to circuit response (Monte Carlo-, device-, and circuit-simulation)
- Calculation of error rates for different circuits and environments

Advanced topics in SER prediction

- Advanced technologies and device geometries (bulk vs. SOI/FinFET)
- Charge sharing, angular dependence, sub LET-threshold effects, and SER at near/sub threshold conditions
- Application examples

The use of SER prediction in radhard-by-design (RHBD)

Comparison to experimental results – how good is today's SER prediction?

Jeff Kauppila is a Research Assistant Professor with Vanderbilt University's Institute for Space and Defense Electronics (ISDE), where he works in the area of radiation effects modeling and radiation-hardened design for microelectronics. He received his Ph.D. in Electrical Engineering (2015), M.S. in Electrical Engineering (2003), and his B.E. in Electrical Engineering (2001) all from Vanderbilt University. Dr. Kauppila joined ISDE in 2003 and his research focuses on the development of radiation-effects-enabled compact models, integration of models with existing- and custom-developed process-design-kits (PDK), and the application of the radiation-enabled models in the design of radiation-hardened strategic defense systems electronics. Dr. Kauppila is actively involved in the development and design of integrated circuits and test structures used to extract and calibrate electrical and radiation-enabled model parameters. Dr. Kauppila has analog/mixed signal design experience in bipolar junction transistor, bulk CMOS, silicon-on-insulator CMOS, and FinFET technologies with minimum process feature sizes from 6 µm down to 14 nm. Dr. Kauppila is a licensed professional engineer in the state of Tennessee.

ENVIRONMENT & DEVICES, SEE - "SINGLE EVENT MODELING FOR RAD-HARD-BY-DESIGN FLOWS"

Jeff Kauppila
Vanderbilt University, Institute for Space and Defense Electronics

Dr. Jeff Kauppila, Vanderbilt University, Institute for Space and Defense Electronics, will discuss the use of single-event modeling and simulation in the design of radiation-hardened-by-design (RHBD) circuits. The escalating costs to fabricate modern RHBD ASICs require engineers to consider radiation effects early in the physical design phase through modeling and simulation. The presentation will focus on recent advancements in single-event modeling of transients and upsets through circuit simulation. Model topologies, attributes, and limitations will be discussed. Techniques utilized to calibrate and validate the behavior of single-event models will also be discussed. The presentation will conclude with a discussion of the use of single-event models in RHBD optimization, and the integration of radiation-enabled models within the typical tools found in rad-hard ASIC design flows.

Introduction and overview

Traditional / historical SEE modeling techniques

Trends and techniques in SEE compact modeling
- Bias-dependence of single-event currents
- Bulk technology modeling
- SOI technology modeling
- FinFET technology modeling

Calibration and validation of SEE compact models
- Model calibration with 3-D TCAD
- SEE measurement for data-based validation

Application of SEE compact models in rad-hard-by-design flows
- Model calibration with 3-D TCAD
- SEE measurement for data-based validation

Technical Program

TECHNICAL INFORMATION

"On behalf of the Technical Program Committee, I would like to invite you to attend the 2016 NSREC Technical Sessions. Thanks to our authors, session chairs and reviewers, we have assembled an excellent technical program, which will provide the latest advances in nuclear, space and terrestrial radiation effects."

Philippe Paillet, CEA
Technical Program Chair

The NSREC technical program will consist of contributed oral, poster papers, a data workshop, three invited presentations, a Young Professionals talk, and a Women in Engineering talk. The oral presentations will be 12 minutes in duration with an additional 3 minutes for questions. The Technical Sessions and Chairpersons are:

- **Photonic Devices and Integrated Circuits**
  Chair: Kyle Miller, Ball Aerospace
- **Single Event Effects: Transient Characterization**
  Chair: Jeffrey Warner, Naval Research Laboratory
- **Basic Mechanisms of Radiation Effects**
  Chair: Sylvain Girard, University of St-Etienne
- **Radiation Effects in Devices and Integrated Circuits**
  Chair: Alessandro Paccagnella, University of Padova
- **Hardness Assurance**
  Chair: Philippe Adell, NASA JPL
- **Hardening By Design**
  Chair: Lawrence Clark, Arizona State University
- **Single Event Effects: Mechanisms and Modeling**
  Chair: Michael King, Sandia National Laboratories
- **Single Event Effects: Devices and Integrated Circuits**
  Chair: Bharat Bhuva, Vanderbilt University
- **Dosimetry**
  Chair: Michael Trinczek, TRIUMF
- **Space and Terrestrial Environments**
  Chair: Julien Mekki, CNES

POSTER SESSION

Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session on Tuesday through Friday, Oregon Ballroom 203-204. The formal Poster Session will be held on Thursday from 2:50 to 5:30 PM and the authors will be available at that time to discuss their work. The Poster Session is chaired by Paul Marshall, NRL.

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, Oregon Ballroom 203-204. Authors will be available on Wednesday to discuss their work from 2:20 to 4:45 PM. A workshop record will be mailed to all registered conference attendees. The workshop chair is Bert Vermeire, Space Micro.

INVITED SPEAKERS

- **Where's the Spruce Goose?** *Colonel Larry Wood, USMC (retired), former Executive Director, Evergreen Aviation & Space Museum*
- **VLSI Technology Reliability Beyond the 'Golden Age' of Moore's Law Silicon Scaling** *Jeffrey Hicks, Intel*
- **Cascadia Subduction Zone - Are We Ready for the Big One?** *Scott Burns, Professor Emeritus of Geology, Portland State University*

WOMEN IN ENGINEERING YOUNG PROFESSIONALS

- **Women in Leadership: A Personal Perspective** *Nita Patel, L-3 Warrior Systems*
- **Reflections at a Half-Century or How I Stumbled Through** *Ken Galloway, Vanderbilt University*

LATE-NEWS PAPERS

Late-news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The deadline for submission is May 13, 2016. Detailed instructions for submitting a late-news summary are available on the NSREC web site at ***www.nsrec.com***.

Technical Program Tuesday

OREGON BALLROOM 201-202

8:30 AM **OPENING REMARKS**
Robert Reed, Vanderbilt University, General Chair

8:35 AM **AWARDS PRESENTATION**
Allan Johnston, J-K Associates, Radiation Effects Steering Group, Executive Chair

9:05 AM **TECHNICAL SESSION OPENING REMARKS**
Philippe Paillet, CEA, Technical Program Chair

SESSION A **PHOTONIC DEVICES AND INTEGRATED CIRCUITS**

9:10 AM SESSION INTRODUCTION
Chair: Kyle Miller, Ball Aerospace

A-1 **In-Depth Analysis on Radiation Induced Multi-Level Dark Current**
9:15 AM **Random Telegraph Signal in Silicon Solid State Image Sensors**
C. Durnez [1, 2, 3], V. Goiffon [1], C. Virmontois [2], P. Magnan [1], L. Rubaldo [3]
[1] ISAE-SUPAERO; [2] CNES; [3] SOFRADIR

Multi-level random telegraph signals (RTS) are studied in CMOS image sensors (CIS) exposed to neutron radiations by using a new analysis tool to investigate the origin of this phenomenon. New RTS characteristics are reported.

A-2 **Dark Current Spectroscopy in Proton, Carbon and Neutron Irradiated**
9:30 AM **Pinned Photodiode CMOS Image Sensors**
J.-M. Belloir [1, 2, 3], V. Goiffon [1], C. Virmontois [2], P. Paillet [3], M. Raine [3], P. Magnan [1], O. Gilard [2]
[1] ISAE-SUPAERO; [2] CNES; [3] CEA

Dark current spectroscopy is tested in proton, carbon and neutron irradiated pinned photodiode CMOS image sensors to detect and identify radiation-induced bulk defects in silicon and study their dependence on particle and particle energy.

A-3 **Radiation Effects Dependence on Epitaxial Layer Thickness in Pinned**
9:45 AM **Photodiode CMOS Image Sensors**
C. Virmontois [1], M. Estribeau [2], C. Durnez [1], P. Cervantes [2], B. Avon [2], V. Goiffon [2], P. Magnan [2], A. Materne [1], A. Bardoux [1]
[1] CNES; [2] ISAE-SUPAERO

This paper focuses on the radiation-induced degradations in CMOS images sensors using several epitaxial layer thicknesses. In this work, we evaluate the radiation effect behavior related to this layer thickness.

A-4 **Radiation Hardening of Digital Color CMOS Camera-on-a-Chip Building**
10:00 AM **Blocks for Multi-MGy Total Ionizing Dose Environments**
V. Goiffon [1], F. Corbiere [1], S. Rolando [1], J. Baer [1], A. Chabane [1], P. Cervantes [1], M. Estribeau [1], P. Magnan [1], S. Girard [2], P. Paillet [3], M. Van Uffelen [4], L. Mont Casellas [4], R. Scott [5]
[1] ISAE-SUPAERO; [2] CEA; [3] UdL - Université de Saint-Etienne; [4] Fusion for Energy; [5] Oxford Technologies Ltd.

The TID hardness of digital color CMOS camera-on-a-chip building blocks (radiation hardened pixel array, color filter arrays and radiation hardened column ADCs) is demonstrated in the multi-MGy range using Co-60 irradiations.

10:15 – 10:40 AM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

BREAK

A-5
10:40 AM

Radiation Hardened Architecture of a Single-Ended Raman-Based Distributed Temperature Sensor

D. Di Francesca [1], S. Girard [1], I. Planes [1, 2], A. Cebollada [3], A. Alessi [1], I. Reghioua [1], C. Cangialosi [1], A. Ladaci [1], S. Rizzolo [1, 4], V. Lecoeuche [3], A. Boukenter [1], A. Champavère [3], Y. Ouerdane [1]
[1] UdL - Université de Saint-Etienne; [2] ANDRA; [3] Viavi Solutions; [4] AREVA

We validate the feasibility of a radiation-hardened-by-design Raman distributed temperature sensor employing two adapted excitation lasers. This single-ended system is robust against radiation effects limiting the integration of other Raman DTS.

A-6
10:55 AM

Evaluation of Distributed OFDR-Based Sensing Performances in Mixed Neutron/Gamma Radiation Environments

S. Rizzolo [1, 2, 3], A. Boukenter [1], E. Marin [1], M. Cannas [2], A. Morana [1], J. Perisse [4], J.-R. Mace [5], Y. Ouerdane [1], B. Nacir [6], P. Paillet [7], C. Marcandella [7], M. Gaillardin [7], S. Girard [1]
[1] UdL - Université de Saint-Etienne; [2] Universita degli Studi di Palermo; [3] Areva Centre Technique; [4] Areva NP; [5] Areva; [6] CNESTEN; [7] CEA

We tested the OFDR based sensors robustness in neutron and gamma environment up to 10^{17} n/cm^2 fluence and 2 MGy (SiO_2) dose, exhibiting high radiation tolerance and promising performance for their integration in mixed radiation environments.

A-7
11:10 AM

Radiation-Hardened Fiber Bragg Grating Based Sensors for Harsh Environments

A. Morana [1], S. Girard [1], E. Marin [1], J. Perisse [2], J.-S. Genot [2], J. Kuhnhenn [3], J. Grelin [4], L. Hutter [4], G. Melin [5], L. Lablonde [5], T. Robin [5], B. Cadier [5], J.-R. Mace [6], A. Boukenter [1], Y. Ouerdane [1]
[1] UdL - Université de Saint-Etienne; [2] Areva NP; [3] Fraunhofer INT; [4] SmartFibres; [5] iXBlue; [6] Areva

We tested, up to 1 MGy dose, the robustness of FBG-based sensors in the framework of the European project HOBAN. The results are promising for applications in harsh environments (350 °C temperature, MGy dose).

A-8
11:25 AM

Comparison of Pre and Post-Radiation Low-Frequency Noise Spectra of Mid-Wave Infrared nBn Detectors with Superlattice Absorbers

E. Garduno, V. Cowan, G. Jenkins, C. Morath
Air Force Research Laboratory

Voltage and temperature-dependent noise spectra of Type-II Strained Layer Superlattice (T2SLS) mid-wave infrared photodetectors were compared for pre and post-radiation with total ionizing dose of 100 krad(Si).

POSTER PAPERS

PA-1 **More Accurate Quantum Efficiency Damage Factor for 63 MeV Proton-Irradiated III-V Unipolar Barrier Infrared Detectors**

C. P. Morath, E. A. Garduno, V. M. Cowan, G. D. Jenkins
Air Force Research Laboratory

Updated theory and data on the degradation of the detector quantum efficiency in III-V unipolar barrier infrared detectors due to displacement damage from 63 MeV proton irradiation for more accurate damage factors.

11:40 AM – 1:10 PM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

LUNCH

SESSION B **SINGLE EVENT EFFECTS: TRANSIENT CHARACTERIZATION**

1:10 PM SESSION INTRODUCTION

Chair: Jeffrey Warner, Naval Research Laboratory

B-1 1:15 PM **Detailed SET Measurement and Characterization of a 65 nm Bulk Technology**

M. Glorieux [1], A. Evans [1], V. Ferlet-Cavrois [2], D. Alexandrescu [1], S. Clerc [3], G. Gasiot [3], P. Roche [3]
[1] IROC Technologies; [2] European Space Agency; [3] STMicroelectronics

This paper presents a detailed characterization of SETs in a 65 nm process technology including a comparison of the accuracy of three novel SET pulse measurement circuits embedded on the same die.

B-2 1:30 PM **Single-Event Transient Response of Comparator Pre-amplifiers in a Complementary SiGe Technology**

A. Ildefonso [1], N. E. Lourenco [1], Z. E. Fleetwood [1], M. T. Wachter [1], A. S. Cardoso [1], N. J.-H. Roche [2], A. Khachatrian [3], D. McMorrow [4], S. P. Buchner [4], J. H. Warner [4], P. Paki [5], M. Kaynak [6], B. Tillack [6], D. Knoll [6], and J. D. Cressler [1]
[1] Georgia Institute of Technology; [2] The George Washington University; [3] Sotera Defense; [4] US Naval Research Laboratory; [5] Defense Threat Reduction Agency; [6] IHP Microelectronics

The single-event transient response of the pre-amplification stage of latched comparators designed using either *npn* or *pnp* SiGe HBTs is studied via two-photon absorption (TPA) carrier injection and mixed-mode TCAD simulations.

B-3 1:45 PM **Application of a Focused, Pulsed X-ray Beam to the Investigation of Single-Event Transients in $Al_{0.3}Ga_{0.7}N$/GaN HEMTs**

A. Khachatrian [1], N. J-H. Roche [2], S. Buchner [3], A. Koehler [3], T. Anderson [3], K. Hobart [3], D. McMorrow [3], S. D. LaLumondiere [4], N. P. Wells [4], J. Bonsall [4], E. C. Dillingham [4], P. Karuza [4], D. L. Brewe [5], W. T. Lotshaw [4], S. C. Moss [4], V. Ferlet-Cavrois [6], and M. Muschitiello [6]
[1] Sotera Defense; [2] The George Washington University; [3] US Naval Research Laboratory; [4] The Aerospace Corporation; [5] Argonne National Laboratory; [6] European Space Agency

A focused, pulsed x-ray beam was used to investigate the effects of charge trapping on SET characteristics in pristine and irradiated $Al_{0.3}Ga_{0.7}N$/GaN HEMTs. The results show good agreement with previous measurements using pulsed laser light.

POSTER PAPERS

PB-1 Analysis of Single-Event Effects in a Radiation-Hardened Low-Jitter PLL under Heavy Ion and Pulsed Laser Irradiation

Z. J. Chen, M. Lin, Y. L. Zheng, Z. H. Sang, S. C. Zou
Shanghai Institute of Microsystem and Information Technology

A radiation-hardened low-jitter PLL with current-based charge pump is designed in 130 nm PD-SOI. Heavy-ion and pulsed-laser testing results demonstrate the hardness assurance, by means of proposed accumulated phase jitter.

PB-2 Single Event Transient and Dose Effect Study in 28 nm UTBB FDSOI Technology

A. Evans [1], R. Liu [2], L. Chen [2], Y. Li [2], G. Maximilien [1], D. Alexandrescu [1], Q. Wu [2], R. Wong [3], S.-J. Wen [3]
[1] IROC Technologies; [2] University of Saskatchewan; [3] Cisco Systems

This paper presents novel techniques for measuring single event transients and monitoring dose effects under heavy-ion irradiation in a 28 nm UTBB FDSOI technology.

PB-3 Characterization of Single-Event Transient Pulse Broadening Effect in 65 nm Bulk Inverter Chains Using Heavy Ion Microbeam

Y. Chi [1], R. Song [1], S. Shi [2], B. Liu [1], L. Cai [2], C. Hu [1], G. Guo [2]
[1] National University of Defense Technology; [2] China Institute of Atomic Energy

The PIPB effect is characterized by heavy-ion microbeam irradiation. An odd-even separated layout is implemented to improve the experiment resolution. Results show bigger transistor size inhibits the PIPB effect more.

PB-4 Single-Event Effects in a W-Band (75-110 GHz) Radar Receiver Implemented in 90 nm, 300 GHZ SiGe HBT Technology

S. Zeinolabedinzadeh [1], A. C. Ulusoy [2], F. Inanlou [3], H. Ying [1], Y. Gong [1], Z. E. Fleetwood [1], N. J.-H. Roche [4], A. Khachatrian [5], D. McMorrow [6], S. P. Buchner [6], J. H. Warner [6], P. Paki [7], and J. D. Cressler [1]
[1] Georgia Institute of Technology; [2] IHP Microelectronic; [3] Jet Propulsion Laboratory; [4] The George Washington University; [5] Sotera Defense; [6] Naval Research Laboratory; [7] Defense Threat Reduction Agency

This paper investigates single-event effects in a W-band (75-110 GHz) SiGe HBT radar receiver. A novel methodology to ease the burden of SEE evaluation, and a circuit technique to mitigate the SET propagation are proposed.

PB-5 Heavy-Ion Induced Charge Collection in Ge-Channel pMOS FinFETs

I. K. Samsel [1], E. X. Zhang [1], S. M. Austin [1], R. A. Reed [1], D. M. Fleetwood [1], M. L. Alles [1], R. D. Schrimpf [1], D. Linten [2], J. Mitard [2]
[1] Vanderbilt University; [2] IMEC

Charge collection behavior of Ge-channel p-type FinFETS demonstrates location dependence of transient polarity distinct from Ge-based planar devices, and the total collected charge is also shown to depend strongly on gate bias.

PB-6 **Low-Energy Proton-Induced Single Event Transients in Nanometer Bulk CMOS Technology**

Z. Wu [1], S. Chen [1], G. Guo [2], P. Huang [1]
[1] National University of Defence Technology; [2] China Institute of Atomic Energy

We first find that low-energy (< 30 MeV) protons can induce long-duration (> 200 ps) SETs in nanometer bulk CMOS technology. SETs induced by oxygen recoils may be wider than those induced by silicon recoils.

SESSION C BASIC MECHANISMS OF RADIATION EFFECTS

2:00 PM SESSION INTRODUCTION

Chair: Sylvain Girard, University of St-Etienne

C-1 2:05 PM **Simulation of Single Particle Displacement Damage in Silicon – Part I: Global Approach and Primary Interaction Simulation**

M. Raine [1], N. Richard [1], A. Jay [2], V. Goiffon [2], S. Girard [3], M. Gaillardin [1], P. Paillet [1]
[1] CEA; [2] ISAE-SUPAERO; [3] UdL - Université de Saint-Etienne

A comprehensive approach is developed for the simulation of single particle displacement damage in silicon. The first step corresponding to Monte Carlo simulation of the primary interaction is presented.

C-2 2:20 PM **Simulation of Single Particle Displacement Damage in Silicon - Part II: Generation and Long Time Relaxation of the Damage Structure**

A. Jay [1], M. Raine [2], N. Richard [2], N. Mousseau [3], V. Goiffon [1], A. Hemeryck [4], P. Magnan [1]
[1] ISAE-SUPAERO; [2] CEA; [3] Université de Montréal; [4] LAAS

Simulation of displacement cascades induced by silicon atoms in bulk silicon is performed using molecular dynamics followed a new simulation technique allowing to access long time relaxation of the damage structure, up to seconds.

C-3 2:35 PM **Displacement Damage in Bipolar Junction Transistors: Beyond Messenger-Spratt**

H. J. Barnaby [1], R. D. Schrimpf [2], K. F. Galloway [2], X. Li [3], J. Yang [3], C. Liu [3]
[1] Arizona State University; [2] Vanderbilt University; [3] Harbin Institute of Technology

Older large geometry BJTs damaged by atomic displacement are susceptible to neutral base recombination. Recombination in the depletion region is shown to be a contributor to degradation in smaller devices and at lower voltages.

C-4 2:50 PM **Theory of Quantum Transport in Graphene Devices with Radiation Induced Coulomb Scatterers**

S. W. LaGasse [1], C. D. Cress [2], H. L. Hughes [2], J. U. Lee [1]
[1] SUNY Polytechnic Institute; [2] US Naval Research Laboratory

Quantum transport modeling is used to study total ionizing dose effects on graphene devices. Pristine transfer curves are matched using a fixed contact doping. Radiation effects are included by randomly generated Coulomb scattering potentials.

C-5 3:05 PM

Total Ionizing Dose (TID) Effects in GaAs MOSFETs with La Based Epitaxial Gate Dielectrics

S. Ren [1], M. Bhuiyan [1], J. Zhang [2], M. Si [2], R. Jiang [3], K. Ni [3], X. Wan [1], S. Chang [1], E. X. Zhang [3], R. A. Reed [3], D. M. Fleetwood [3], P. Ye [2], T.-P. Ma [1]
[1] Yale University; [2] Purdue University; [3] Vanderbilt University

Charge trapping mechanisms in GaAs MOSFETs are studied by the AC transconductance dispersion method. Al_2O_3/La_2O_3 gated devices show both electron and hole trapping, whereas $Al_2O_3/La_{1.8}Y_{0.2}O_3$ gated devices show primarily hole trapping.

POSTER PAPERS

PC-1

Extrapolated Range Expression for Electrons Down to ~10 eV

C. Inguimbert [1], J. Pierron [1], M. Belhaj [1], J. Puech [2]
[1] ONERA; [2] CNES

The commonly used expressions of the "extrapolated range" of electrons are given for energies down to ~1 keV. An empirical equation valid down to ~10 eV has been formulated for 41 different elements.

PC-2

Gamma and Electron NIEL Dependence of Irradiated GaAs

M. El Allam [1], C. Inguimbert [2], T. Nuns [2], A. Meulenberg [3], A. Jorio [1], I. Zorkani [1]
[1] University Sidi Mohamed Ben Abdellah; [2] ONERA; [3] Science for Humanity Trust

^{60}Co gamma rays are used to investigate the relevance of the NIEL scaling law for both electrons and gamma rays in gallium arsenide. A displacement threshold energy of 21 eV is found for GaAs material.

PC-3

Atomic-level Simulation of Displacement Damage and Effective NIEL in GaAs

F. Gao [1], N. Y. Chen [1], S. Gray [1], E. Hernandez-Rivera [1], D. H. Huang [2] and D. A. Cardimona [2]
[1] University of Michigan; [2] US Air Force Research Laboratory

Molecular dynamics is applied to simulate defect production in GaAs. Damage contains disordering regions related to nonlinear defect production. Defect formation displays power-law relation for a new energy partition function used to calculate NIEL.

PC-4

Displacement Damage Coefficients: An Alternative Method in Modeling Solar Cell Degradation in Space

S. R. Messenger
SRM Consulting

A new method is introduced to model solar cell degradation in space using Monte Carlo transport techniques to produce displacement damage coefficients (DDCs). Some examples are given for multijunction and silicon solar cells.

PC-5

Total Ionizing Dose Effects on Passivated Black Phosphorus Transistors

C. Liang [1], Y. Su [2], E. X. Zhang [1], M. L. Alles [1], R. D. Schrimpf [1], D. M. Fleetwood [1], S. Koester [2]
[1] Vanderbilt University; [2] University of Minnesota

TID irradiation and bias-stress responses of HfO_2 passivated black phosphorous transistors are investigated. Devices are quite stable to bias stressing. Net hole trapping is observed for irradiation under positive or negative bias.

PC-6 **Total Ionizing Dose (TID) Effects in Ultra-Thin Body Ge on Insulator (GOI) Junctionless CMOSFETs with Recessed Source/Drain and Channel**

S. Ren [1], H. Wu [2], R. Jiang [3], M. Bhuiyan [1], K. Ni [3], J. Chen [3], E. X. Zhang [3], R. A. Reed [3], D. M. Fleetwood [3], P. Ye [2], T.-P. Ma [1]
[1] Yale University; [2] Purdue University; [3] Vanderbilt University

Both top and bottom gates in Ge GOI NFETs and PFETs contribute to x-ray-induced ΔVth due to net hole trapping. Ge channel thickness and post-oxidation processing can strongly affect the radiation response.

PC-7 **Effects of Proton Irradiation on the Gate-Voltage Dependence of the 1/f Noise of GaN/AlGaN HEMTs**

P. Wang, R. Jiang, J. Chen, E. X. Zhang, M. W. McCurdy, R. D. Schrimpf, D. M. Fleetwood
Vanderbilt University

The voltage dependence of low-frequency noise of GaN/AlGaN HEMTs is usually modeled in terms of mobility fluctuations. Noise measurements before and after proton irradiation are shown to be more consistent with number fluctuations.

PC-8 **Comparison of Gain Degradation and DLTS in pnp Si BJTs Irradiated with Different Ion Species**

B. A. Aguirre, E. Bielejec, R. M. Fleming, G. Vizkelethy, B. Vaandrager, J. M. Campbell, W. J. Martin, D. B. King
Sandia National Laboratories

We studied the effect of light and heavy ion irradiation on pnp Si BJTs. We observe a mismatch in measured vacancy number predicted by SRIM and measured by DLTS for equivalent gain degradation.

PC-9 **Electrical and Spectral Properties of 1-MeV Electron Beam Irradiated Wafer Bonded Four-Junction Solar Cell**

A. Aierken [1], P. Dai [2, 3], S. Lu [2], H. Maria [1, 3], S. Uchida [4], L. Ji [2], M. Tan [2], Y. Wu [2], L. Bian [2], Q. Guo [1], H. Yang [2]
[1] Chinese Academy of Sciences, Urumqi; [2] Chinese Academy of Sciences, Suzhou; [3] Chinese Academy of Sciences, Beijing; [4] Chiba Institute of Technology

1-MeV electron irradiated wafer bonded GaInP/GaAs+InGaAsP/InGaAs four-junction solar cell have been studied. The degradation of cell performance was mainly caused by decreased open-circuit voltage of InGaAsP/InGaAs sub-cells.

PC-10 **Changes of Photoluminescence of Electron Beam Irradiated Self-Assembled InAs/GaAs Quantum Dots**

M. Li-Ya, G. Qi, A. Er-Ken, L. Yu-Dong, Z. Dong, W. Lin
Chinese Academy of Sciences

We studied the effects of 1 MeV electron irradiation on the photoluminescence of InAs/GaAs quantum dots. Intensity of the photoluminescence is observed to a slight increase with low irradiation doses. An energy shift was observed.

PC-11 **Structural and Material Changes in GeSe/Ag Bilayers Induced by Proton Irradiation**

T. Nichol, M. Mitkova
Boise State University

We present results on structural and material changes in chalcogenide glasses and chalcogenide glass/Ag bilayers induced by proton irradiation as a function of dose.

3:20 – 3:45 PM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

BREAK

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

3:45 PM SESSION INTRODUCTION

Chair: Alessandro Paccagnella, University of Padova

D-1 **Total Ionizing Dose Effects on a K-band Quadrature LC-Tank VCO in a**
3:50 PM **32 nm CMOS SOI Technology**

T. D. Loveless [1], S. Jagannathan [2], E. X. Zhang [3], D. M. Fleetwood [3], J. S. Kauppila [3], L. W. Massengill [3]
[1] University of Tennessee at Chattanooga; [2] NXP Semiconductors; [3] Vanderbilt University

Combined effects of TID and temperature on a K-band VCO fabricated in a 32 nm SOI technology are presented. Measured performance demonstrates the need for combined effects testing for advanced RF design characterization and qualification.

D-2 **Low-Energy Electron Irradiation of NAND Flash Memories**
4:05 PM

M. J. Gadlage [1], A. H. Roach [1], J. M. Labello [2], M. R. Halstead [1], M. J. Kay [1], A.R. Duncan [1], J. D. Ingalls [1], J. P. Rogers [2]
[1] NSWC Crane; [2] AEDC

Data on NAND Flash memories exposed to low energy electrons are presented. The total-dose induced data corruption by electrons is significantly greater than when tested to the same total dose in a Co-60 source.

D-3 **Worst-Case Bias for Irradiation of AlGaN/GaN HEMTs**
4:20 PM

R. Jiang [1], E. X. Zhang [1], M. W. McCurdy [1], J. Chen [1], X. Shen [1, 2], D. M. Fleetwood [2], R. D. Schrimpf [1], S. W. Kaun [3], E. C. H. Kyle [3], J. S. Speck [3], S. T. Pantelides [1]
[1] Vanderbilt University; [2] University of Memphis; [3] University of California Santa Barbara

As fabrication-induced defect densities decrease, radiation damage and TID effects become more important in GaN/AlGaN HEMTs. Worst-case bias for radiation-induced transconductance degradation can vary significantly with process conditions.

D-4 **Total Ionizing Dose Effects on Strained Ge pMOS FinFETs on Bulk Si**
4:35 PM

E. X. Zhang [1], D. M. Fleetwood [1], J. A. Hachtel [1, 2], C. Liang [1], R. A. Reed [1], M. L. Alles [1], R. D. Schrimpf [1], D. Linten [3], J. Mitard [3], M. F. Chisholm [2], S.T. Pantelides [1, 2]
[1] Vanderbilt University; [2] Oak Ridge National Laboratory; [3] IMEC

Strained Ge pMOS FinFETs exhibit superior TID response and ON/OFF current ratios to planar Ge pMOS devices. Little variation in TID response is observed as a function of fin width and gate length.

D-5 4:50 PM

Total Ionizing Dose Effects on Piezoelectric Micromachined Ultrasonic Transducers

W. Liao, E. X. Zhang, M. L. Alles, C. X. Zhang, H. Gong, K. Ni, A. L. Sternberg, D. M. Fleetwood, R. A. Reed, R. D. Schrimpf
Vanderbilt University

Total ionizing dose effects on piezoelectric micromachined ultrasonic transducers (pMUTs) are investigated with 10-keV x-rays under different bias conditions. The corresponding changes in mechanical properties are evaluated using impedance analysis methods.

D-6 5:05 PM

Gate Bias and Geometry Dependence of Total-Ionizing-Dose Effects in InGaAs Quantum-Well MOSFETs

K. Ni [1], E. X. Zhang [1], R. D. Schrimpf [1], D. M. Fleetwood [1], R. A. Reed [1], M. L. Alles [1], J. Lin [2], J. A. del Alamo [2]
[1] Vanderbilt University, [2] Massachusetts Institute of Technology

The effects of total-ionizing-dose irradiation are investigated in InGaAs quantum-well MOSFETs. Irradiation and stress effects are additive or compensatory to each other, depending on gate bias. The degradation increases with channel length.

POSTER PAPERS

PD-1

Comparison of a 65 nm CMOS Ring- and LC-Oscillator Based PLL in Terms of TID and SEU Sensitivity

J. Prinzie [1], J. Christiansen [2], P. Moreira [2], M. Steyaert [1], P. Leroux [1]
[1] KU Leuven; [2] CERN

This paper presents experimental results for a CMOS ASIC with a ring- and LC-oscillator PLL that is irradiated up to a total dose of 600 Mrad. Single-event upset tests were performed with heavy ions.

PD-2

Combined X-ray and Gamma Ray Testing to Investigate the TID Tolerance of RTG4

N. Rezzak, J. Wang, V. Nguyen, D. Dsilva
Microsemi SoC

X-ray testing on flip-chip FPGA to study the RTG4 TID tolerance is investigated. Shielding is used to identify the most sensitive circuits. X-ray testing is complemented with gamma irradiation to understand the RTG4 TID limit.

PD-3

Low Energy Proton Irradiation Effects on Commercial Enhancement Mode GaN HEMTs

X. Wan [1, 4], O. K. Baker [1], M. W. McCurdy [2], E. X. Zhang [2], M. Zafrani [3], S. P. Wainwright [3], J. Xu [4], H. L. Bo [4], R. A. Reed [2], D. M. Fleetwood [2], T. P. Ma [1]
[1] Yale University; [2] Vanderbilt University; [3] Freebird Semiconductor Corporation; [4] Tsinghua University

Low-energy proton irradiation leads to an increased density of charged donor defects in enhancement mode GaN/AlGaN HEMTs, and high-voltage stress leads to an increased density of charged acceptor defects.

PD-4 **Degradation Characteristics of Normally-off p-AlGaN gate AlGaN/GaN HEMTs with 5 MeV Proton Irradiation**

D. M. Keum, G. Cho, H. Cho, H. Kim
Hongik University

Proton irradiation experiments were performed on normally-off pAlGaN gate AlGaN/GaN HEMTs. The degradations in output and subthreshold characteristics, proportional to irradiation doses, are attributed to displacement damage and hole reduction in pAlGaN layer.

PD-5 **Total-Ionizing-Dose Effects in Piezoresistive Micromachined Cantilevers**

H. Gong [1], W. Liao [1], E. X. Zhang [1], A. L. Sternberg [1], M. W. McCurdy [1], J. L. Davidson [1], M. L. Alles [1], R. A. Reed [1], D. M. Fleetwood [1], R. D. Schrimpf [1], P. D. Shuvra [2], J. Lin [2], S. McNamara [2], B. W. Alphenaar [2], K. M. Walsh [2]
[1] Vanderbilt University; [2] University of Louisville

The response of silicon, T-shape, asymmetric piezoresistive micromachined cantilevers to 10-keV x-rays is reported. The resonance frequency decreases by 25 ppm at 2.1 Mrad(SiO_2), and recovers during post-irradiation annealing.

PD-6 **Total-Ionizing-Dose Effects on Resistance Stability of Programmable Metallization Cell Based Memory and Selectors**

W. Chen [1], R. Fang [1], H. J. Barnaby [1], M. N. Kozicki [1], M. B. Balaban [1], Y. Gonzalez-Velo [1], J. L. Taggart [1], A. Mahmud [1], K. Holbert [1], A. Edwards [2]
[1] Arizona State University; [2] Air Force Research Laboratory

Non-volatile Programmable Metallization Cells (PMCs) for memory and volatile PMCs for selector applications are presented in this work. Gamma-ray irradiation impact on material variants of both device types are experimentally investigated.

PD-7 **Total Ionizing Dose Radiation Effects in a New Type of FinFET Oxide Fill**

H. L. Hughes [1], P. McMarr [2], J. Lee [3], M. L. Alles [4], B. Doris [5]
[1] US Naval Research Laboratory; [2] Sotera; [3] Albany College; [4] Vanderbilt University; [5] IBM

A new type of oxide, called flowable, has been introduced into the FinFET process flow. Radiation induced net positive charge in flowable oxides is shown to be significant and a concern for FinFET TID hardness.

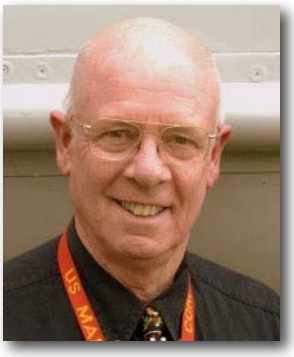
5:20 PM END OF TUESDAY SESSIONS

5:30 – 7:00 PM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

INDUSTRIAL EXHIBITS RECEPTION

Technical Program Wednesday

OREGON BALLROOM 201-202
INVITED TALK
8:45 – 10:00 AM



Where's the Spruce Goose?
Colonel Larry Wood, USMC (retired), former Executive Director, Evergreen Aviation & Space Museum

The Evergreen Aviation & Space Museum located in McMinnville is about 45 minutes south of Portland. Created in 1991, and home to Howard Hughes' wooden flying boat, the Spruce Goose, the museum has over 240,000 square feet of display space for more than 130 artifacts. The Museum is a Smithsonian affiliate and has over 250 volunteers and docents that assist in running the museums on daily basis and assist with artifact restoration as well as grow programs. The Museum challenges guests to discover and learn about aviation and space, man and unmanned flight, and most recently, the power of water. The campus has five facilities and sees over 200,000 people annually. The Evergreen Space Museum is also home to EASA, the Engineering and Aerospace Sciences Academy, a partnership with the McMinnville School District, where over 120 students meet daily and take engineering and science classes. When these students graduate from this program, they will have credits to be able to move into their sophomore year at select colleges. Through this partnership the museum is part of many after school programs including a cube-sat program, a science experiment group that has sent three experiments to the International Space Station, FIRST robotics teams, Boy and Girl Scout tours and onsite specialty programs.

Larry Wood was commissioned 2/Lt USMC upon graduation from the University of Washington in 1966. In 1968 he was one of the first Marines to graduate from USAF pilot training, and received Naval Aviator wings in October, 1968. He served a tour in Vietnam from 1969-1970 flying the A-4 Skyhawk out of Chu Lai as an attack pilot, then flying the two seat TA-4F from Da Nang as a Fast FAC. Over the next 27 years Wood completed numerous tours as a flight instructor, aircraft maintenance officer, Squadron and Group Commanding Officer, a tour in Washington, and two tours as an instructor at the Naval War College, before he retired as a Colonel in June 1997. Following his first retirement, he taught middle school science for 8 years in the Salem-Keizer schools before retiring a second time in 2006. After two years as a volunteer docent at the Evergreen Aviation & Space Museum, he became the museum's education director and then Executive Director, finally retiring a third time in June of 2015. Wood continues to volunteer at the museum as a Friday docent and makes his home in Salem. He is married to the former Judith Ann Stokes and has three grown children and four grandchildren.

10:00 – 10:25 AM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

BREAK

SESSION E
10:25 AM

HARDNESS ASSURANCE
SESSION INTRODUCTION
Chair: Philippe Adell, NASA JPL

E-1 10:30 AM
Beyond Ground-Based Tests: Using Cubesats for Single Event Effects Hardness Assurance

B. D. Sierawski [1], K. M. Warren [1], A. L. Sternberg [1], R. A. Austin [1], J. M. Trippe [1], R. A. Reed [1], R. A. Weller [1], M. L. Alles [1], R. D. Schrimpf [1], L. W. Massengill [1], D. M. Fleetwood [1], A. Monterio [2], G. Buxton [2], J. Brandenburg [2], B. Fisher [2], R. Davis [2]
[1] Vanderbilt University; [2] Radio Amateur Satellite Corporation

Small satellites can complement ground tests to explore the impact of SEE mechanisms. A CubeSat is used to determine the contribution of low-energy proton SEU by enabling comparisons between observations and error rate predictions.

E-2 10:45 AM
Evaluating Constraints on Heavy-Ion SEE Susceptibility Imposed by Proton SEE Testing and Other Mixed Environments

R. L. Ladbury, J.-M. Lauenstein
NASA GSFC

We develop assessment metrics for effectiveness of proton SEE data for bounding heavy-ion SEE susceptibility. The metrics range from simple geometric criteria requiring no knowledge of the test articles to bounds of SEE rates.

E-3 11:00 AM
Simplified SEE Sensitivity Screening for COTS Components in Space

R. Garcia Alia [1], M. Brugger [1], S. Danzeca [1], J. Mekki [2], C. Poivey [3], V. Ferlet-Cavrois [3], E. Daly [3], A. Zadeh [3], R. Gaillard [4]
[1] CERN; [2] CNES; [3] ESA; [4] Consultant

A benchmarked Monte Carlo based approach is introduced for time and cost efficient screening of the SEE sensitivity of COTS components for space applications.

E-4 11:15 AM
Proton on Metal Fission Environments in an IC Package

T. L. Turflinger [1], D. A. Clymer [2], J. S. George [1], L. W. Mason [2], S. Stone [2], R. Koga [1], E. R. Beach [2], K. Huntington [2]
[1] The Aerospace Corporation; [2] Lockheed Martin Corporation

A study of proton-induced destructive SEE (DSEE) from Au-plated lid fission fragments has been expanded. Eleven additional lid materials (Z = 26-83) are studied. New analysis has allowed generalized RHA to be developed.

E-5 11:30 AM
Response Variability in Commercial MOSFET SEE Qualification

J. S. George [1], D. A. Clymer [2], T. L. Turflinger [1], L. W. Mason [2], S. Stone [2], R. Koga [1], E. R. Beach [2], K. D. Huntington [2], J.-M. Lauenstein [3], J. Titus [4]
[1] The Aerospace Corporation; [2] Lockheed Martin Corporation; [3] NASA GSFC; [4] NAVSEA Crane

SEE evaluation of next generation MOSFETs indicated large part-to-part variation in the safe operating area for drain-source voltage (VDS). Implications for radiation qualification requirements are explored.

E-6 11:45 AM

Inclusion of Radiation Environment Variability in Total Dose Hardness Assurance Methodology

M. A. Xapsos [1], C. Stauffer [2], A. Phan [2], S. S. McClure [3], R. L. Ladbury [1], J. A. Pellish [2], K. A. LaBel [1]
[1] NASA GSFC; [2] ASandD, Inc.; [3] JPL

Variability of the space radiation environment can have a significant impact on parts categorization for total dose hardness assurance methods. A new approach is proposed to account for this.

POSTER PAPERS

PE-1

Heavy Ion Irradiation Fluence Dependence for Single-Event Upsets of NAND Flash Memory

D. Chen [1], E. Wilcox [2], R. Ladbury [1], H. Kim [2], A. Phan [2], K. LaBel [1]
[1] NASA GSFC; [2] AS&D, Inc.

We investigate the SEE susceptibility of the Micron 16 nm NAND flash. We observed that upset cross sections decreased with increasing fluence. We attribute the effect to the variable upset sensitivities of the memory cells.

PE-2

Robust Duplication with Comparison Methods in Microcontrollers

H. Quinn, Z. Baker, T. Fairbanks, J. Tripp, G. Duran
LANL

Commercial microprocessors could be useful in spacecrafts, as long as the effect of single-event effects on the software can be masked. Results for a modification of duplication with comparison mitigation are presented.

PE-3

Neutron Displacement Damage Sensors: Extending the ASTM E1855 Standard Test Method to Neutron Fluences below 10^{12}

A. M. Tonigan, E. J. Parma, W. J. Martin
Sandia National Laboratories

The 2N1486 transistor is selected and demonstrated as an effective neutron displacement damage sensor below the lower bound of the ASTM test method E1855.

PE-4

A Modeling Approach to Assess Total Dose Response of COTS Analog Electronics for Fast Infusion

P. C. Adell [1], D. Sheldon [1], H. Schone [1], M. Rousselet [1], H. J. Barnaby [2]
[1] Jet Propulsion Laboratory; [2] Arizona State University

Simulations are used to reproduce the degradation trends induced by total dose for a commercial regulator. Results indicate that the risk-of-failure for a part can be evaluated with minimum radiation-testing.

12:00 – 1:30 PM
INDUSTRIAL EXHIBITS AREA/
EXHIBIT HALL A

LUNCH

SESSION F **HARDENING BY DESIGN**
1:30 PM SESSION INTRODUCTION
Chair: Lawrence Clark, Arizona State University

F-1 **Novel Charge-Steering Latch Design in 16-nm FinFET for Improved Soft**
1:35 PM **Error Hardness**
B. Narasimham [1], K. Chandrasekharan [1], J. K. Wang [1], B. L. Bhuva [2]
[1] Broadcom; [2] Vanderbilt University

A novel charge-steering based latch hardening technique is presented. Alpha, heavy-ion, proton test results from a 16-nm FinFET process indicates significant SEU hardness comparable to DICE at low LETs with low performance trade off.

F-2 **On the Use of Inverse-Mode SiGe HBTs as an Active Gain Stage in**
1:50 PM **Single-Event Tolerant RF Low-Noise Amplifiers**
I. Song [1], M.-K. Cho [1], N. E. Lourenco [1], Z. E. Fleetwood [1], S. Jung [1], N. J. Roche [2], A. Khachatrian [2], S. P. Buchner [2], D. McMorrow [2], P. Paki [3], J. D. Cressler [1]
[1] Georgia Institute of Technology; [2] US Naval Research Laboratory; [3] Defense Threat Reduction Agency

A full inverse-mode SiGe HBT-based LNA is proposed for SET mitigation. A through-wafer two-photon absorption pulsed-laser experiment was conducted. The proposed LNA exhibited 85% reduction in transient peaks.

F-3 **Combinational Logic Hardening Using Function-Driven Shannon**
2:05 PM **Decompositions**
H. Jiang [1], H. Zhang [1], T. R. Assis [2], B. L. Bhuva [1], L. W. Massengill [1], S.-J. Wen [3], R. Wong [3]
[1] Vanderbilt University; [2] Robust Chip, Inc.; [3] Cisco Systems, Inc.

An approach to design radiation tolerant combination logic circuits based on function-driven generalizations of Shannon decompositions is proposed. Heavy-ion exposures clearly show the effectiveness of this approach in reducing logic errors.

POSTER PAPERS

PF-1 **Single-Event Upset Performance of Stacked Flip-Flop Designs at the 28-nm FDSOI Technology Node**
H. Wang [1], J. S. Kauppila [2], L. Chen [1], R. Liu [1], B. L. Bhuva [1], K. L. Lilja [3], M. Bounasser [3], S. S. -J. Wen [4], R. Wong [4], R. Fung [4], S. Baeg [5], L. W. Massengill [2]
[1] University of Saskatchewan; [2] Vanderbilt University; [3] Robust Chip Inc.; [4] Cisco Systems; [5] Hanyang University

Heavy ion results were obtained for multiple flip-flop topologies in the 28-nm FDSOI technology. The hardened designs, utilizing the transistor-stacking RHBD technique, show significant reductions in SEU cross-section compared to standard designs.

PF2 The Specific Design Aspect for 65-nm CMOS Spaced Transistor Groups DICE Cells

V. Y. Stenin [1], Y. V. Katunin [2], P. V. Stepanov [2]
[1] National Research Nuclear University (Moscow Engineering Physics Institute); [2] Scientific Research Institute for System Analysis of the Russian Academy of Sciences

The new layout topology design of DICE memory cells was implemented to the reliable static cache and multiport RAM's, which have been designed, simulated, fabricated and have been characterized using pulsed laser technique.

PF-3 Neutron Cross-Section of a Hybrid-Hardened LEON3 Soft Core Processor Implemented in Low-End SRAM FPGA

A. Lindoso, L. Entrena, M. Garcia-Valderas, L. Parra
University Carlos III of Madrid

This work implements a hybrid-hardened LEON3 in a low-end FPGA (Artix7) and evaluates the neutron cross-section. It can be fully embedded in a low-end FPGA with reduced overhead and low intrusiveness.

PF-4 Analyzing Reliability and Performance Trade-Offs of HLS-Based Designs in SRAM-Based FPGAs under Soft Errors

F. L. Kastensmidt, L. Tambara, J. Tonfat, A. Flores
Institute of Informatics, UFRGS

We investigate different design optimizations using high level synthesis for FPGAs. Results show that it is possible to achieve significantly better MWBF by applying performance optimizations that does not considerably compromise the cross section.

PF-5 Radiation Hardening by Design of SiGe HBT Current-Mode Logic Circuits

S. Jung [1], I. Song [1], Z. E. Fleetwood [1], N. E. Lourenco [1], A. Ildefonso [1], M. A. Oakley [1], J. D. Cressler [1], D. McMorrow [2], S. P. Buchner [2], J. H. Warner [2], N. J. Roche [3], A. Khachatrian [4], P. Paki [5]
[1] Georgia Institute of Technology; [2] US Naval Research Laboratory; [3] George Washington University; [4] Sotera Defense; [5] Defense Threat Reduction Agency

We investigate radiation hardening by design techniques in DC bias blocks in high-speed SiGe HBT CML circuits.

PF-6 Ionizing Dose-Tolerant Enhancement-Mode Cascode for High-Voltage Power Devices

A. F. Witulski [1], A. Sternberg [1], J. Rowe [1], R. D. Schrimpf [1], J. Zydel [2], J. Schaf [2]
[1] Vanderbilt University; [2] Moog Inc.

An enhancement-mode cascode power device topology allows a high-voltage commercial device to be used with a low-voltage radiation-tolerant device to enable a switch that functions well at high total ionizing dose.

RADIATION EFFECTS DATA WORKSHOP
2:20 – 4:45 PM
OREGON BALLROOM 203-204

INTRODUCTION

Chair: Bert Vermeire, Space Micro

W-1 **Guide to the 2015 IEEE Radiation Effects Data Workshop Record**
D. M. Hiemstra
MDA

The 2015 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

W-2 **The Collation of the Electronic Components Intended to the Spacecraft Equipment Critical to SEE**
V. S. Anashin, A. E. Koziukov, P. A. Chubunov, K. Z. Faradian, S. A. Yakovlev, A. V. Perebeynos, A. V. Vlasov
URSC-ISDE

The paper presents SEE test results of COTS components considered to be applied in the satellite equipment and critical to SEL and/or catastrophic failure. They were provided to confirm electronic components required hardness level.

W-3 **Compendium of Total Ionizing Dose and Displacement Damage Results from NASA Goddard Space Flight Center**
M. J. Campola [1], D. J. Cochran [2], D. Chen [1], M. C. Casey [1], A. J. Boutte [1], S. M. Alt [1], E. P. Wilcox [2], K. A. LaBel [1], J. A. Pellish [1], R. L. Ladbury [1], J.-M. Lauenstein [1], M. V. O'Bryan [2], M. A. Xapsos [1]
[1] NASA GSFC; [2] AS&D

Vulnerability of a variety of candidate spacecraft electronics to total ionizing dose and displacement damage is studied. Devices tested include optoelectronics, digital, analog, linear bipolar devices, and hybrid devices.

W-4 **Compendium of Single Event Effects Results from NASA Goddard Space Flight Center**
M. V. O'Bryan [1], K. A. LaBel [2], C. M. Szabo [1], D. Chen [2], M. J. Campola [2], M. C. Casey [2], J.-M. Lauenstein [2], J. A. Pellish [2], M. D. Berg [1]
[1] AS&D; [2] NASA GSFC

We present the results of single event effects (SEE) testing and analysis investigating the effects of radiation on electronics. This paper is a summary of test results.

W-5 **Compendium of Ball Aerospace TID and SEE Test Results**

T. R. Oldham, J. Lee
Ball Aerospace

We have conducted TID and SEE tests on a variety of parts intended for application in a number of Ball Aerospace space systems. Results and discussion are presented.

W-6 **Recent Gallium Nitride Power HEMT Single-Event Testing Results**

L. Z. Scheick
Jet Propulsion Laboratory

The results of recent Single Event Effect (SEE) testing of newly available power GaN HEMTs are presented.

W-7 **SEE and TID Effects in Transistors and Voltage Reference Devices**

J. S. George, J. R. Srour, M. A. Tockstein, B. P. Kwan, A. W. Wright, J. Bonsall, R. Koga, S. C. Davis
The Aerospace Corporation

We tested two transistor and two voltage reference devices for single event effects and combined displacement damage and total ionizing dose effects. The results of these tests are reported along with on-orbit rate calculations.

W-8 **Displacement Damage Testing of Intersil Analog and Power Management Parts**

N. W. van Vonno [1], K. A. Scott [2], L. G. Pearce [1], J. S. Gill [1], F. Ballou [1]
[1] Intersil; [2] Boeing Satellite Systems

We report the results of 1 MeV equivalent neutron testing of a range of Intersil power management and analog parts, including operational amplifiers, voltage references, linear voltage regulators, comparators, power MOSFET drivers and pulse width modulators.

W-9 **Measurements of Proton Displacement Damage in Several Commercial Optocouplers**

F. Irom, G. R. Allen, B. G. Rax
Jet Propulsion Laboratory

This paper reports radiation test results for a variety of optocouplers. These data were collected to evaluate these devices for possible use in NASA spacecraft.

W-10 **Heavy Ion Induced Single-Event Latchup Screening of Integrated Circuits Using Commercial off-the-Shelf Evaluation Boards**

G. R. Allen, F. Irom, L. Scheick, S. Vartanian, M. O'Connor
Jet Propulsion Laboratory

We present heavy ion single-event latchup (SEL) screening data for a variety of commercial-off-the-shelf (COTS) devices intended for use on low-cost missions.

W-11 **Radiation Evaluation of the TPS7H3301-SP Linear Regulator for Double Data Rate (DDR) Applications**

J. Cruz-Colon, M. Hamlym, V. Zhu, B. A. Dahl, R. C. Baumann
Texas Instruments

Single Events Effect (SEE) characterization results for a new Double Data Rate (DDR) linear voltage regulator is summarized, showing very robust SEE performance up to 65.1 MeV-cm^2/mg.

W-12 **The Effects of Co-60 Gamma Exposure on Common Commercial Components of Embedded Systems**

M. Nancekievill, B. Lennox, P. R. Green, S. Watson
University of Manchester

Researching the effects of gamma exposure on COTS components, specifically power regulation and supply, to aid development of nuclear decommissioning embedded systems for surveying and monitoring in sub-soil/aquatic environments.

W-13 **Proton and Heavy Ion Sensitivity of Commercial Instrumentation and Precision Operational Amplifiers**

S. C. Davis, R. Koga, J. S. George
The Aerospace Corporation

We performed proton and heavy-ion testing of selected commercial instrumentation and precision operational amplifiers. Based on these tests, we present cross section results and on-orbit upset rates for single event effects.

W-14 **Multifunctional Equipment and Test Results for Total Ionizing Dose Testing of Analog Integrated Circuits**

A. S. Bakerenkov [1], P. A. Chubunov [1, 2], V. S. Anashin [2], A. S. Rodin [1], V. A. Felitsyn [1]
[1] Moscow Engineering Physics Institute; [2] URSC–ISDE

Multifunctional equipment for total ionizing dose testing of different functional types of analog integrated circuits and discrete transistors is developed and described. Corresponding test results for several types of analog devices are presented and discussed.

W-15 **Evaluation of Elevated Temperature Irradiation on LM139 Bipolar Linear Microcircuit**

G. K. Ott [1], J. F. Salzman [2]
[1] Cobham RAD Solutions; [2] Texas Instruments

In this study samples of bipolar linear microcircuit LM139 were irradiated at a combination of dose rates and temperatures to evaluate our ability to use the ETI (Elevated Temperature Irradiation) technique to accelerate ELDRS effects.

W-16 **ELDRS Characterization to 300 krad of Texas Instruments High Speed Amplifier LMH6702**

K. Kruckmeyer, T. Trinh
Texas Instruments

The LMH6702 was tested to 300 krad at 10 mrad/s. Testing to 300 krad took one year. The LMH6702 was found to be ELDRS-free.

W-17 **Heavy-Ion Testing Results for Several Commercial and Military Grade Parts**

B. R. Buck, K. Bojanowski, A. Cunningham
MIT Lincoln Laboratory

We report the results of testing five components for single event effects at the 88-inch Cyclotron at Lawrence Berkeley National Laboratory.

W-18 **Heavy Ion and Proton Single Event Susceptibility of Commercial Analog Switch Microcircuits**

R. Koga, S. Bielat, S. Davis, J. George
The Aerospace Corporation

We present observations of heavy ion and proton induced single event effects in selected COTS analog switch integrated microcircuits.

W-19 **Single Event Effects Testing of a Commercial Off-The-Shelf Analog-to-Digital Converter in a Camera Link Application**

M. J. Campola [1], C. Thayer [2], J. P. Doty [3], E. P. Wilcox [4]
[1] NASA GSFC; [2] MIT; [3] Noqsi Aerospace; [4] AS&D

Single event effect data are presented on the Analog Devices AD7984. The recent heavy-ion test results showcase application-specific results for the commercial part in its intended application.

W-20 **Single Event Effects Characterization of TI ADS1282-SP High Resolution ADC**

S. Narayanan, W. Vonbergen, J. Cruz-Colon, V. Narayanan
Texas Instruments

The single event effects behavior of the ADS1282SP, a high dynamic range ADC, are presented. No latchup events were detected up to LET of 43.6 MeV.cm^2/mg at 85 °C and 125 °C.

W-21 **The Use of 14-MeV Monoenergetic Neutrons to Improve the Single Event Latch up Response of the Texas Instruments VSP1221**

A. R. Benedetto [1], J. Salzman [2], M. Tostanoski [3], J. M. Benedetto [4]
[1] Colorado State University; [2] Texas Instruments; [3] IRCOS; [4] Cobham RAD Solutions

The SEL response of the VSP1221 is improved by exposure to 14 MeV monoenergetic neutrons while only causing small changes in the parametric response. This approach could be used to advance COTS components in spaceborne applications.

W-22 Radiation Hardness of the CLARO8 ASIC: a Fast Single-Photon Counting Chip for the LHCb Experiment at CERN

M. Andreotti [1], W. Baldini [1], M. Baszczyk [2], R. Calabrese [1], A. Candelori [3], P. Carniti [4], L. Cassina [4], A. Cotta Ramusino [1], P. Dorosz [2], M. Fiorini [1], A. Giachero [4], C. Gotti [4], W. Kucewicz [2], E. Luppi [1], M. Maino [4], R. Malaguti [1], S. Mattiazzo [3], L. Pappalardo [1], G. Pessina [4], L. Tomassetti [1]
[1] University of Ferrara; [2] AGH University of Science and Technology and INP; [3] University of Padova; [4] University of Milano Bicocca

Radiation hardness tests of the CLARO8 ASIC, designed in AMS 0.35 micron CMOS technology for the upgrade of the CERN LHCb RICH detectors, are presented, including measurements of total-ionizing dose and single event effects.

W-23 Total Ionizing Dose Characterization of an 8-Bit 200 MSps Switched-Capacitor Pipeline A-to-D Converter in 32 nm SOI CMOS

A. Zanchi, M. Cabanas-Holmen, M. Yao, B. Meaker, A. Amort
The Boeing Company

A radhard by design 8-bit 32 nm SOI CMOS pipeline ADC shows no AC performance nor non-linearity worsening vs. TID @ 200 MSps, -1 dBFS sine wave input, maintaining >42 dBFS SNR, >61 dBc SFDR to 1 Mrad(Si) after calibration.

W-24 Single Event Effects in 14-nm Intel Microprocessors

A. R. Duncan [1], C. M. Szabo [2], K. A. LaBel [3], M. J. Gadlage [1], D. P. Bossev [1], A. Williams [1], A. H. Roach [1], M. J. Kay [1], J. D. Ingalls [1]
[1] NSWC CRANE; [2] AS&D; [3] NASA GSFC

Single event effects data on 14-nm Intel microprocessors are presented. Heavy ion test data with respect to angle, rotation and test condition is discussed. Proton test data from four different facilities is analyzed.

W-25 Single Event Effects Testing of the Hardened Texas Instruments MSP430F5739 Microcontroller with Embedded Ferroelectric Memory

J. Aarestad [1], P. Eaton [2], W. Burke [2], D. Alexander [1], J. Salzman [3], K. Avery [4]
[1] COSMIAC; [2] Microelectronics Research & Development Corporation; [3] Texas Instruments; [4] Air Force Research Laboratories

MSP430F5739 tests at LBNL Cyclotron used the Milli-Beam apparatus to restrict exposure to specific blocks. Instruction lock-step techniques synchronized DUT outputs with an unexposed device. We report cross-sections for the device.

W-26 Input Size Effects on the Radiation-Sensitivity of Modern Parallel Processors

D. Oliveira [1], L. Pilla [2], F. Fernandes [1], C. Lunardi [1], P. Navaux [1], L. Carro [1], P. Rech [1]
[1] Universidade Federal do Rio Grande do Sul; [2] UFSC, Florianopolis, SC, Brazil

We inspect the importance of varying input dimensions to characterize parallel processors. Experimental results obtained with different input dimensions allow the evaluation and comparison of Intel Xeon-Phis and NVIDIA GPUs parallel processes management reliability.

W-27 **Single-Event Effects and Total Dose Testing of the Intersil ISL72027SEH CAN Bus Transceiver**

N. W. van Vonno, A. G. Robinson, L. G. Pearce, E. J. Thomson
Intersil

We report the results of destructive and nondestructive single-event effects testing and total dose testing of the Intersil ISL72027SEH Controller Area Network (CAN) bus transceiver together with a brief discussion of the CAN protocol.

W-28 **SEL and TID on a Radiation Hardened 1:1 Bus Switch Family**

M. Von Thun, S. Sapp, D. Walz, G. R. Anderson, T. Farris
Cobham Semiconductor Solutions

Radiation testing was performed on a Cobham designed radiation-hardened 1:1 Bus Switch. SEL immunity and TID results are reviewed.

W-29 **SEL and TID on a Radiation Hardened CAN Transceiver**

M. Von Thun, D. Bass, D. Walz, G. R. Anderson, J. Mitchell, T. Farris
Cobham Semiconductor Solutions

Radiation testing was performed on a Cobham designed radiation-hardened CAN transceiver. SEL immunity and TID results are reviewed.

W-30 **Single Event Upset Characterization of the Kintex UltraScale Field Programmable Gate Array Using Proton Irradiation**

D. M. Hiemstra, V. Kirischian, J. Brelski
MDA

Proton induced SEU cross-sections of the SRAM which stores the logic configuration and certain functional blocks of the Kintex UltraScale FPGA are presented. Upset rates in the space radiation environment are estimated.

W-31 **An Analysis of High-Current Events Observed on Xilinx 7-Series and UltraScale Field-Programmable Gate Arrays**

D. S. Lee [1], G. Swift [2], M. Wirthlin [3]
[1] Sandia National Laboratories; [2] Swift Engineering and Radiation Services; [3] Brigham Young University

This study examined high-current events observed in Xilinx field-programmable gate arrays irradiated with heavy ions. A probable cause and proposed changes to the test methodology to prevent these high-current events is described.

W-32 **Design and Test of Xilinx Embedded ECC for MicroBlaze Processors**

Z. Baker, H. Quinn
Los Alamos National Laboratory

The Xilinx Virtex-5QV is robust to configuration errors, but has block RAM upsets. Various approaches to scrubbing block RAM to support the Xilinx MicroBlaze soft processor were tested at LANSCE.

W-33 Heavy-Ion Testing on SEU of Flip-Flops, PLLs and SERDES in RTG4 Flash FPGA

D. Dsilva, J.-J. Wang, N. Rezzak, S. Cui
Microsemi

Heavy ion SEE testing of the RTG4 Reprogrammable Flash FPGAs is performed. SEU/SET is studied for the Flip-Flops and PLLs in triplicated mode and SEFI is studied for the SERDES/PCIe.

W-34 SEE Site Localization Using Masking, Imaging, and Laser Techniques: A Case Study on Xilinx 28 nm 7-Series FPGAs

W. Rudge [1], B. Boesch [1], C. Dinkins [1], D. Vail [1], J. Bruckmeyer [1], G. Swift [2]
[1] Harris Corporation; [2] Swift Engineering and Radiation Services

A novel methodology for localizing sparse SEE-susceptible sites was successfully used to isolate the die region and identify the sensitive subcircuit responsible for a low-current latchup susceptibility in Xilinx 28 nm 7-Series FPGAs.

W-35 Total Ionizing Dose Effects and Annealing Behavior of a Commercial 16 Mb Magneto-Resistive Random Access Memory

H. H. Zhang [1], J. S. Bi [1], L. Chen [2], J. Li [1], L. Ji [1], H. Hu [1], L. Hao [1], M. Liu [1]
[1] Chinese Academy of Sciences; [2] University of Saskatchewan

Total ionizing dose effects by cobalt-60 and following room temperature annealing behaviors of 16 Mb commercial MRAM are experimentally evaluated in detail. The results are useful for radiation-tolerant MRAM development aiming at space applications.

W-36 Total Ionizing Dose Response of SDRAM, DDR2 and DDR3 Memories

M. Amrbar, S. M. Guertin
Jet Propulsion Laboratory

TID response of SDRAM, DDR2 and DDR3 memories are reported in static bias, and auto refresh modes. Data analysis reveals some types of memory have significant increases in stuck bits during TID exposure when refreshed.

W-37 Single Event Testing of SDRAM, DDR2, and DDR3 Memories

S. M. Guertin, M. Amrbar
Jet Propulsion Laboratory

SEE test results are presented for SDRAM, DDR2, and DDR3. No tested devices exhibited SEL. SBUs were observed, but no MBUs were observed in data words. SEFI data were taken at low and high speed.

W-38 TID Induced Functional Failure in 65 nm Commercial SRAMs at Dose Lower than 300 krad

Q. Zheng, J. Cui, H. Zhou, D. Yu, D. Su, X. Yu, Q. Guo, W. Lu
Chinese Academy of Sciences

65 nm commercial SRAMs have been tested for total dose effects. Functional failure in devices is detected at dose lower than 300 krad and exhibits peculiar functional failure mode.

W-39 TID/SEE Tests of the Radiation Hardened DDR2 SDRAM Memory Solution

P.-X. Wang [1], C. Sellier [1], P. Southiratn [2], D. Nguyen [3], K. Grurmann [4]
[1] 3D PLUS; [2] SODETEST; [3] ManTech International; [4] DSI

We report on radiation tests results of a state of the art RH DDR2 SDRAM Memory solution. The hard errors (TID/SEL) verified at die level, and soft errors (SEU/SEFI) verified at system level.

W-40 Radiation Hardness Performance of 2 Gbit Low Power DDR SDRAM Fabricated on Epitaxial Wafer for Space Applications

M. Y. Park, J.-S. Chae, C. Lee, J. Lee, I. H. Shin, S. Ji
Korea Advanced Institute of Science and Technology

Radiation hardness performance of 2 Gbit low-power double data rate synchronous dynamic random access memories (LPDDR SDRAMs) fabricated on a 4 micrometer epitaxial layer (38 nm CMOS technology) are presented.

W-41 Total Ionizing Dose and Heavy Ion Effects of 4 Mb Serial-Peripheral-Interface NOR Flash Memory

J. Bi [1], L. Chen [2], J. Li [1], L. Ji [1], H. Hu [1], M. Liu [1]
[1] Chinese Academy of Sciences; [2] University of Saskatchewan

The impacts of total ionizing dose by cobalt-60 and heavy ions on the 4 Mb SPI NOR flash memory were studied in detail. Electrical parameters degradation and SEU bit map are demonstrated with physical explanations.

W-42 SEE Testing of the 4 Gb Samsung and Spansion Flash NAND

D. L. Hansen, R. Hilman, F. Meraz, J. Montoya, G. Williamson
Maxwell Technologies

Single event effect (SEE) testing was performed on the Samsung and Spansion 4 Gb NAND flash devices. Testing and analysis showed that MBU became more prevalent at higher LET values.

W-43 Heavy Ion and Proton Test Results for 4 Gb Micron NAND Flash Memory

J. S. Hack, K. Altvater, D. Brown, P. Dudek, D. Jaeger, E. Lane, J. Lindley, B. Song, T. Tittel
Northrop Grumman Mission Systems

This paper describes the methodology and test results from heavy ion and proton testing of the Micron 4 Gb NAND flash memory, with particular attention to characterization of the previously observed transient high current effect.

W-44 Heavy Ion, Proton and Electron Single-Event Effect Measurements of a Commercial Samsung NAND Flash Memory

F. Irom, G. R. Allen, D. J. Sheldon
Jet Propulsion Laboratory

Heavy ion, proton and electron SEE measurements of 8 Gb Samsung SLC NAND are reported. An increase SEU was observed on devices that had TID, previously. The proton and electron susceptibility is less than expected.

W-45 3 MeV Proton Irradiation of Commercial State of the Art Photonic Mixer Devices

M. Grimm, B. Voß, E. Wendler
University of Applied Sciences, Jena

Ten identical novel commercial off-the-shelf near range sensors whose working principle is based on a time of flight measurement were irradiated with 3 MeV protons. Degradation effects were observed from 7 x 10^{10} p/cm^2.

W-46 1.8 MeV Electron Radiation Effects on $Al_{0.5}Ga_{0.5}N$ p-i-n Solar-Blind Ultraviolet Light Detector

Bo Wang [1, 2], Yudong Li [1], Lin Wen [1, 2], Qi Guo [1, 2], Diyuan Ren [1], Erkin [1], Wu Lu [1], Chenfa He [1], Xuefeng Yu [1], Jing Sun [1]
[1] Xinjiang Technical Institute of Physics and Chemistry; [2] Chinese Academy of Sciences

1.8 MeV electron irradiation induced degradation of electrical characteristics of high Al content $Al_{0.5}Ga_{0.5}N$ solar-blind light detectors were measured. These parameters had similar degradation tendencies, attributed to shallow levels near the dopant levels in the material.

W-47 Gamma Radiation Induced Effects in Silicon Nitride and Amorphous Silicon Films and Photonic Devices

Q. Du [1], Y. Huang [1, 2], O. Ogbuu [1], V. Singh [1], C. Monmeyran [1], N. Patel [1], A. Agarwal [1], J. Hu [1]
[1] Massachusetts Institute of Technology; [2] Xiamen University

Gamma-ray induced radiation damage is studied in silicon nitride and hydrogenated amorphous silicon materials and photonic devices. Our results reveal that radiation induced surface oxidation accounts for the observed refractive index drift.

W-48 Effect of Gamma Exposure on Chalcogenide Glass Films for Microphotonic Devices

S. Novak [1, 2], V. Singh [3], C. Monmeyran [3], A. Ingram [4], Z. Han [3], H. Lin [3], N. Borodinov [1], N. Patel [3], Q. Du [3], J. Hu [3], I. Luzinov [1], R. Golovchak [5], A. Agarwal [3], K. Richardson [1]
[1] Clemson University; [2] University of Central Florida; [3] Massachusetts Institute of Technology; [4] Opole University of Technology; [5] Austin Peay State University

Bulk and thermally evaporated film forms of As_2Se_3 and $Ge_{23}Sb_7S_70$ were subjected to gamma irradiation and characterized periodically after exposure. Differences in the effect of exposure were observed between bulk and film forms.

W-49 On-Orbit Measurements of TID and Dose Rate from Two RADFETs on Board NANOSAT-1B Satellite

M. Álvarez, J. J. Jiménez, P. Manzano, D. Escribano, C. Hernando, I. Arruego
National Institute for Aerospace Technology

TID and dose rate data from two different RADFETs from Tyndall on board NANOSAT-1B from 2009 to the end of mission (July 2015) are presented. Data are in agreement with prediction models.

W-50 **Laser Single Event Effects Response of Optek and Infineon Hall Effect Sensors**

M. Newton [1], H. Wang [1], L. Chen [1], D. M. Hiemstra [2], V. Kirischian [2]
[1] University of Saskatchewan; [2] MDA

Single photon absorption laser single event effects test results for the Optek and Infineon hall effect sensors are presented. The results are compared to previously published heavy ion data for the Optek sensor.

W-51 **Two Photon Absorption Laser Facility for Single Event Effect Testing**

M. Newton [1], B. Danger [1], H. Wang [1], L. Chen [1], D. M. Hiemstra [2], V. Kirischian [2]
[1] University of Saskatchewan; [2] MDA

The laser facility for single event effect (SEE) testing at the Saskatchewan Structural Sciences Centre is introduced. SEE studies via two photon absorption (TPA) are described. Data on a Virtex-5 FPGA are provided.

W-52 **TID Irradiation Facility Utilizing Novel Alanine Dosimetry**

A. M. Sanchez, V. Brisan, A. DiFonzo
VPT RAD

VPT provides cobalt-60 gamma irradiation facilities and test solutions utilizing NIST traceable alanine dosimetry. This innovative dosimetry technique ensures that gamma exposures meet or exceed the requirements of MIL STD-750/883 TM 1019.

W-53 **IC SEE Comparative Studies at UCL and JINR Heavy Ion Accelerators**

A. O. Akhmetov [1], D. V. Bobrovskiy [1], A. S. Tararaksin [1], A. G. Petrov [1], L. N. Kessarinskiy [1], D. V. Boychenko [1], A. I. Chumakov [1], A. Rousset [2], C. Chatry [2]
[1] Moscow Engineering Physics Institute; [2] TRAD Test & Radiation

The paper presents new experimental results on single event effects (SEL, SEU, SET) in modern ICs obtained at "U-400M" heavy ion accelerator (JINR, Dubna, Russia) and UCL heavy ion accelerator (Louvain-la-Neuve, Belgium).

4:45 PM END OF WEDNESDAY SESSIONS

OREGON BALLROOM 201-202
INVITED TALK
8:45 – 10:00 AM

VLSI Technology Reliability Beyond the 'Golden Age' of Moore's Law Silicon Scaling
Jeffrey Hicks, Intel

In the 50 years since Gordon Moore's seminal paper, the exponential growth of integrated electronics capabilities he predicted, has been sustained, fueled largely by successful scaling of Si-based semiconductor devices. Improvements in reliability commensurate with the increases in component density and functionality has been an essential element of this success story despite the discovery of mechanisms such as radiation induced soft errors which were unknown at the time of Gordon's paper. This talk will discuss the reliability obstacles which have been encountered and overcome, particularly on recent generations of Si technology where increasing levels of innovation have been required. We will look forward to the challenges now facing continued scaling and what this may mean for the reliability community.

Jeffrey Hicks is a Fellow and Director of Technology Reliability Pathfinding in Intel's Technology Development Quality and Reliability Group. He received his BS in Applied Physics from Cal Tech in 1980 and joined Intel's Technology Development Group in Santa Clara CA in that year as a reliability engineer working on Bipolar and EPROM non-volatile memory technologies. In his subsequent years at Intel to date Mr. Hicks has served in numerous Quality and Reliability functions spanning Technology Development, Manufacturing, Product, and Customer Quality and Reliability. He currently manages Reliability Pathfinding for Intel's chip technologies. He has authored or coauthored over 20 refereed papers including two best of conference (IRPS), has been issued four patents, and is the recipient of four Intel achievement awards. He serves on the board of IRPS.

10:00 – 10:25 AM
OREGON BALLROOM 203-204

BREAK

SESSION G
10:25 AM

SINGLE EVENT EFFECTS: MECHANISMS AND MODELING
SESSION INTRODUCTION
Chair: Michael King, Sandia National Laboratories

G-1
10:30 AM

Proton Dominance of Sub-LET Threshold GCR SEE Rate
R. Garcia Alia [1], V. Ferlet-Cavrois [2], M. Brugger [1], S. Brandenburg [3], E. Daly [2], M. Muschitiello [2], G. Santin [2], A. Zadeh [2]
[1] CERN; [2] ESA; [3] KVI-CART

Through a benchmarked Monte Carlo model, the proton and heavy ion sub-LET threshold GCR SEE rates are evaluated and compared, showing that protons dominate in the full LET threshold range.

G-2
10:45 AM

Low Energy Proton (LEP) SEUs in 32 nm SOI SRAMs at Low V_{dd}
K. P. Rodbell [1], M. S. Gordon [1], K. G. Stawiasz [1], P. Oldiges [1], K. Lilja [2], M. Turowski [2]
[1] IBM; [2] Robust Chip

Single Event Upset (SEU) modeling cross-sections versus measurements (heavy ions, MeV and low energy protons (LEP)) are shown for a 32 nm SOI SRAM, from 0.4 - 1.05 V.

G-3 11:00 AM
Analysis of the Suitability of LET for Parameterising SEE Cross Sections of Nanoscale MOSFET Devices

P. Truscott [1], F. Lei [2], V. Ferlet-Cavrois [3], G. Santin [3]
[1] Kallisto Consultancy Ltd; [2] RadMod Research Ltd; [3] European Space Agency

Geant4 simulations are used to explore whether ion LET remains the best metric for parameterising energy-deposition spectra in 14 nm and 28 nm devices, and show alternative metrics (such as restricted dE/dx) provide more consistent performance.

G-4 11:15 AM
Using TCAD Modeling to Compare Heavy-Ion and Laser-Induced Single Event Transients in SiGe HBTs

Z. E. Fleetwood [1], N. E. Lourenco [1], A. Ildefonso [1], J. H. Warner [2], M. T. Wachter [1], J. Hales [3], N. J. J. -H. Roche [4], A. Khachatrian [3], D. McMorrow [2], S. P. Buchner [2], P. Paki [5], J. D. Cressler [1]
[1] Georgia Institute of Technology; [2] US Naval Research Laboratory; [3] Sotera Defense; [4] The George Washington University; [5] Defense Threat Reduction Agency

TCAD modeling techniques are investigated and used to compare single event transients extracted from heavy-ion and pulsed-laser measurements across a variety of SiGe HBT test structures.

G-5 11:30 AM
The Impact of Technology Scaling on the Single-Event Transient Response of SiGe HBTs

N. E. Lourenco [1], Z. E. Fleetwood [1], A. Ildefonso [1], M. T. Wachter [1], N. J.-H. Roche [2], A. Khachatrian [3], D. McMorrow [4], S. P. Buchner [4], J. H. Warner [4], H. Itsuji [5], D. Kobayashi [5], K. Hirose [5], P. Paki [6], J. D. Cressler [1]
[1] Georgia Institute of Technology; [2] The George Washington University; [3] Sotera Defense; [4] US Naval Research Laboratory; [5] Japan Aerospace Exploration Agency; [6] Defense Threat Reduction Agency

The impact of technology scaling on SEE response of SiGe HBTs is investigated via pulsed-laser and broadbeam testing of device and circuit test structures. TCAD simulations are utilized to ascertain the underlying transient mechanisms.

G-6 11:45 AM
Heavy Ion Induced Degradation in SiC Schottky Diodes: Bias and Energy Deposition Dependence

A. Javanainen [1, 2], K. F. Galloway [1], C. Nicklaw [3], V. Ferlet-Cavrois [4], A. Bosser [2], J.-M. Lauenstein [5], F. Pintacuda [6], R. A. Reed [1], R. D. Schrimpf [1], R. A. Weller [1], A. Virtanen [2]
[1] Vanderbilt University; [2] University of Jyväskylä; [3] Silvaco, Inc.; [4] European Space Agency; [5] NASA-GSFC; [6] STMicroelectronics

Experimental results on ion-induced leakage current increase in SiC Schottky power diodes are presented. Monte Carlo simulations and TCAD show that degradation is due to the synergy between applied bias and ion energy deposition.

POSTER PAPERS

PG-1 Upsets in Erased Floating Gate Cells with High-Energy Protons

S. Gerardin [1], M. Bagatin [1], A. Paccagnella [1], A. Visconti [2], M. Bonanomi [2], M. Calabrese [2], L. Chiavarone [2], V. Ferlet-Cavrois [3], J. R. Schwank [4], M. R. Shaneyfelt [4], N. Dodds [4], M. Trinczek [5], E. Blackmore [5]
[1] Università di Padova; [2] Micron Technology; [3] ESA; [4] Sandia National Laboratories; [5] TRIUMF

We present evidence of a possible new mechanism leading to upsets in erased floating gate cells. Memories exposed to high energy protons seem to exhibit negative charge transfer between programmed and erased cells.

PG-2 The Power Law Shape of Heavy Ions Experimental Cross Section

F. Wrobel [1], A. D. Touboul [1], V. Pouget [1], L. Dilillo [1], E. Lorfevre [2], F. Saigne [1]
[1] Université Montpellier; [2] CNES

Assuming continuous variation of the charge collection in the sensitive volume, we find analytically that heavy ion SEU cross section follows a power law. Results are in agreement with experimental data from 250 nm to 28 nm.

PG-3 Single-Event Measurement and Analysis of Antimony-Based P-Channel Quantum-Well MOSFETs with High-k Dielectric

M. J. Barth [1], A. Kumar [2], J. H. Warner [3], B. R. Bennett [4], J. B. Boos [3], C. D. Cress [3], N. J.-H. Roche [5], P. Paillet [6], M. Raine [6], M. Gaillardin [6], D. McMorrow [3], K. Saraswat [2], S. Datta [7]
[1] The Pennsylvania State University; [2] Stanford University; [3] US Naval Research Laboratory; [4] Office of Naval Research; [5] George Washington University; [6] CEA; [7] University of Notre Dame

This work presents the first measurements of the heavy-ion-induced transient response of $In_{0.33}Ga_{0.67}Sb$ QW-MOSFETs. Sentaurus TCAD is used to model the charge deposition, transport, and collection characteristics.

PG-4 Disruptive Effects of Bulk FinFET Structures on Single-Event Cross Sections

P. Nsengiyumva, D. R. Ball, M. L. Alles, J. S. Kauppila, W. T. Holman, R. A. Reed, B. L. Bhuva, L. W. Massengill
Vanderbilt University

Interpretation of the measured and simulated SEU responses of bulk planar and FinFET circuits using a short pulse metric quantitatively explains the observed divergence of low-LET FinFET cross-sections from simple geometric scaling predictions.

PG-5 A Simplified Engineering Model for Predicting Pulsed-Laser-Induced Carrier Generation in Semiconductors

J. M. Hales [1, 2], A. Khachatrian [1, 2], S. Buchner [1], N. J.-H. Roche [1, 3], J. Warner [1], D. McMorrow [1]
[1] US Naval Research Laboratory; [2] Sotera Defense Solutions; [3] George Washington University

Simplified analytical expressions for calculating the pulsed-laser induced charge generation are presented for charge deposition by single-photon and two-photon absorption. Good agreement with experimental results is observed.

12:00 – 1:30 PM LUNCH

SESSION H **SINGLE EVENT EFFECTS: DEVICES AND INTEGRATED CIRCUITS**
1:30 PM SESSION INTRODUCTION
Chair: Bharat Bhuva, Vanderbilt University

H-1 **On-Orbit Upset Rate Prediction at Advanced Technology Nodes: A**
1:35 PM **28 nm FD-SOI Case Study**
V. Malherbe [1], G. Gasiot [1], D. Soussan [1], J.-L. Autran [2], P. Roche [1]
[1] STMicroelectronics; [2] Aix-Marseille University

We derive on-orbit single event upset rates of a 28 nm FD-SOI SRAM by combining heavy-ion experimental data with radiation environment simulations. Various modeling approaches are discussed regarding the cell's radiation response.

H-2 **Effects of Threshold Voltage Variations on Single-Event Response of**
1:50 PM **Sequential Circuits at Advanced Technology Nodes**
H. Zhang [1], H. Jiang [1], T. R. Assis [2], N. N. Mahatme [3], L. W. Massengill [1], B. L. Bhuva [1], S.-J. Wen [4], R. Wong [4]
[1] Vanderbilt University; [2] Robust Chip, Inc.; [3] NXP Semiconductors; [4] Cisco Systems, Inc.

Single-event cross-sections of flip-flops and logic circuits in 16-nm bulk FinFET technologies with different V_T options are investigated to show SVT option has the highest SE cross-section.

H-3 **Single-Event Upsets Induced by Direct Ionization from Low-Energy**
2:05 PM **Protons in Floating Gate Cells**
M. Bagatin [1], S. Gerardin [1], A. Paccagnella [1], A. Visconti [2], A. Virtanen [3], H. Kettunen [3], A. Costantino [4], V. Ferlet-Cavrois [4], A. Zadeh [4]
[1] Università di Padova; [2] Agrate Brianza; [3] University of Jyväskylä; [4] ESA

Experimental evidence of single event upsets induced by proton direct ionization in floating cells is reported for advanced NAND Flash memories. Energy dependence, threshold LET, and technology scaling trends are discussed.

H-4 **Quantitative Analysis of Temporal Masking Effect of Flip-flop SEUs in**
2:20 PM **Bulk 40 nm Sequential Circuits**
R. M. Chen [1], Z. J. Diggins [2], N. N. Mahatme [3], L. Wang [1], E. X. Zhang [2], Y. R. Chen [2], Y. N. Liu [4], B. Narasimham [5], A. F. Witulski [2], B. L. Bhuva [2], L. W. Massengill [2], D. M. Fleetwood [2]
[1] Tsinghua University; [2] Vanderbilt University; [3] NXP Semiconductors; [4] Beijing Microelectronics Technology Institute; [5] Broadcom Corporation

Temporal masking effect of flip-flop SEUs is quantitatively analyzed and demonstrated under different frequencies and supply voltages in a commercial bulk 40 nm technology. Simulation and experimental data show good agreement with analytical models.

H-5 2:35 PM

SER Performance of Sense-Amplifier Based Flip-Flop Design in a 16-nm Bulk FinFET CMOS Process

H. Jiang [1], H. Zhang [1], T. R. Assis [2], B. Narasimham [3], B. L. Bhuva [1], W. T. Holman [1], L. W. Massengill [1]
[1] Vanderbilt University; [2] Robust Chip, Inc.; [3] Broadcom Corp.

Single-event cross-sections for sense-amplifier based flip-flop design for high-speed operations are evaluated over particle LET, temperature, and frequency. Results show significant increases in cross section as a function of frequency increases, but not so for temperature.

POSTER PAPERS

PH-1

First Results of Radiation Experiments on a 28-nm Single-Chip Many-Core Processor

V. Vargas [1, 3], P. Ramos [1, 3], V. Ray [2], C. Jalier [2], B. D. de Dinechin [2], M. Baylac [4], F. Villa [4], S. Rey [4], B. Minguez [2], R. Velazco [1]
[1] University of Grenoble-Alpes; [2] Kalray; [3] Universidad de las Fuerzas Armadas ESPE; [4] University of Grenoble

This work evaluates the SEE static and dynamic sensitivity of a single-chip many-core processor built in 28 nm CMOS technology exposed to 14 MeV neutron radiation with its cache memories enabled and disabled.

PH-2

Effects of Angular Incidence on Single-Event Cross-Section of Flip-Flop Designs in 16-nm Bulk FinFET Technology

H. Zhang [1], H. Jiang [1], T. R. Assis [2], S. Ball [1], L. W. Massengill [1], B. L. Bhuva [1], B. Narasimham [3]
[1] Vanderbilt University; [2] Robust Chip, Inc.; [3] Broadcom Corporation

3D-TCAD simulation and heavy-ion experiments are used to investigate angular dependence of upset cross-sections for flip-flop (FF) designs. Upset cross-section trends for FinFET node are different from previously reported trends for planar nodes at roll and tilt angles.

PH-3

A Hybrid Approach to FPGA Configuration Scrubbing in High-Radiation Environments

A. Stoddard, A. Gruwell, P. Zabriskie, M. Wirthlin
Brigham Young University

This paper presents an FPGA configuration scrubbing architecture that uses a combination of built-in error-correction circuitry and external scrubbing to detect and correct radiation upsets. Radiation beam test results are presented, validating this scrubbing architecture.

PH-4

Heavy-Ion Micro Beam Study of a Flash-Based FPGA Microcontroller Implementation

C. U. Ortega [1], A. Evans [2], K. Marinis [1], E. Costenaro [2], H. Laroussi [1], K.-V. Obbe [3], G. Magistrati [1], V. Ferlet-Cavrois [1]
[1] ESA; [2] IROC Technologies; [3] GSI

A processor mapped to a flash-based FPGA was tested with a heavy-ion micro-beam. Individual ions were localized spatially and temporally. Flip-Flop TMR reduces SDCs but the SET contribution is significant.

PH-5 **A Layout-Based Fault Injection Methodology for SER Prediction: Implementation and Correlation with 65 nm Heavy Ion Experimental Results**

B. Coeffic [1], V. Malherbe [2], J.-M. Daveau [1], G. Gasiot [1], L. Naviner [3], J.-L. Autran [2], P. Roche [1]
[1] STMicroelectronics; [2] Aix-Marseille University; [3] Telecom ParisTech

We present a methodology for netlist level digital fault injection based on layout information and physical parameters to improve SER prediction. It is applied to three processors and predictions are compared to radiation experiments results.

PH-6 **Persistent Laser-Induced Leakage in a 20 nm Charge-Pump Phase-Locked Loop**

Y. P. Chen [1], T. D. Loveless [2], A. L. Sternberg [1], E. X. Zhang [1], J. S. Kauppila [1], B. L. Bhuva [1], W. T. Holman [1], M. L. Alles [1], R. D. Schrimpf [1], L. W. Massengill [1]
[1] Vanderbilt University; [2] University of Tennessee-Chattanooga

A persistent loss-of-lock error resulting from non-recoverable TPA laser-induced damage is experimentally observed in a 20 nm charge-pump PLL. The laser-induced damage is consistent with results from 28 nm bulk transistors.

PH-7 **Soft Error Tolerance of Redundant Flip-Flops by Heavy-Ion Beam Tests in 65 nm bulk and FDSOI Processes**

E. Sonezaki, M. Hifumi, J. Furuta, K. Kobayashi
Kyoto Institute of Technology

We evaluate tolerance for soft errors of low power redundant FFs by combining redundant FFs and low power techniques by heavy ions. They are fabricated in 65 nm bulk and Thin-BOX FDSOI processes.

PH-8 **Improvements in Reliability of the LEON3 Soft Processor Using TMR and Scrubbing**

A. Keller, M. Wirthlin
Brigham Young University

Neutron testing demonstrates a 49x improvement in reliability when TMR and scrubbing are applied to the LEON3 processor for SEU mitigation. TMR alone shows an 8x improvement. TMR and scrubbing are needed for optimal improvement.

PH-9 **Single Event Effects in Si and SiC Power MOSFETs due to Terrestrial Neutrons**

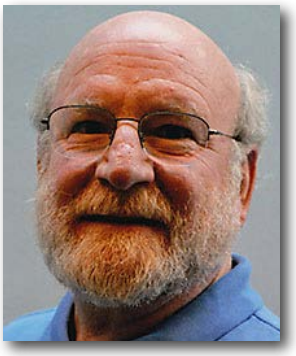
A. Akturk [1], R. Wilkins [2], J. McGarrity [1], B. Gersey [2]
[1] CoolCAD Electronics LLC; [2] Prairie View A&M University

Experimental investigation of neutron induced single event failures and the associated device cross sections as well as low altitude failure-in-time curves in silicon (Si) and silicon carbide (SiC) power MOSFETs at room temperature are reported along with possible explanation of failure mechanisms in SiC devices.

Technical Program Thursday

POSTER SESSION
2:50 – 5:30 PM
OREGON BALLROOM 203-204

INTRODUCTION



Chair: Paul Marshall, NRL

5:30 PM END OF THURSDAY SESSIONS

5:30 – 7:15 PM
OREGON BALLROOM 201-202

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

Technical Program Friday

OREGON BALLROOM 201-202
INVITED TALK
8:45 – 10:00 AM

Cascadia Subduction Zone - Are We Ready for the Big One?
Scott Burns, Professor Emeritus of Geology, Portland State University

In the Pacific Northwest of the United States, the Juan de Fuca plate is being subducted under the North American Plate at the Cascadia Subduction Zone. The lecture will discuss the hazards of and the preparedness for ground shaking, liquefaction, landslides and tsunamis along the subduction zone. What are the differences of recurrence intervals for large earthquakes on the northern and southern margins? Much of the region was not thought to be an earthquake region so earthquake building standards are fairly recent. How does the chance of crustal, plate and subduction quakes affect building codes, emergency preparedness, siting of critical facilities, building of bridges, and transportation corridors in the region? What have we learned from recent subduction quakes around the world that can be applied to the Pacific Northwest? What can the region expect after a large quake?

Scott Burns is a Professor Emeritus of Geology and Past-Chair of the Dept. of Geology at Portland State University where he just finished his 26th year of teaching. He was also Associate Dean of the College of Liberal Arts and Sciences at P.S.U. from 1997-1999. His first book, Environmental, Groundwater and Engineering Geology: Applications from Oregon, came out January of 1998. His second book, Cataclysms on the Columbia, the Great Missoula Floods came out in October of 2009. Scott actively helps local TV and radio stations and newspapers bring important geological news to the public. He has BS (Chemistry) and MS (Physical Science) degrees from Stanford University in California, plus a Ph.D. in geology from the University of Colorado, Boulder. He has won several national awards in geology: distinguished practice award from the engineering geology division of GSA in 2012, the Richard Jahns Award for engineering geology (top engineering geologist in the U.S.) from GSA and AEG in 2011, the Shoemaker Award for Public Service to the US (GSA) in 2011, and on the state level, the "Outstanding Scientist for Oregon for 2014" from the 73 year old Oregon Academy of Sciences. He has been married for 41 years to Glenda, and they have three children: Lisa (38), Doug (35) and Tracy (32). The Burns family lives in Tualatin, Oregon.

10:00 – 10:25 AM
OREGON BALLROOM 203-204

BREAK

SESSION I
10:25 AM

DOSIMETRY
SESSION INTRODUCTION
Chair: Michael Trinczek, TRIUMF

I-1
10:30 AM

Demonstration of a Passive Wireless Radiation Detector Using Fully-Depleted Silicon-on-Insulator Varactors
Y. Li, M. A. Reynolds, B. J. Gerbi, S. J. Koester
University of Minnesota

A wireless, passive sensing device for Co-60 gamma radiation is demonstrated using FDSOI varactors. These devices have potential to realize an ultra-small wireless dosimeter with high sensitivity for in-vivo radiation cancer therapy.

I-2 10:45 AM
The Role of Sample Geometry on Ultra-Low Alpha Particle Emissivity Measurements

M. S. Gordon [1], K. P. Rodbell [1], C. E. Murray [1], B. D. McNally [2]
[1] IBM; [2] XIA

The detection efficiency of an ionization counter and resulting energy spectra of samples can be dependent on the sample geometry.

I-3 11:00 AM
Total Dose Measurement Circuit Design Based on a Voltage Reference Topology

K. J. Shetler, W. T. Holman, J. S. Kauppila, A. F. Witulski, B. L. Bhuva, E. X. Zhang, L. W. Massengill
Vanderbilt University

A circuit design for measuring radiation exposure that can be integrated in various CMOS processes is presented. It is based on a voltage reference topology, where effects of radiation degradation are amplified in the output.

I-4 11:15 AM
Potential of Copper- and Cerium-doped Optical Fiber Materials for Proton Beam Dosimetry

S. Girard [1], B. Capoen [2], H. El Hamzaoui [2], M. Bouazaoui [2], G. Bouwmans [2], A. Morana [1], A. Boukenter [1], O. Duhamel [3], P. Paillet [3], M. Raine [3], M. Gaillardin [3], M. Trinczek [4], C. Hoehr [4], E. W. Blackmore [4], Y. Ouerdane [1]
[1] UdL - Université de Saint-Etienne; [2] Université de Lille; [3] CEA; [4] TRIUMF

We demonstrate the potential of sol-gel silica fiber materials doped with copper and cerium ions to monitor the proton flux and fluences through radiation-induced luminescence and optically stimulated luminescence techniques.

POSTER PAPERS

PI-1
Influence of the Damage Partition Function on the Uncertainty of the Silicon Displacement Damage Metric

P. J. Griffin, P. J. Cooper
Sandia National Laboratories

The effect of energy partition functions on silicon displacement kerma is presented. Uncertainty due to knowledge of electronic and nuclear ion interaction potentials is propagated into energy-dependent uncertainty contribution for silicon displacement damage metrics.

PI-2
In-Situ Measurement of Total Ionising Dose Induced Changes in Threshold Voltage and Temperature Coefficients of RADFETs

J. Hofman [1], A. Jaksic [2], R. Sharp [1], N. Vasovic [2], J. Haze [3]
[1] Cobham; [2] Tyndall National Institute; [3] Brno University of Technology

Fifteen RADFETs were irradiated and threshold voltage shifts and temperature sensitivity of the shift were measured. The results show that radiation-induced decrease in carrier mobility has a predominant effect on RADFET temperature sensitivity.

PI-3 **Improvements to Solid State Microdosimetry by Chord Length Customizing for Radiation Fields**

D. Bolst [1], S. Guatelli [1], L. T. Tran [1], L. Chartier [1], D. Prokopovich [2], M. Reinhard [2], M. L. F. Lerch [1], A. B. Rosenfeld [1]
[1] University of Wollongong; [2] Australian Nuclear Science and Technology Organization

A Monte Carlo simulation was developed to study the chord length distributions for various shapes commonly used in SOI microdosimeters under different radiation fields, this will allow greater accuracy in silicon microdosimetry.

SESSION J SPACE AND TERRESTRIAL ENVIRONMENTS

11:30 AM SESSION INTRODUCTION

Chair: Julien Mekki, CNES

J-1 11:35 AM **New Data Modelling for SEEs in the Stratospheric Radiation Environment**

A. Hands [1], F. Lei [2], K. Ryden [1], C. Dyer [1, 3], C. Underwood [1], C. Mertens [4]
[1] Surrey Space Centre, University of Surrey; [2] RadMod Research; [3] CSDRadConsultancy; [4] NASA Langley Research Center

The upper atmosphere is a transition region between the neutron-dominated aviation environment and proton-dominated satellite environment. We report high altitude balloon measurements and model results characterizing this radiation environment for single event effects in avionics.

J-2 11:50 AM **Monte Carlo Assessment of Galactic Cosmic Rays Induced Single Event Effects**

A. Infantino, M. Brugger, R. Garcia Alia
CERN

FLUKA was used to evaluate the SEE rate in SRAM memories in different radiation environments. Results show that direct ionization from charged particles becomes predominant between 0.2-1.1 fC compared to neutron radiation.

J-3 12:05 PM **Shielding a MCP Detector for a Spaceborne Mass Spectrometer Against the Harsh Jupiter Radiation Environment**

M. Tulej [1], S. Meyer [1], M. Lüthi [1], D. Lasi [1], A. Galli [1], D. Piazza [1], P. Wurz [1], R. Marcinkowski [2], D. Reggiani [2], H. Xiao [2], W. Hajdas [2], A. Cervelli [3], S. Karlsson [4], L. Kalla [4], M. Grande [5], T. Knight [5], S. Barabash [4]
[1] Space Research and Planetary Sciences, University of Bern; [2] Paul Scherrer Institute; [3] Albert Einstein Center for Fundamental Physics; [4] Swedish Institute of Space Physics; [5] Aberystwyth University

Experiments with high-energy electrons (17.5–345 MeV/c) and GEANT4 modelling are applied to size and shape an effective layered shielding suppressing the radiation-induced noise on the MCP detector of a mass spectrometer at Jupiter's moon Europa.

POSTER PAPERS

PJ-1 **Improvements of FLUKA Calculation of the Neutron Albedo**

N. Combier [1], A. Claret [1], P. Laurent [1], V. Maget [2], D. Boscher [2], A. Ferrari [3], M. Brugger [3]
[1] CEA; [2] ONERA; [3] CERN

This paper presents recent improvements of Monte-Carlo simulations based on Fluka and MASHcode aiming to calculate the energetic and angular distribution of the neutron albedo above the Earth.

PJ-2 **Seasonal Variations of Cosmic-Ray-Induced Atmospheric Neutron at High-Altitude in Medium Geomagnetic Latitude and Antarctica Environment**

G. Hubert
ONERA

In this paper, the seasonal variations of cosmic-ray-induced atmospheric neutron were investigated thanks to continuously neutron spectra measurements over a long term period (from 2011 to 2016). Medium and polar geomagnetic latitude were considered.

12:20 PM END OF CONFERENCE

RESG NEWS

Allan Johnston
Executive Chairman

Janet Barth
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 among its members.

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

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

NSREC 2016 will be held in Portland, Oregon, July 11 – 15, 2016 at the The DoubleTree Hotel and Oregon Convention Center. Robert Reed and his 2016 conference committee have assembled a strong technical program and social events that will provide abundant opportunities for discussing radiation effects with old and new friends in the international radiation effects community.

Supporters of the NSREC include Atmel, BAE Systems, Boeing, Cobham Semiconductor Solutions, Freebird Semiconductor, Honeywell, International Rectifier HiRel Products, Inc., Intersil Corporation, Northrop Grumman, Southwest Research Institute, and VPT Rad. We thank our supporters for their significant and continuing commitments to the conference, and we welcome other organizations to consider becoming supporters of the IEEE NSREC.

NSREC 2017 will be held in New Orleans, Louisiana, July 17 – 21 at the New Orleans Marriott. The conference chair is Véronique Ferlet-Cavrois of ESA/ESTEC. Ronald Lacoe of The Aerospace Corporation will be chair of the 2018 NSREC, which is planned for Kona, Hawaii. John Stone, SWRI, has been named the 2019 NSREC chair.

As always, papers presented at the NSREC are eligible for publication in the December issue of the *IEEE Transactions on Nuclear Science*. It is particularly important for authors to upload their papers prior to the conference for consideration for publication in the December 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.

EDITORS
Dan Fleetwood
Vice-Chair of Publications

All papers accepted for oral or poster presentation to the technical program will be eligible for publication in a special issue of the *IEEE Transactions on Nuclear Science* (December 2016), 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 8, 2016). Data Workshop papers are published in a Workshop Record and are not candidates for publication in the *IEEE Transactions on Nuclear Science.* This process 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 six 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 2016 NSREC are:

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

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

Sylvain Girard, Associate Editor, Université de Saint-Etienne
Email: sylvain.girard@univ-st-etienne.fr

Simone Gerardin, Associate Editor, University of Padova
Email: simone.gerardin@dei.unipd.it

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

Daisuke Kobayashi, Associate Editor, JAXA
Email: d.kobayashi@isas.jaxa.jp

Ivan Sanchez Esqueda, Associate Editor, USC ISI
Email: isanchez@isi.edu

RESG NEWS

ARE YOU A MEMBER OF IEEE?

Now is the time to join the Institute of Electrical and Electronics Engineers (IEEE) and the Nuclear Plasma Sciences Society (NPSS). Why? First of all, you'll become a member of the largest professional engineering society in the world. About 60% of NSREC attendees are IEEE members. Full membership in IEEE costs less than $200. 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 three publications each year:

- ***IEEE Transactions on Nuclear Science***. This IEEE journal is the official archive of research papers presented at the NSREC Conference.
- ***Radiation Effects Data Workshop Record***. Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components.
- ***NSREC Short Course Notebook***. Published each July, this notebook contains tutorial presentations on the basic physics of radiation effects in circuits and systems. It includes the instructors' notes and text, and is given to participants of the annual Radiation Effects Short Course.

A complimentary copy of the *2016 IEEE Radiation Effects Data Workshop Record* and the December special NSREC issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee. A CD and USB flash drive containing the *NSREC Short Course Notes (2016)* will be given to short course attendees.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 14, from 5:30 - 7:15 PM in Oregon Ballroom 201-202. All conference attendees and spouses are encouraged to attend. We will discuss the 2016 conference and future IEEE Nuclear and Space Radiation Effects Conferences. There will 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.

Awards

2015 NSREC OUTSTANDING CONFERENCE PAPER AWARD

The Contribution of Low-Energy Protons to the Total On-Orbit SEU Rate

N. A. Dodds, M. J. Martinez, P. E. Dodd, M. R. Shaneyfelt, F. W. Sexton, J. D. Black, D. S. Lee, S. E. Swanson, B. L. Bhuva, K. M. Warren, R. A. Reed, J. Trippe, B. D. Sierawski, R. A. Weller, N. Mahatme, N. J. Gaspard, T. Assis, R. Austin, S. L. Weeden-Wright, L. W. Massengill, G. Swift, M. Wirthlin, M. Cannon, R. Liu, L. Chen, A. T. Kelly, P. W. Marshall, M. Trinczek, E. W. Blackmore, S.-J. Wen, R. Wong, B. Narasimham, J. A. Pellish, and H. Puchner

2015 MERITORIOUS CONFERENCE PAPER

RHA Implications of Proton on Gold-Plated Package Structures in SEE Evaluations

T. L. Turflinger, D. A. Clymer, L. W. Mason, S. Stone, J. George, M. Savage, R. Koga, E. Beach, and K. Huntington

2015 OUTSTANDING STUDENT PAPER AWARD

Effects of Applied Bias and High Field Stress on the Radiation Response of GaN/AlGaN HEMTs

J. Chen, Y. S. Puzyrev, R. Jiang, E. X. Zhang, M. W. McCurdy, D. M. Fleetwood, R. D. Schrimpf, S. T. Pantelides, A. R. Arehart, S. A. Ringel, P. Saunier, and C. Lee

2015 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

2015 Compendium of Recent Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory's Radiation Effects Group

G. R. Allen, L. Z. Scheick, F. Irom, S. M. Guertin, P. C. Adell, M. Amrbar, and S. Vartanian

Radiation Effects Evaluation of a Commercial 180 nm Ferroelectric Memory Technology for Harsh Environments

B. A. Dahl, J. Cruz-Colon, R. Baumann, S. Khan, J. Rodriguez, T. San, and J. Rodriguez

2015 RADIATION EFFECTS AWARD

The 2015 Radiation Effects Award was presented to Cheryl Marshall, NASA GSFC (ret.), during the opening ceremonies of the 2015 conference. Cheryl's citation reads "For contributions to the understanding of the basic mechanisms of displacement damage and single event effects in microelectronic and photonic devices."

2016 RADIATION EFFECTS AWARD

The winner of the 2016 Radiation Effects Award will be announced Tuesday morning, July 12. The purpose of the 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.

2017 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2017 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.

A cash award and plaque will be presented at the 2016 IEEE NSREC, Portland, Oregon in July, 2016. Nomination forms are available electronically in PDF Format or in Microsoft Word format at ***http://ieee-npss.org/technical-committees/radiation-effects/***. Additional information can be obtained from Simone Gerardin, Member-at-Large for the Radiation Effects Steering Group. Simone can be reached at ***simone.gerardin@dei.unipd.it*** or +39 049 827 7786.

Conference Information

CONFERENCE LOCATION

Photo courtesy of Rob Finch and Travel Portland

PORTLAND, one of the most eclectic and vibrant cities in the U.S., is located in the Pacific Northwest with the "expected" clean air and moderate summer weather with flora and fauna galore. That alone makes for a delightful visit but … it's the unique and voluminous "unexpected" features of Portland that amaze visitors.

With an abundance of activities to be experienced in the downtown area or various neighborhoods, you must learn to slow down and smell the roses, drink the area brews or fruit of the vine, and savor the local cuisine.

The compact downtown offers access to parks, museums and TAX FREE shopping. With no state sales tax, your spending money goes much farther than elsewhere so shopping in the local boutiques or even the major department stores is a fiscally-responsible experience! Active outdoor enthusiasts can hike along forested trails or jet-ski on the river, but if you don't want to be THAT active, then simply walk along endless paths of flowers in the International Rose Test Gardens.

Across the river from Portland's downtown is the Lloyd District, home for the NSREC in July. The actual conference venue will be the modern Oregon Convention Center (OCC), a short four blocks from the host hotel. With the meeting space (upstairs, Level 2) and exhibit space (downstairs, Level 1), there is more than ample space for the conference in this state-of-the-art, ecology-oriented (green) facility.

The host hotel, the DoubleTree by Hilton Portland, is a short four blocks from the OCC. Although the walk is easy, the city of Portland is providing one complimentary ticket to each registered conference attendee for the following TriMet transport services: MAX Light Rail, Portland Bus or Portland Streetcar. The ticket will be applicable on Monday through Friday during the conference and will be included in each attendee's registration packet.

ALL of the above have made Portland into an excellent site for the conference attendees and for family members who choose to accompany them. Join us this summer to explore this laid-back, casual city, Portland – the city of Roses.

BREAKFASTS, LUNCH AND BREAKS

The 2016 IEEE NSREC will provide continental breakfast (at the DoubleTree) and refreshments at breaks (at the OCC) during the NSREC Short Course and Technical Sessions. Lunch is included for Short Course attendees on Monday. A light lunch will be provided on Tuesday and Wednesday in the Exhibit Hall at the OCC. These meals and refreshments are for *registered conference attendees only*. Please see the schedule for times and locations.

BUSINESS CENTER

The Oregon Convention Center has contracted with a company called "Eleven Wireless" to operate a self-service business center that includes facilities for photocopying, faxing, and computer printing. For additional services, they list contact information for the local UPS Store, which can handle large print jobs, banner creation or small individual shipping services. The OCC Business Center is open seven days a week (but only when OCC is open due to active events) from 7:00 AM to 11:00 PM. Costs associated with this center must be paid by credit card.

Conference Information

ROOMS FOR SIDE MEETINGS

Several meeting rooms are available for use by any registered conference attendee at the Oregon Convention Center (OCC) 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 room A103 on Level 1 of the OCC.

Note: *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 OCC and are the responsibility of the attendee hosting the meeting.

CHILD CARE REIMBURSEMENT

The 2016 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 2016. 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 29, 2016). 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 May 26, 2016. 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 2016 NSREC.

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 10. 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)
3) MasterCard, VISA, or American Express credit card

Registrations can be submitted online 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 and payment do not arrive at ETCic by July 1, then it would be better 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

On **Sunday, July 10**, and in conjunction with the Welcome Reception, registration will take place at the DoubleTree Hotel. Both rooms are just across the hall from the reception in the Multnomah and Holladay Rooms.

Not yet registered, go to **"On-Site Registration"** in Ross Island Room, first floor
Already registered, go to **"Pre-Registration"** in Morrison Room, first floor

For the rest of the week, **Monday through Friday, July 11–15**, conference registration will take place at the Oregon Convention Center (OCC).

Not yet registered, go to **"On-Site Registration"** on Level 1, Room A103
Already registered, go to **"Pre-Registration"** on Level 2 in the Oregon Ballroom pre-function area

ON-SITE REGISTRATION HOURS

Sunday, July 10	**5:00 PM – 8:00 PM**	**DoubleTree**
Monday, July 11	**7:30 AM – 5:00 PM**	**OCC**
Tuesday, July 12	**7:30 AM – 5:00 PM**	**OCC**
Wednesday, July 13	**7:30 AM – 3:00 PM**	**OCC**
Thursday, July 14	**7:30 AM – 3:00 PM**	**OCC**
Friday, July 15	**7:30 AM – 10:00 AM**	**OCC**

CONFERENCE CANCELLATION POLICY

A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 10, 2016, 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

DOUBLETREE BY HILTON PORTLAND

1000 NE MULTNOMAH STREET

PORTLAND, OR 97232

TEL: 503-281-6111

CONFERENCE VENUE

OREGON CONVENTION CENTER (OCC)

777 NE MARTIN LUTHER KING JR. BLVD.

PORTLAND, OR 97232

The host hotel for the 2016 NSREC is the 4-star **DoubleTree by Hilton Portland**. The property is located across the street from a neighborhood park and a MAX (light rail) line on one side and the Lloyd Center Shopping Complex on the other. The hotel is a short four block walk from the Oregon Convention Center OR you use your "complimentary" MAX Light Rail ticket and enjoy the ride!

The DoubleTree is structured in a 15-story South tower and a 9-story North tower that are connected in the middle with the public and meeting room space. Hotel amenities include two restaurants, one cocktail lounge, 24-hour health club (complimentary to hotel guests), seasonal outdoor pool, concierge, business center, room service, lobby ATM, parking garage, and a coffee bar. The 477 guest rooms are comfortably furnished in contemporary design. All rooms are non-smoking and feature large windows with dramatic views, individual climate control, flat-screen TV with cable, complimentary basic wireless internet (upgraded internet speeds available at an additional cost), work desk, coffee maker, hair dryer, iron and ironing board, multiple phones with voice mail, alarm iPod player and room service. Standard rooms have one queen bed. Premium rooms have one king or two queen beds and are a bit larger than the standard rooms.

Guest room rates for a standard room (queen bed) or premium room (king or two-double beds) are as follows:

NEGOTIATED GROUP RATE:
$155.00 single/double per night for standard guest room (queen bed)
$165.00 single/double per night for premium guest room (king or two-double)
GOVERNMENT PER DIEM:
$151.00 single/double* per night for standard guest room (queen bed)
$161.00 single/double* per night for premium guest room (king or two-double)

Taxes will be added to all rates listed above. Triple or quad occupancy is possible only in the premium rooms at the rate of $180.00 per night. There is no additional charge for children 15 years of age and under when sharing a room with an adult and utilizing existing beds.

*To be eligible for the government rate, guests must provide current government or military ID.

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

HOTEL RESERVATIONS

The preferred method to make reservations is by using the web link:

GROUP BLOCK:
http://doubleTree.hilton.com/en/dt/groups/personalized/R/RLLC-DT-IE3-20160709/index.jhtml
GOVERNMENT BLOCK:
http://doubleTree.hilton.com/en/dt/groups/personalized/R/RLLC-DT-I3G-20160709/index.jhtml

Registration and Travel

After accessing the appropriate web link, please enter your arrival and departure dates and then follow the prompts. Based on availability, you will be given the opportunity to choose a standard room or an upgraded (larger) room at an additional cost.

Reservations can also be made by calling DoubleTree Reservations toll-free at 1-800-996-0510 within the U.S. or Canada. Or, you can call the hotel directly at 1-503-281-6111 and ask for "in-house reservations." To get the special rates, advise the agent of the following group name:

Group block: **IE3** Government block: **I3G**

All rooms must be guaranteed by providing a credit card or a one-night check deposit to the hotel. The cut-off for IEEE NSREC reservations is at 5:00 PM Pacific Daylight Time on Friday, June 10, 2016. Once the room block has been filled OR after the cut-off date (whichever comes first!), room accommodations will be confirmed on a space or rate available basis. Early reservations are strongly suggested!

EARLY DEPARTURE: 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 because there is a $25.00 fee charged if you leave the hotel earlier than scheduled.

CANCELLATION: Any cancellations must be made by no later than 4:00 PM, THREE (3) days prior to your scheduled arrival. If the cancellation is made by that time, then no penalty will be charged. If cancellation is made past this time frame, then one night's room and tax will be charged as a cancellation fee.

NO-SHOW: Any reservations that do not show up on the scheduled day of arrival will be charged one night's room and tax as a no-show fee and the remainder of the reservation will be automatically cancelled. If there are any last minute changes to travel plans (flight delays, inclement weather, etc.), please notify the hotel as soon as possible.

AIRPORT AND TRANSPORTATION INFORMATION

Portland International Airport is located 11 miles from the DoubleTree by Hilton Portland, about a 20-25 minute drive. Taxis can be found on the baggage claim level, outside near the center section of the terminal. Airport shuttles and car rental shuttles are on this same level but are closer to the parking garage.

1) Taxis to the hotel are based on time and distance and will normally cost between $36.00 - $42.00 one way.

2) The TriMet MAX Light Rail (MAX) is the simplest and least expensive form of transportation from the airport to the DoubleTree. The MAX Red Line stops less than a half-block from the hotel so if you're traveling somewhat "light", this is the best option. Follow the signs in the airport to the MAX Light Rail Station, located near baggage claim. Purchase a ticket for $2.50 at one of the kiosks. Take the Red Line eastbound (it's the only way the train goes from this station) to the Lloyd Center/NE 11th Avenue station.

COMPLIMENTARY TRIMET PASS

As a special concession to the NSREC attendees, Portland's Convention & Visitor's Bureau is supplying a complimentary TriMet pass to be used for attendee transportation to get to the Oregon Convention Center for July 11-15.

Of course, these can be used all over the city for personal purposes, as well. They will be distributed in your registration packet.
https://trimet.org/max/

3) There is no "scheduled" airport shuttle from Portland International Airport to the DoubleTree but Blue Star Airport Express will drop-off or pick-up at this location with ADVANCE reservations. The fee is $14 one-way or $24 round trip.
http://www.bluestarbus.com

PARKING AND DRIVING DIRECTIONS

Public transportation is really easy to master in Portland so a car is not necessary. However, if you do opt to rent a car, then you'll be pleased to know that conference attendees staying at the DoubleTree are eligible for a 50% discount on overnight parking. The daily valet parking is at $25 per night and self-parking is at $20 per night. Directions from the airport follow.

Airport to the DoubleTree: Follow signs off airport property to I-205 South. Stay on the interstate to exit 21B and merge onto I-84/US-30 West towards Portland. Take exit 1 towards Lloyd Center. Keep right at the fork and follow signs to Lloyd Center, merging onto NE 11th Avenue. Turn left onto NE Multnomah Street to circle the property and arrive at the entrance. The hotel entrance will be on your left.

GETTING AROUND TOWN

Public transportation in Portland is excellent and is the recommended mode of transport.

PORTLAND PUBLIC TRANSPORTATION

The TriMet MAX Light Rail (MAX) is one of the fastest and easiest ways to get around Portland. The DoubleTree's front entrance is a very short walk (less than five minutes) from the Lloyd Center/NE 11th Avenue MAX Station. Lines from this station include the Blue, Green and Red lines which will take you to sites all over the city.

As a special concession to the NSREC attendees, Portland's Convention & Visitor's Bureau is supplying a complimentary TriMet pass to be used for attendee transportation to get to the Oregon Convention Center for July 11-15. Of course, these can be used all over the city for personal purposes, as well. They will be distributed in your registration packet.
https://trimet.org/max

SIGHTSEEING TRANSPORTATION

You can easily use the MAX Light Rail to get from point to point but…Big Pink Trolley Tours also offers hop-on/hop-off tours of the city.
http://graylineofportland.net/

BICYCLES AND WALKING

Many restaurants and a shopping center are within walking distance of the DoubleTree and the downtown is just a short MAX ride away. The downtown is compact, eclectic and highly active so there is much to explore simply by walking. For those who want to cover a bit more territory, bicycles are available to rent in several areas.
http://www.portlandoregon.gov/transportation/39402

CAR RENTAL

All major car companies have rental stations at Portland International Airport but, of course, you'll then have to pay daily parking at the hotel. You may choose to consider renting a car ONLY on the day(s) that you might actually need the vehicle. Near the DoubleTree, you'll find Hertz at 1441 NE 2nd Ave, Portland, OR 97232, tel 503-282-2644, or Enterprise at 611 E Burnside St, Portland, OR 97214, tel 503-230-1212.

Industrial Exhibits

Keith Avery
Industrial Exhibits Chair

The **2016 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 **2016 NSREC Industrial Exhibits** will be in Exhibit Hall A of the Oregon Convention Center on Tuesday and Wednesday. Conference breaks will be hosted in the Exhibit Area on Tuesday and Wednesday along with a light lunch on Tuesday and Wednesday (for registered attendees only). NSREC badges must be worn at all times.

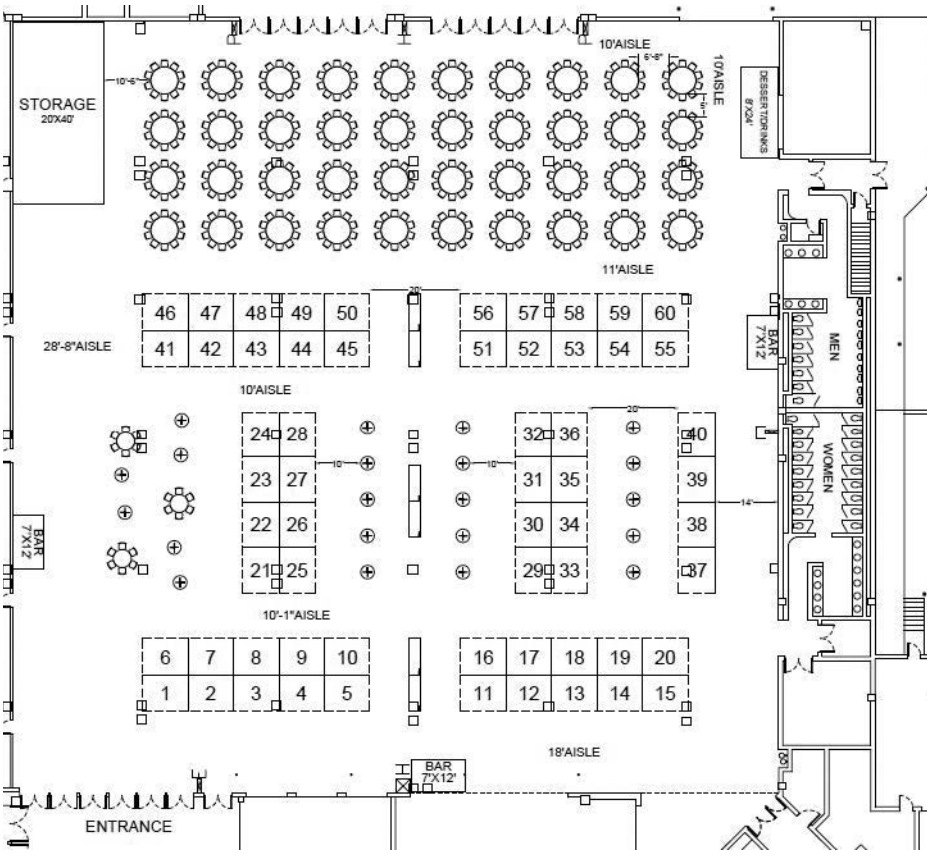
Tuesday evening, the exhibitors will host the **Industrial Exhibits Reception** featuring light hors d'oeuvres in the Exhibit Area. The Reception is open to all NSREC attendees and their guests.

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

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

Keith Avery
Air Force Research Laboratory
Phone: 505-846-0210
Email: keith.avery.2@us.af.mil

Or visit the 2016 NSREC Industrial Exhibits web site: ***www.nsrec.com/exhibit.htm***



Industrial Exhibits

Please check our web site (***www.nsrec.com***) for a current listing of companies exhibiting at 2016 NSREC.

NSREC
INDUSTRIAL EXHIBITS

OREGON CONVENTION CENTER

EXHIBIT HALL A

EXHIBIT HALL HOURS

TUESDAY, JULY 12

9:30 AM – 7:00 PM
10:15 AM MORNING BREAK
11:40 AM LUNCH
3:20 PM AFTERNOON BREAK

5:30 PM – 7:00 PM
RECEPTION

WEDNESDAY, JULY 13

9:30 AM – 2:00 PM
10:00 AM MORNING BREAK
12:00 PM LUNCH

(All of the exhibit events, excluding the Tuesday reception, are for registered attendees only)

EXHIBITORS

Organization	Internet Site	Booth
3D Plus	www.3d-plus.com	1
Analog Devices	www.analog.com	11
Anaren / MSK Products	www.anaren.com	16
Atmel	www.atmel.com	53
BAE Systems	www.baesystems.com	45
The Boeing Co.	www.boeing.com	41
Brookhaven National Labs	www.bnl.gov	30
Cobham Semiconductor Solutions	www.cobham.com/HiRel	26, 27, 28
Crane Aerospace & Electronics - Interpoint	www.craneae.com/interpoint	5
Cypress / DPACI	www.dpaci.com, www.cypress.com	54
EMPC	www.empc.com	29
Foss Therapy Services	www.fosstherapyservices.net	29
Freebird Semiconductor Corporation	www.freebirdsemi.com	7
HILEVEL Technology, Inc	www.hilevel.com	22
Honeywell	www.honeywell.com	2
Hopewell Designs	www.hopewelldesigns.com	18
International Rectifier HiRel Products, Inc.	www.infineon.com/Hirel, www.irf.com	31
Intersil Corporation	www.intersil.com	60
ISDE/Vanderbilt	isde.vanderbilt.edu	57
ixblue	www.ixblue.com	44
JD Instruments	www.jdinstruments.net	36
J.L. Shepherd & Associates	www.jlshepherd.com	21
Jazz Semiconductor Trusted Foundry	www.jazztrusted.com	32
Lawrence Berkeley National Laboratory	cyclotron.lbl.gov	17
Linear Technology Corporation	www.linear.com	33
Los Alamos National Lab - LANSCE	lansce.lanl.gov	19
Maxwell Technologies	www.maxwell.com	22
Micropac Industries, Inc.	www.micropac.com	8
Micro-RDC	www.micro-rdc.com	34
Microsemi Corporation	www.microsemi.com	10
Modular Devices, Inc.	www.mdipower.com	25
National Reconnaisance Office	acq.westfields.net	39
Northrop Grumman Corporation	www.northropgrumman.com	4
PULSCAN	www.pulscan.com	9
Robust Chip, Inc	www.robustchip.com	56
Science and Technology Facilities Council - ChipIR	www.stfc.ac.uk	46
Silvaco	www.Silvaco.com	50
STMicroelectronics	www.st.com	40
Synopsys, Inc.	www.synopsys.com	6
Texas A&M Cyclotron Institute	www.cyclotron.tamu.edu/ref	20
Texas Instruments	www.ti.com/space	43
Triad Semiconductor	www.triadsemi.com	3
ULTRA TEC	www.ultratecusa.com	24
Vorago Technologies	www.voragotech.com	12
VPT Rad	www.vptrad.com	52
VPT, Inc.	www.vptpower.com	51

2016 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 _____

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

SPECIAL FUNCTIONS

☐ I am an IEEE Young Professional and will attend the IEEE Young Professionals Breakfast on Wednesday, July 13

☐ I plan to attend the Women in Engineering (WIE) Lunch on Thursday, July 14

REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 10, 2016

	Early	Late	
IEEE Member *			
Short Course	$280	$335	$_____
Technical Sessions	$525	$630	$_____
Non-IEEE Member			
Short Course	$355	$420	$_____
Technical Sessions	$675	$800	$_____
Full-Time Students who are IEEE Members *			
Short Course	$130	$335	$_____
Technical Sessions	$150	$630	$_____

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

Card No. _____

Expiration Date _____ Security Code _____

Name on card _____

Cardholder Signature _____

Billing address _____

_____

_____

CANCELLATIONS

A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of conference registration fees requested after June 10, 2016, 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 23, 2016.*

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

2016 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 23, 2016.*

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 10, 2016. 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
Highlights of Portland *Tuesday, July 12*				
Adult (17 yrs+)	$35.00	$40.00	____	$_____
Child (4-16 yrs)	$20.00	$25.00	____	$_____
Infant (0-3 yrs)	$0.00	$0.00	____	$_____
Social, World Forestry Center *Wednesday, July 13*				
Adult (21 yrs+)	$50.00	$65.00	____	$_____
Teen (13-20 yrs)	$35.00	$45.00	____	$_____
Child (6-12 yrs)	$15.00	$25.00	____	$_____
Infant (0-5 yrs)	$0.00	$0.00	____	$_____
Oregon Museum of Science and Industry *Thursday, July 14*				
Adult (19 yrs+)	$25.00	$30.00	____	$_____
Child (3-18 yrs)	$15.00	$20.00	____	$_____
Infant (0-2 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

Card No. _____

Expiration Date _____ Security Code _____

Name on card _____

Cardholder Signature _____

Billing address _____

_____

_____

Social Program

"Welcome to Portland! Portland's fun and unexpected attractions range from gardens and museums to (tax-free) retailers of coffee, doughnuts and books. We hope you have time to explore this lovely little city full of local art, peaceful gardens, craft beer and lots of great food."

Steven S. McClure
Jet Propulsion Laboratory
Local Arrangements Chair

Courtesy of Travel Portland

Welcome to Portland! In Portland, it's easy to find limitless recreation, fabulous food and drink and flourishing culture. See for yourself, and come early or stay late to enjoy all that Portland has to offer. With no sales tax, Portland is a haven for shoppers. You'll find retailers large and small, international and local within easy reach of downtown hotels. The nearby Pearl District is home to galleries, boutiques, chic restaurants and the legendary Powell's City of Books. An award-winning airport, efficient light rail system and pedestrian-friendly city blocks in the central city make getting around town a real pleasure

Foodies love the "lovacore" cuisine, meaning that everything has been raised, grown or foraged within a fairly short distance. This craze has allowed inspired chefs to create imaginative and tasty dishes that are not found elsewhere. Additionally, the craze has extended to the streets. Portland's selection of food carts — the city has more than 600 — has drawn global acclaim (CNN declared Portland home to the world's best street food). Most carts are grouped in "pods" all around town, making it easy to sample several carts at a time.

Being close to the Willamette Valley and Columbia River Valley, there is easy access to excellent wines, particularly Pinot Noir for which the area is most highly famed. In the interest of bringing some of this wine-making experience closer to town, urban wineries have popped up all over the city. Additionally, Portland is the largest craft beer market in the U.S. boasting both high quality and interesting variety.

The conference committee has designed a social program that will allow both adults and children to get a taste and feel of the Portland experience. We are certain you will enjoy the city and encourage you to make this an adventure and visit the many scenic sites and explore the wine country.

SUNDAY, JULY 10
5:00 TO 7:00 PM

REGISTRATION
WELCOME RECEPTION

Join your colleagues for a reception with light hors d'oeuvres at the DoubleTree Hotel in the Multnomah and Holladay Rooms on the first floor. 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.

Social Program

TUESDAY, JULY 12
9:30 AM TO 3:30 PM

HIGHLIGHTS OF PORTLAND

Photo courtesy of Jim Fullan and Travel Portland

On Tuesday morning, we'll meet at 9:15 AM to load the coaches at the DoubleTree's Ballroom entrance and then promptly depart at 9:30 AM. For those companions who wish to see the "NSREC's Conference Opening" at the Oregon Convention Center, there will be an additional pick-up a few minutes later at the MLK bus "pull out" in front of the Oregon Ballroom terrace. This tour will then explore some of Portland's neighborhoods, stopping at the International Rose Test Gardens. For lunch, companions will have a choice of lunch venues (on your own) but we encourage everyone to try the gourmet food carts "Portland style". After lunch, the tour continues with a guided walking tour of the city.

International Rose Garden - Portland's International Rose Test Garden is the oldest official continuously operated public rose test garden in the United States. Each year hundreds of thousands of visitors from around the world enjoy the sights and scents of the gardens. The garden's spectacular views and more than 8,000 roses make it one of the city's most notable signature landmarks. Located in Washington Park, the best rose-viewing months are May-September. Our tour includes a guided tour of the garden. You will have the choice to explore the gardens on your own OR you can tour the gardens with your guide.

Lunch "Portland Style" – For lunch, the buses will bring you to Alder Street in downtown Portland for lunch on your own. Portland is renowned for its extensive list of portable eateries known as food carts! Everywhere you look, Portland is mentioned in the press for great food, and lately it is all about the food cart explosion and their mobile cuisine. Yes, you can get fried fast food at some food carts, but you can also find high quality healthy cuisine made with the finest local ingredients.

If you prefer, there are a number of local restaurants in the area.

Best of Portland Walking Tour - Resident Experts (aka guides) will unlock the best-kept secrets of "Bridgetown" as they delight and entertain you with stories about early and modern Portland while touring this enlightened city, rich with artwork, parks, fountains, bridges, downtown light-rail and streetcars, fountains and friendly people. This walk meanders through the most fascinating portions of the city, leading eventually to the waterfront. Remember to bring your camera for great photo opportunities and for a shot of the world's smallest park.

Arrive back at the DoubleTree at 3:30 PM.

TUESDAY, JULY 12
5:30 TO 7:00 PM
OREGON CONVENTION CENTER (OCC), EXHIBIT HALL A, LEVEL 1

INDUSTRIAL EXHIBITS RECEPTION

Join us for the 2016 Industrial Exhibits Reception hosted by your NSREC exhibitors. NSREC attendees and their registered guests are invited to the Oregon Convention Center to visit the booths and enjoy some complimentary hors d'oeuvres. *All attendees and registered guests must show their badges in order to enter the NSREC Industrial Exhibits.*

Social Program

WEDNESDAY, JULY 13
7:00 TO 8:30 AM
OCC ROOM A106
LOWER LEVEL

IEEE YOUNG PROFESSIONALS BREAKFAST

A special breakfast will be held in the OCC Room A106, Lower Level for IEEE member attendees who are Young Professionals (***www.facebook.com/ieeeyp***). This is an excellent opportunity for newer industry members to informally discuss radiation effects and to become better acquainted. Our guest speaker, Kenneth F. Galloway, is a Distinguished Professor of Engineering at Vanderbilt University. An alumnus of Vanderbilt, he earned his doctorate from the University of South Carolina and went on to hold professional appointments at Indiana University, NAVSEA-Crane, the National Institute of Standards and Technology, the University of Maryland, and the University of Arizona. He returned to Vanderbilt and served as Dean of Engineering from 1996 until 2012. His talk: Reflections at a Half-Century or How I Stumbled Through.

Dr. Galloway's research and teaching activities are in solid-state devices, semiconductor technology, and radiation effects in electronics. He has published numerous technical papers in these areas. He has served as General Chairman of the Institute of Electrical and Electronics Engineers (IEEE) Nuclear and Space Radiation Effects Conference (NSREC) and General Chairman of the IEEE International Electron Devices Meeting (IEDM). For his work, Dr. Galloway has been elected a Fellow of the IEEE, the American Association for the Advancement of Science (AAAS), and the American Physical Society (APS). In 2002, he received the IEEE Nuclear and Plasma Sciences Society Radiation Effects Award, and in 2007, he received the IEEE Nuclear and Plasma Sciences Society Richard F. Shea Distinguished Member Award.

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***.

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

WEDNESDAY, JULY 13
5:15 TO 10:15 PM

CONFERENCE SOCIAL

DINING WITH TREES AT THE WORLD FORESTRY CENTER

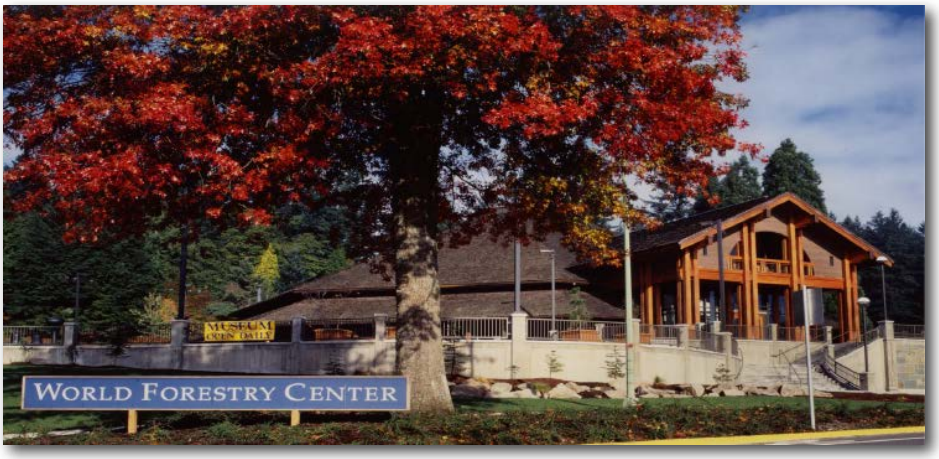


Photo courtesy of the World Forestry Center

Located in Portland's beautiful Washington Park, the World Forestry Center provides a unique venue for this year's Social. This picturesque site includes the Discovery

Social Program

Photo courtesy of the World Forestry Center

Photo courtesy of the World Forestry Center

Museum, numerous nature trails, and a vintage locomotive display. The 20,000 square foot Discovery Museum is sure to delight anyone from ages 3 to 103. Attendees will be both educated and entertained as they learn about the importance of forests and trees in our lives, as well as environmental sustainability. Built in dramatic Cascadian style architecture, the stunning Discovery Museum has been a Portland icon since 1971. Visitors can take a wet-free raft ride, see the forest from a bird's-eye-view, learn about different people who work in the forest, and "travel" to Russia, China, South Africa and Brazil to discover how those regions are utilizing their forests and the challenges they face.

The first floor of the museum focuses on forests of the Pacific Northwest and the role they play in providing habitat, water, recreation, wood, and a multitude of other benefits.

The second floor of the museum is divided into two major sections. One half of the space is the Special Exhibits Gallery devoted to temporary exhibits that explore art, history and culture from around the world. The other half explores forests around the world and their connections to people.

Beer tasting will be in Cheatham Hall; cocktails, wine and beer will be throughout the facility. Dining will be both indoor and outdoor (tented) with a variety of cuisine to suit any palate, followed by dessert. Popular local musical artists will be providing entertainment across the event. Cocktails, beer and wine will be served starting in Cheatham Hall at 6:00 PM and finishing at 10:00 PM in the museum. Beer tasting will be available between 6:00 and 8:00 PM. The buffet will be served in Cheatham Hall and on the outdoor Plaza starting at 6:30 and continue to 8:00 PM. Desserts will be served in the museum from 8:00 to 9:30 PM.

Please note, there are many sites and activities in Washington Park. Attendees and family members my be interested in visiting hiking paths, the Children's Museum, the Oregon Zoo, the Veteran's Memorial, the Rose Garden, and more. If you and your family would like to visit the WFC earlier than our Conference Social "start time", then simply let the admittance personnel know you will be attending this evening's function. As the weather in July can still be cool and have a small probability of precipitation, a light jacket is recommended.

Motor coaches will depart from the DoubleTree's Ballroom entrance, between 5:15 and 6:00 PM and return between 9:30 and 10:15 PM. Attendees may also choose to arrive or depart via either the MAX Red or Blue lines. Complimentary passes will be provided to attendees in their registration packet.

Washington Park map:
http://explorewashingtonpark.org/sites/default/files/Washington%20Park%20Map%20off%20peak.pdf
Washington Park activities: ***http://explorewashingtonpark.org/exploring***
Free Park shuttle: ***http://explorewashingtonpark.org/getting-here#shuttle***

Social Program

THURSDAY, JULY 14
9:30 AM TO 3:30 PM

PORTLAND AERIAL TRAM, OREGON MUSEUM OF SCIENCE AND INDUSTRY DAY TRIP

Photo courtesy of Portland Aerial Tram

Photo courtesy of Portland Aerial Tram

The **Portland Aerial Tram** is one of the only aerial commuter trams in the country. The Tram cabins travel 3,300 linear feet from South Waterfront to Marquam Hill. Traveling at 22 miles per hour, the Tram cabins rise 500 feet during the four-minute trip. The tram is actually part of Portland's public transportation systems delivering 20,000 people a day to the Oregon Health & Science University's main campus.

The upper deck has views of downtown Portland and the largest enclosed sky bridge in North America. As you exit the upper terminal, take a right to enter an outdoor patio with seating and views of the terminal, the surrounding region and, on a clear day, Mount Hood and Mount St Helens. And our chances for clear days in July are very good. Be sure to bring a camera for spectacular views of the city and surrounding areas. Also, you should have time to grab a "Summit Espresso" a short distance away in OHSU.

Photo courtesy of the Oregon Museum of Science and Industry

The Oregon Museum of Science and Industry (OMSI), one of the nation's leading science museums, is 219,000 square feet of brain-powered fun. Five enormous halls bring science to life with hundreds of interactive exhibits and displays. You can experience an earthquake, take part in live lab demonstrations, see a movie in the Empirical Theater, explore the universe in a world-class planetarium and even tour a real submarine, the USS Bluefin. Located on the east bank of the Willamette River, the waterfront provides many photo opportunities.

Note that there are additional admission prices for the submarine tour and the theater.

We'll meet at the DoubleTree's Ballroom entrance at 9:15 AM and depart to the Aerial Tram at 9:30 AM. Depart to the OMSI around 11:00 AM for free time and lunch on your own at the museum. We'll arrive back at the hotel around 3:30 PM.

Social Program

IEEE Women in Engineering

A special lunch will be held in the OCC Room A106, Lower Level, for Women in Engineering, sponsored by the IEEE NPSS Society. This event is open to any interested attendees as a chance to meet, socialize and discuss issues pertinent to women in this field. This lunch will also include a short talk by Nita Patel from L-3 Warrior Systems. For more information, please contact Janet Barth, ***jbarth@ieee.org***.

Young Professionals are also encouraged to attend.

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

THURSDAY, JULY 14
12:00 TO 1:30 PM
OCC ROOM A106
LOWER LEVEL

WOMEN IN ENGINEERING LUNCH

Nita Patel, P.E., is a Systems and Software Engineering Director at L-3 Warrior Systems, manufacturer of night-vision and electro-optical systems. Nita has been involved in many facets of IEEE, including her current role as Women in Engineering International Leadership Conference Chair, Second Vice President of the IEEE Computer Society and Board of Governors member of Eta Kappa Nu. Nita is your host for 23-24 May 2016 WIE ILC in San Jose, CA. She is excited about leading this collaborative, educational, innovation focused conference themed Lead Beyond, Accelerating Innovative Women Who Change the World. Outside of IEEE, Nita is active with Toastmasters International and the United States Chess Federation. Nita received her MS Computer Engineering, BS Electrical Engineering and BS Mathematics from Southern Methodist University.

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 at the DoubleTree Hotel, Oregon Room, behind the front desk on the first floor.

ACTIVITIES

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 23.

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.

Local Activities

GENERAL INFORMATION

Photo courtesy of Travel Portland

PORTLAND, one of the most eclectic and vibrant cities in the U.S., is located in the Pacific Northwest with the "expected" clean air and moderate summer weather with flora and fauna galore. That alone makes for a delightful visit but … it's the unique and voluminous "unexpected" features of Portland that amaze visitors.

With an abundance of activities to be experienced in the downtown area or various neighborhoods, you must learn to slow down and smell the roses, drink the area brews or fruit of the vine, and savor the local cuisine.

Foodies love the "lovacore" cuisine, meaning that everything has been raised, grown or foraged within a fairly short distance. This craze has allowed inspired chefs to create imaginative and tasty dishes that are not found elsewhere. Additionally, the craze has extended to the streets. Portland's selection of food carts — the city has more than 600 — has drawn global acclaim (CNN declared Portland home to the world's best street food). Most carts are grouped in "pods" all around town, making it easy to sample several carts at a time.

There is plenty to do and see in Portland and the surrounding communities. Pick up everything you need in Portland without sales tax. From handmade items to designer goods, you'll find it all tax-free.

MT. HOOD

Photo courtesy of Travel Oregon

Mt. Hood's perpetually snowy peak — crowned by eleven glaciers, one for every thousand feet it rises above sea level — can be seen from the DoubleTree. Home of the historic Timberline Lodge, a WPA project built between 1936 and 1938, which hosts some of the only year-round skiing anywhere on earth. The lodge's design mirrors the lines of the mountain, and was constructed out of stone and wood from the surrounding forest. It's also a great place to sit by the fire, have a glass of wine and marvel at the massive peak outside. Beautiful alpine lakes with names like Lost, Trillium and Mirror dot Mt. Hood's flanks, each offering its own unique view of the mountain. Forests and valleys fill with lavender and wildflowers in the spring, and apples and pears and berries in the summer and fall — so much so that the epic drive between the mountain and the town of Hood River is called the Fruit Loop. Mt. Hood is approximately 90 minutes from Portland by car. A day tour can also be booked at ***http://www.city-discovery.com/portland/***

WILLAMETTE VALLEY WINERY TOURS

The Willamette Valley is known for its world class Pinot Noir. Visit wineries and tasting rooms surrounded by beautiful vistas and views of the Cascade Mountains. Explore quiet back country roads leading to rustic barnyard tasting rooms or state of the art wineries. There are many tour companies available which can be found online. We recommend booking a tour a few weeks in advance to be safe. Information and tour company contacts can be found at ***http://willamettewines.com***

CULINARY WALKING TOURS

If you are more of a "foodie", or just prefer food to go with your wine or beer, Portland offers unique and delicious walking tours where you'll taste the foods and sip the drinks - while discovering Portland's amazing culinary scene. If you watch the Food Network and often consider yourself a "foodie," then this exploration is for you. Live like Anthony Bourdain, ***http://www.forktownfoodtoursportland.com***

Local Activities

DOWNTOWN BEER TASTING TOURS

Portland is a craft beer mecca. And people here take beer seriously. There are many ways to get from Pint A to Pint B, both walking tours and tours providing transportation are available. The hard part will be picking which areas or breweries to visit. Several options can be found at ***http://www.brewvana.com***

DINING IN PORTLAND

Dining in Portland is truly an experience you will not forget. Portlandians take great pride in their restaurants. The quality and variety of restaurants in Portland is phenomenal. Don't be afraid to ask about the menu, likely you will get an earful about how the food is raised or grown, where it comes from and just exactly how organic it is. For ideas about where to have your Portland dining experience see ***http://www.travelportland.com/collection/restaurant-round-ups/***

Photo courtesy of Travel Portland

COLUMBIA GORGE WATERFALLS/WINE TOUR

The Pacific Northwest offers endless rugged beauty, and on this small-group tour from Portland, you'll explore the gorgeous waterfalls of Columbia Gorge, admire views of wet forests, spot wildlife like eagles and osprey, and tour the vineyards of several wineries, with wine tastings included. Your naturalist guide will teach you about the area's history and landscape, and ensure comfortable transportation by luxury vehicle. Wine tours of the Columbia Gorge can be booked online, ***http://www.columbiagorgewine.com***

Photo courtesy of Travel Portland

PORTLAND JAPANESE GARDEN

In the scenic hills above Washington Park, the Japanese Garden is a haven of tranquil beauty which has been proclaimed one of the most authentic Japanese gardens outside of Japan. Encompassing 5.5 acres and five separate garden styles, the garden includes an authentic Japanese Tea House, meandering streams, intimate walkways and an unsurpassed view of Mount Hood. Guided tours are included with cost of admission.

Photo courtesy of Portland Japanese Garden

VOODOO DOUGHNUT

Located in Old Town's popular nightlife district, Voodoo Doughnut is one of the city's most unusual and delicious culinary destinations. The doughnuts, topped with creative ingredients such as bacon, Captain Crunch and Oreos, are almost as fun to look at as they are to eat. Locals and visitors line up 24 hours a day for what may be the most innovative doughnuts in the world. Be prepared for adorable mustached faces to look up at you from your food (mirroring the many bearded young men you'll encounter biking around Portland).

Photo courtesy of Voodoo Doughnut

Local Activities

PORTLAND ART MUSEUM

Find out why the oldest museum in the Northwest, the Portland Art Museum, is internationally renowned for exciting art experiences. Located in the heart of downtown's cultural district, the museum campus includes an outdoor sculpture court and historical interiors. Tour the world and travel through history in magnificent permanent collection galleries (featuring an extensive collection of Native American art), six stories of modern art and special exhibitions. Each Sunday features activities for families.

Photo courtesy of Portland Art Museum

PITTOCK MANSION

High in the West Hills of Portland, Pittock Mansion soars 1,000 feet above the city's skyline. A century-old symbol of Portland's dramatic transformation from a small lumber town to a bustling city, it's an architectural wonder. With picture-perfect views of rivers, forests, bridges and mountaintops — and 23 storied rooms teeming with treasures — no other place in town offers a more breathtaking view or a more revealing glimpse of Portland's past.

Photo courtesy of Travel Portland

PORTLAND FARMERS MARKET

Photo courtesy of Travel Portland

Widely considered one of the world's finest farmers' markets, the Portland Farmers Market operates eight weekly markets, spring through fall. In addition to fresh produce, the market is a go-to spot for prepared food items, as well as cheeses, meats, flowers and more.

The flagship market is held on Saturdays in the South Park Blocks at Portland State University. On Mondays, the market comes to Pioneer Courthouse Square (June-September), and Wednesday's market is held in the South Park Blocks of the Cultural District (May-November).

LAN SU CHINESE GARDEN

A year-round wonder, the Lan Su Chinese Garden is an authentically built Ming Dynasty style garden. Covered walkways, bridges, pavilions and a richly planted landscape frame a picturesque lake in this urban oasis built by artisans from Portland's sister city of Suzhou. Public and audio tours are available, and the garden's teahouse serves light snacks and traditional teas. Lan Su hosts many events, including a two-week Chinese New Year celebration and summer concerts.

Photo courtesy of Lan Su Chinese Garden

MOUNT ST. HELENS

Located in southwestern Washington about 50 miles northeast of Portland, Oregon, Mount St. Helens is the youngest of the major Cascade volcanoes, having formed in the last 2,200 years. Mount St Helens is an example of a composite volcano which are known to erupt explosively and pose considerable danger to nearby life and property. Before 1980, Mount St. Helens towered to 9,677 ft and was known as the "Fujiyama of America" thanks to its snow capped peak and symmetrical slopes. Mount St. Helens can be reached by car in approximately 1.5 hours, or book a tour at ***http://www.seatosummit.net/tour/mt-st-helens-tours/***

Photo courtesy of Sea to Summit Tours

Local Activities

OREGON COAST

Where Oregon meets the Pacific Ocean, you'll find rocky vistas, mile upon mile of public beaches, artistic enclaves, working fishing towns, family attractions, micro-brews, seafood and, yes, even surfing. The Oregon coast is within 1.5 hours from Portland by car. Alternatively several tour companies offer day tours to coastal areas, ***http://www.viator.com/tours/Portland/Oregon-Coast-Day-Trip-from-Portland-Astoria-and-Cannon-Beach/d5065-5765COASTAL***

Photo courtesy of Travel Portland

BICYCLE TOURS

As a change of pace, pedal through NW and SW Portland, stopping for some hoppy refreshment at several of the 40 microbreweries and brewpubs that dot the cityscape. Possible stops include Bridgeport, Deschutes, Lucky Labrador, New Old Lompoc, Rogue or one of McMenamins historic pubs. Enjoy sampling unique beers and tour behind the scenes to see brewmasters in action! Read more about Portland Brewery Bike Tour at ***http://www.viator.com/tours/Portland/Portland-Brewery-Bike-Tour/d5065-5740BIKEBREW#media?aid=vcps***

SEGWAY CITY TOURS

Zip through Portland's historic and developing west-side neighborhoods on this guided Segway tour! Select a 1-hour riverfront tour or a 2-hour historical downtown tour, and enjoy quality sightseeing aboard your electric Segway. Visit locations like the Steel Bridge, Pearl District, historic Chinatown and the Portland Art Museum for a window into the city's industrial and cultural past. Read more about Portland Segway Tours, ***http://www.viator.com/tours/Portland/Portland-Segway-Tour/d5065-6334SEGWAY?aid=vcps***

Photo courtesy of Portland Segway Tours

PORTLANDIA TOUR

Photo courtesy of Travel Portland

Discover the city that Carrie Brownstein and SNL alum Fred Armisten put on the map as a place 'young people go to retire'. On this 3-hour Portlandia tour, visit filming locations around the city such as the site of "Stu's Stews," and experience Portland's coffee culture with stops at a hip local cafe and Voodoo Doughnuts. Schedule your 'Portlandia' Tour of Portland at ***http://www.viator.com/tours/Portland/Portlandia-Tour-of-Portland/d5065-5765PORTLANDIA?aid=vcps***

PORTLANDIA FILMING SITES

The popular sketch comedy show, which has returned for its sixth season on the Independent Film Channel (IFC) in January 2016, spotlights and spoofs the wackier sides of life in Portland. Find out where the show and the city overlap. ***http://www.travelportland.com/collection/portlandia/***

Photo courtesy of Travel Portland

Local Activities

OREGON HISTORICAL SOCIETY MUSEUM

The Oregon Historical Society's is located in the heart of Portland's Cultural District on the South Park Blocks. Street parking is available, and public lots are easily accessible for visitors. OHS is also located within blocks of bus and light rail lines. Museum admission also includes entrance to the Society's Research Library, which is open Tuesday through Saturday. ***http://www.ohs.org/museum/***

HISTORIC OREGON CITY/ END OF THE OREGON TRAIL

Photo courtesy of Historic Oregon City

During the mid-1800s, 400,000 settlers set out on a 2,000-mile adventure that stretched from Missouri to Oregon City, half an hour southeast of Portland. At the End of the Oregon Trail Interpretive Center and Historic Site visitors can learn about their journeys and discover what it was like to be a pioneer. Made up of several buildings beneath giant wagon frames, the Interpretive Center contains hands-on exhibits where costumed interpreters describe the challenges of packing for the cross-country trek. Little explorers are free to get hands-on with history here by dressing up, packing a wagon and trying their hands at pioneer crafts and activities like candle making. The "Bound for Oregon" video presentation and other exhibits also immerse visitors in historic tales and explain how Oregon City was the end of the trail for many because it was where land claims were granted for Oregon, Washington, Idaho and Wyoming. For information see ***http://www.historicoregoncity.org***

FORT VANCOUVER

Photo courtesy of Fort Vancouver National Trust

This historic site includes a 19th-century fur-trading post, a military museum and the restored houses of Officers Row. Once home to both fur traders and fighter pilots, Fort Vancouver offers an authentic look at life in the Pacific Northwest through the past 200 years. Located just across the Columbia River from Portland in Vancouver, Wash., the region's only national historic site is centered around a complete replica of Fort Vancouver, the fur-trading camp founded by the Hudson's Bay Company in 1825. The fort served as the company's headquarters west of the Rockies and housed the Northwest's first hospital, school, saw mill, shipyard and more. Today, visitors can see authentic demonstrations of period blacksmithing, carpentry, cooking and baking. For information see ***http://fortvan.org***

SAUVIE ISLAND

Natural playgrounds don't come much bigger than Sauvie Island — at 24,000 acres, the Manhattan-size isle is one of the largest river islands in the country and sits at the confluence of the Willamette and Columbia Rivers just 10 miles northwest of downtown Portland. And from one end to the other, families can find an entire day's worth of adventures; it's a hot spot for fruits and veggies, as well as a paradise for bird-watchers, beach-goers, bicyclists and kayakers. Explore the possibilities here, ***http://sauvieisland.org***

Local Activities

EVERGREEN AVIATION & SPACE MUSEUM/WINGS & WAVES WATERPARK

Photo courtesy of Evergreen Museum

The Evergreen Aviation & Space Museum seeks to inspire and educate, promote and preserve aviation and space history, and honor the patriotic service of our veterans. With displays ranging from the elegant aeronautic designs of two unknown bike mechanics – Orville and Wilbur Wright – to an actual Lockheed SR-71 Blackbird that can fly at speeds of over 2,000 miles per hour, the McMinnville, Ore., museum has a little something for everyone. The centerpiece of these aeronautic breakthroughs is the original Spruce Goose, built entirely of wood due to wartime restrictions on metals, which stands as a symbol of American industry during World War II.

For many kids, the museum's biggest attraction is the unique Wings & Waves Waterpark, an indoor, all-season, 70,000-square-foot space topped by a massive Evergreen International Aviation B747-100 aircraft. The educational waterpark teaches visitors about the power of water and its effects on society, and also entertains them with 10 water slides of various sizes, a wave pool and a children's museum. Check out the many attractions here, ***http://www.evergreenmuseum.org***

WHITE WATER RAFTING ON THE CLACKMAS RIVER

Photo courtesy of River Drifters

The Clackamas River is the closest whitewater river to Portland and is perfect for those who are on a time budget. Since the Clackamas River drainage only has a peak of 3500', the optimal time to run the Clackamas River is in the spring and early summer months for larger rapids (from March through June). However, as the water levels begin to drop, the Clackamas River begins to change character and in the Summer months (July and August), the river becomes a tighter, more technical and very fun run! During the Summer months half-day trips are offered on the Clackamas River, which is essentially an excerpt of the rivers' best rapids! Book your experience here, ***http://riverdrifters.net/clackamas/***

WEATHER AND CLOTHING

Typical summertime weather in the Pacific Northwest mild, low humidity, moderate temperatures. Evenings can be cool, so bring a light sweater and/or jacket. You can expect temperatures to average at a high of about 78 °F (26 °C) and a low of about 54 °F (12 °C). There is only a small likelihood of light rain, but there is a chance. The summer is really one of the best parts about Portland. It's warm for several months. There is modest humidity, often in the 50-60% range. You will have comfortable nights to enjoy all the parks and other outdoor recreation and restaurants. The evenings are long and darkness doesn't come until 10:00 PM in early July. The extensive landscape of forests, beaches, rivers, and bike paths become a draw for all to enjoy on long summer nights.

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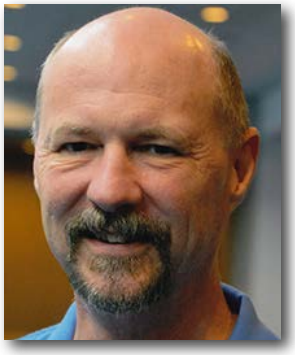
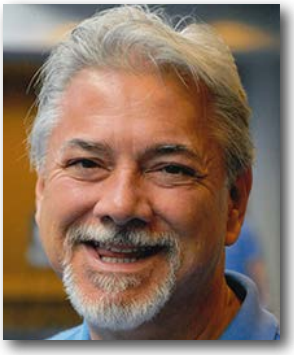


General Chair
Robert Reed
Vanderbilt University
615-473-3462
robert.reed@vanderbilt.edu

Technical Program
Philippe Paillet
CEA
+33 169 265 089
philippe.paillet@cea.fr



Local Arrangements
Steve McClure
Jet Propulsion Laboratory
818-269-5426
steven.s.mcclure@
jpl.nasa.gov

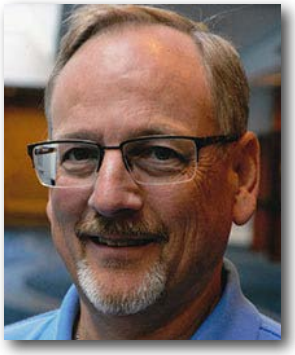
Short Course
Ken Rodbell
IBM
914-945-1012
rodbell@us.ibm.com

Publicity
Teresa Farris
Cobham Semiconductor
Solutions
719-594-8035
teresa.farris@cobham.com

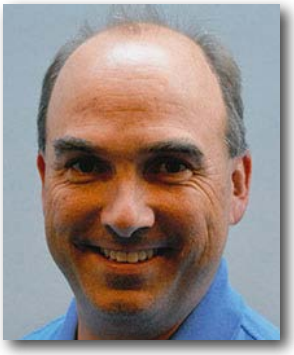
Finance
Robert Walters
Naval Research Lab
Robert.Walters@
nrl.navy.mil

Finance
Brian Sierawski
ISDE, Vanderbilt University
615-343-9833
brian.sierawski@
vanderbilt.edu

Awards
Vincent Pouget
IES-CNRS
+33 467 149 515
vincent.pouget@
ies.univ-montp2.fr



Industrial Exhibits
Keith Avery
AFRL
505-846-0210
keith.avery.2@us.af.mil



Web Developer
Jeff Black
Sandia National
Laboratories
505-844-5020
jefblac@sandia.gov

Co-Web Developer
Martha O'Bryan
AS&D, Inc.
301-286-1412
martha.v.obryan@nasa.gov

Official Reviewers

Philippe Adell, *NASA JPL*

David Alexander, *COSMIAC*

Sarah Armstrong, *NSWC Crane*

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Michael Trinczek, *TRIUMF*

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Nick Van Vonno, *Intersil*

Athina Varotsou, *TRAD*

Bert Vermeire, *Space Micro*

Cedric Virmontois, *CNES*

Jeffrey Warner, *NRL*

Jerry Wert, *Boeing*

Jeff Wilkinson, *Medtronic*

Frédéric Wrobel, *University of Montpellier*

Enxia Zhang, *Vanderbilt University*

Radiation Effects Steering Group

Executive Chair
Allan Johnston
J-K Associates
308 Marine Drive
Coupeville, WA 98239
818-588-0919
JohnstonAH25@gmail.com
(Term expires: 7/18)

Executive Vice-Chair
Janet Barth
NASA Retired Emeritus
7394 Minter Lane
Clarksville, MD 21099
301-602-3706
jbarth@ieee.org
(Term expires: 7/18)

Past Chair
Marty Shaneyfelt
Sandia National Laboratories
P.O. Box 5800, MS-1083
Albuquerque, NM 87185-1083
505-844-6137
shaneymr@sandia.gov
(Term expires: 7/18)

Senior Member-at-Large
Sylvain Girard
Université de Saint-Etienne
18 rue Pr. Benoit Lauras
Saint-Etienne, France
+33 477 915 812
sylvain.girard@univ-st-etienne.fr
(Term expires: 7/16)

Member-at-Large
Simone Gerardin
Padova University
Via Gradenigo 6B
35131 Padova
Italy
+39 049 827 7786
simone.gerardin@dei.unipd.it
(Term expires: 7/17)

Junior Member-at-Large
Tom Turflinger
The Aerospace Corporation
14301 Sullyfield Circle
Unit C CH3-310
Chantilly, VA 20151
571-307-3715
thomas.l.turflinger@aero.org
(Term expires: 7/18)

Secretary
Paul Dodd
Sandia National Laboratories
PO Box 5800, MS-1088
Albuquerque, NM 87185
505-844-1447
pedodd@sandia.gov
(Term expires: 7/18)

Vice-Chair, Publications
Dan Fleetwood
Vanderbilt University
EECS Department
VU Station B, #350092
2301 Vanderbilt Place
Nashville, TN 37235
615-322-2498
dan.fleetwood@vanderbilt.edu
(Term expires: 7/18)

Vice-Chair, Publicity
Teresa Farris
Cobham Semiconductor Solutions
4350 Centennial Blvd.
Colorado Springs, CO 80907
719-594-8035
teresa.farris@cobham.com
(Term expires: 7/18)

Special Publications Assignment
Paul V. Dressendorfer
Sandia National Laboratories (retired)
11509 Paseo del Oso, NE,
Albuquerque, NM 87111
505-292-5965
p.dressendorfer@ieee.org

Vice-Chair, 2016 Conference
Robert Reed
Vanderbilt University
1025 16th Ave, Suite 200
Nashville, TN 37212
615-473-3462
robert.reed@vanderbilt.edu

Vice-Chair, 2017 Conference
Véronique Ferlet-Cavrois
ESA/ESTEC
Keplerlaan 1
2200 AG Noordwijk
The Netherlands
+31 715 656 038
Veronique.Ferlet-Cavrois@esa.int

Vice-Chair, 2018 Conference
Ronald Lacoe
The Aerospace Corporation
PO Box 92957
M2-244
Los Angeles, CA 90009-2957
310-336-0118
ronald.c.lacoe@aero.org

Vice-Chair, 2019 Conference
John Stone
SW Research
6220 Culebra Rd
San Antonio, TX 78238
210-522-5073
jstone@swri.org

NPSS AdCom Member
Dave Hiemstra
MDA
9445 Airport Rd
Brampton, ON L6S 4J3
Canada
905-790-2800
Dave.hiemstra@mdacorporation.com
(Term expires: 12/17)

NPSS AdCom Member
Steve McClure
NASA/JPL
MS 303-200
4800 Oak Grove Dr
Pasadena, CA 91109
818-269-5426
Steven.s.mcclure@jpl.nasa.gov
(Term expires: 12/18)

NPSS AdCom Member
Ronald D. Schrimpf
Vanderbilt University
5635 Stevenson Center
Nashville, TN 37235
615-343-0507
ron.schrimpf@vanderbilt.edu
(Term expires: 12/19)

RADECS Liaison
Véronique Ferlet-Cavrois
ESA/ESTEC
Keplerlaan 1
2200 AG Noordwijk
The Netherlands
+31 715 656 038
Veronique.Ferlet-Cavrois@esa.int
(Term expires: 9/17)

ANNOUNCEMENT and FIRST CALL FOR PAPERS

2017 IEEE NUCLEAR AND SPACE RADIATION EFFECTS CONFERENCE

Short Course and Radiation Effects Data Workshop

July 17 - 21, 2017
The New Orleans Marriott
New Orleans, Louisiana

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Conference Committee

General Chair
Véronique Ferlet-Cavrois,
European Space Agency
Veronique.Ferlet-Cavrois@esa.int

Technical Program
Heather Quinn, LANL
hquinn@lanl.gov

Local Arrangements
John Stone, Southwest Research Institute
jstone@swri.org

Short Course
Jonathan Pellish,
NASA Goddard Space Flight Center
jonathan.pellish@nasa.gov

Publicity
Teresa Farris,
Cobham Semiconductor Solutions
teresa.farris@cobham.com

Finance Chair
Dolores Black, Sandia National Laboratories
dablack@sandia.gov

Awards
Jean-Luc Leray, CEA
jl.leray@anaxajl.net

Industrial Exhibits Chair
Anne Minez, 3Dplus
aminez@3d-plus.com

Web Developer
Jeffrey Black, Sandia National Laboratories
jefblac@sandia.gov

The 2017 IEEE Nuclear and Space Radiation Effects Conference will be held July 17 - 21 at the The New Orleans Marriott, New Orleans, Louisiana. 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 offered on July 17, 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
- Radiation Transport, Energy Deposition and Dosimetry
- Ionizing Radiation Effects
- Materials and Device Effects
- Displacement Damage
- Processing-Induced Radiation Effects

Radiation Effects on Electronic and Photonic Devices and Circuits
- Single Event Effects
- MOS, Bipolar and Advanced Technologies
- Isolation Technologies, such as SOI and SOS
- Optoelectronic and Optical Devices and Systems
- Methods for Hardened Design and Manufacturing
- Modeling of Devices, Circuits and Systems
- Cryogenic or High Temperature Effects
- Novel Device Structures, such as MEMS and Nanotechnologies

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

New Developments of Interest to the Radiation Effects Community

PAPER SUMMARY DEADLINE: FEBRUARY 3, 2017

PROCEDURE FOR SUBMITTING SUMMARIES

Summaries must be received by February 3, 2017

Detailed submission and formatting instructions will be available after January 6, 2017 at www.nsrec.com

Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file consisting of a cover page and an informative two to four page summary describing results appropriate for 12-minute oral or a 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, fax, 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), and an abstract no longer than 35 words. Authors are prompted to state their preference for presentation (oral, poster, or data workshop poster) and for session. Details of the submission process may be found at **www.nsrec.com**. The final category of all papers will be determined by the Technical Program Committee, which is responsible for selecting final papers from initial submissions.

Papers accepted for oral or poster presentation at the technical program are expected to be submitted for publication in the *IEEE Transactions on Nuclear Science* (December 2017). 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*.

NEW ORLEANS, LOUISIANA

Just north of the gulf of Mexico, on the banks of the Mississippi River, lies New Orleans, a 300 year old melting pot of cultures, sights, tastes, and sounds with something for everyone. If you're a WWII buff, be sure to visit the National WWII museum for an immersive experience. If your preference is the natural world, the Audubon Zoo and Aquarium is regularly rated in the top ten. If history is your bag, visit the New Orleans Jazz National Historical Park, and take in a live concert, or spend a day at the Jean Lafitte National Historical Park and Preserve learning about New Orleans' very own pirate. Architecture buffs will enjoy a walking tour of the mansions in the Garden District and exploring the Spanish influenced architecture of the French Quarter. All reachable by a short walk or an easy trolley or bus ride from the conference hotel.

"Crescent City Bridge" Photo by Richard Nowitz - Courtesy of New Orleans Convention and Visitors Bureau

When in New Orleans, don't forget the food. Whether the cuisine is classic and refined Creole, its spicier rural cousin Cajun, or any of the creative fusion efforts for which New Orleans is justly famous, it is hard to get a bad meal. Take a short walk after dinner to visit the live music scene on Frenchman street, where world-class musicians play nightly, and locals take in the scene. New Orleans is the birthplace of Jazz, but you can find Latin, blues, Reggae, or some mixture of them all. Whatever you like, you can find it in New Orleans. Join us in 2017.

Oregon Convention Center

Photo courtesy of Eric Baetscher and OCC

WALK FROM HOTEL TO THE OREGON CONVENTION CENTER (OCC):

- Head west on NE Holladay Street, parallel to the MAX tracks toward NE 9th Avenue
- Walk four blocks and destination will be on your left.

WALK BACK TO HOTEL FROM THE OCC:

- Turn right onto NE Holladay Street, parallel to the MAX tracks
- Walk four blocks east and the hotel will be on the left.

MAX LIGHT RAIL FROM HOTEL TO THE OREGON CONVENTION CENTER (OCC):

- Walk across the street to the Lloyd Center/NE 11th Ave MAX Station
- Take the MAX Red, Blue, or Green Line Westbound
- Get off two stops down at the Convention Center MAX Station.

MAX LIGHT RAIL BACK TO HOTEL FROM THE OCC:

- Board at the Convention Center MAX Station
- Take the MAX Red, Blue, or Green Line Eastbound
- Get off two stops down at the Lloyd Center/NE 11th Ave Station
- The hotel is across the street.

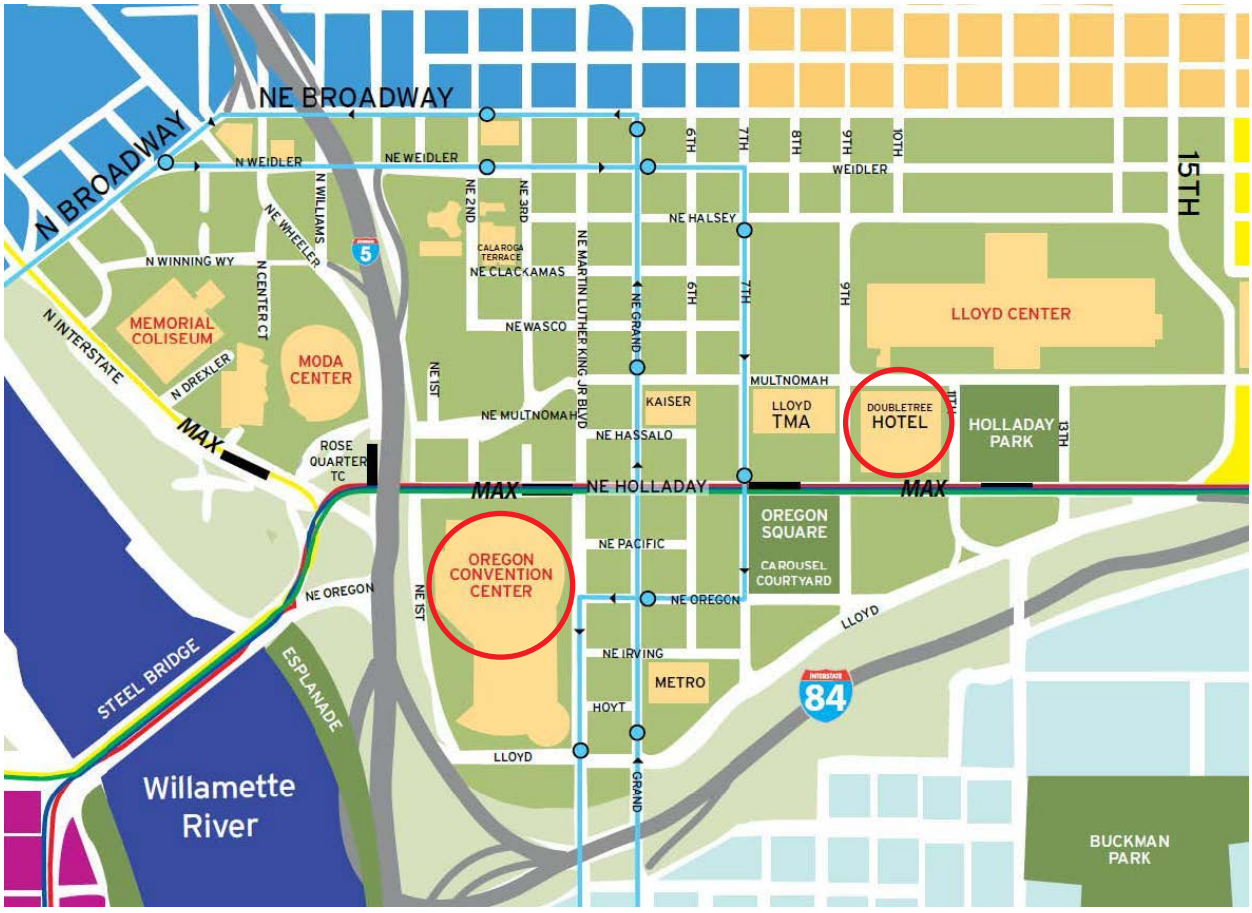

Photo courtesy of Jamie Francis and Travel Portland

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