Conference Facilities

FIRST FLOOR
- AEROBICS
  - Tremont Room

THIRD FLOOR
- BREAKFASTS
  - Third Floor Atrium
- INDUSTRIAL EXHIBITS AND WEDNESDAY LUNCH
  - Gloucester/Back Bay Conference and Exhibition Center
- YOUNG PROFESSIONALS BREAKFAST AND WIE LUNCH
  - Suffolk

FOURTH FLOOR
- REGISTRATION
  - Fourth Floor Atrium
- SHORT COURSE AND TECHNICAL SESSIONS
  - Ballroom Salons E - F
- SHORT COURSE LUNCH
  - Ballroom Salon G
- DATA WORKSHOP
  - Ballroom Salons A - D
- POSTERS
  - Ballroom Salon G
- A/V PREVIEW
  - Orleans

Cover - Boston photo courtesy of the Greater Boston Convention & Visitors Bureau
Cover - sky photo credit: http://hubblesite.org/
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<th>Tuesday July 14</th>
<th>Wednesday July 15</th>
<th>Thursday July 16</th>
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<td>[10:00] Break – Atrium Foyer</td>
<td>[10:00] Part 2 – Design Approaches for Radiation-Survivable Space Power Systems Leif Scheick</td>
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<td>1:00</td>
<td>[1:20] Part 3 – Design Challenges for Optical Payloads Used Within the Space Radiation Environment Terrence Lomheim</td>
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On behalf of the Institute of Electrical and Electronics Engineers (IEEE), its Nuclear and Plasma Sciences Society (NPSS), the Radiation Effects Steering Group (RESG) and the 2015 Nuclear and Space Radiation Effects Conference (NSREC) committee, it is my pleasure to invite you to attend the 52nd NSREC to be held July 13 – 17, 2015. The conference will be in Boston at the Marriott Copley Place, located in the historic Back Bay area of the city.

The conference begins Monday, July 13, with a one-day Short Course titled “Practical Problems in Spacecraft Design”. It is organized by Tim Oldham of Ball Aerospace and consists of four sections taught by experts from our community. The course will provide an introduction to issues in spacecraft design, including primarily radiation issues, but also other issues that constrain spacecraft performance. 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 14 to Friday, July 17. Ronald Lacoe of The Aerospace Corporation 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, Ronald has invited three entertaining speakers to give general interest presentations from Wednesday to Friday.

The Industrial Exhibit, organized by Dave Hansen, Maxwell Technologies, 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 Heather Quinn of Los Alamos National Laboratory has organized an outstanding social program. The Conference Social on Wednesday evening, a New England clambake on the only private island of the Harbor Islands, will highlight the program. Two companion tours are also scheduled. The first, on Tuesday, will be a visit to the preserved mill town of Lowell, cradle of the American Industrial Revolution, which includes a stop at the city’s textile museum. The second, on Thursday, will be a visit to the JFK Presidential Library followed by shopping and lunch at historic Faneuil Hall Marketplace.

The NSREC 2015 conference committee, including Publicity Chair Teresa Farris (Cobham), Finance Chair Jonny Pellish (NASA/GSFC), and Awards Chair Alessandro Paccagnella (DEI – Padova University), welcomes you to one of America’s most memorable cities.

We look forward to seeing you in Boston this July!

Visit us on the web at:
www.nsrec.com
PRACTICAL PROBLEMS IN SPACECRAFT DESIGN
BALLROOM SALONS E - F – MONDAY, JULY 13

8:00 AM SHORT COURSE INTRODUCTION
Tim Oldham, Ball Aerospace

8:10 AM PART 1 — RADIATION ENVIRONMENT INSIDE SPACECRAFT
Dr. Patrick O’Neill, NASA Johnson Space Center

9:40 AM BREAK (Ballroom Foyer)

10:10 AM PART 2 — DESIGN APPROACHES FOR RADIATION-SURVIVABLE SPACE POWER SYSTEMS
Dr. Leif Z. Scheick, Jet Propulsion Laboratory

11:40 AM SHORT COURSE LUNCHEON
(Ballroom Salon G)

1:20 PM PART 3 — DESIGN CHALLENGES FOR OPTICAL PAYLOADS USED WITHIN THE SPACE RADIATION ENVIRONMENT
Terrence S. Lomheim, The Aerospace Corporation

2:50 PM BREAK (Ballroom Foyer)

3:20 PM PART 4 — NO CHARGE LEFT BEHIND: A REVIEW OF THE CHARGING PHENOMENON AND ASSOCIATED HAZARDS
Dr. Joe Mazur, The Aerospace Corporation

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 2015 Short Course Notes
A one day Short Course “Practical Problems in Spacecraft Design” will be presented at the 2015 IEEE Nuclear and Space Radiation Effects Conference (NSREC). The course will provide an introduction to issues in spacecraft design, including primarily radiation issues, but also other issues that constrain spacecraft performance. The course will be beneficial to those new to the field, by introducing advanced concepts and emerging issues. It will also benefit those already experienced in the field.

The Short Course is organized into four sections, starting with a session describing radiation transport through spacecraft shielding, into the interior of the spacecraft. The radiation environment inside the spacecraft is what the electronics are exposed to. The second section deals with power sources and power distribution, which is a critical part of spacecraft design. The third section discusses the design of imaging systems, including, but not limited to, radiation issues. The final section will be the first Short Course presentation on spacecraft charging effects, which is usually identified as the cause of more significant spacecraft anomalies than even single event effects. The presenters for the 2015 Short Course are all recognized experts in their respective areas.

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. In-depth notes will be provided at registration.

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).

Timothy R. Oldham received his B.S. from Michigan State University (1969), his M.S. from American University (1975), and his Ph. D. from Catholic University of America (1982), all in Physics. He started as a summer student, and worked at the Army Research Laboratory and its predecessors, for more than 34 years, on a variety of radiation and electronics reliability research problems. Later, he joined the Radiation Effects and Analysis Group at the NASA Goddard Space Flight Center, as a support contractor. Currently, he is a Staff Consultant for Radiation Effects at Ball Aerospace. He has been elected Fellow of the IEEE for his technical contributions, which are documented in more than 40 journal articles, plus a book and two book chapters. Most of this work was first presented at this conference. He has served as Technical Program Chairman for the NSREC (1990), as General Conference Chairman (1994), and as Chairman of the Radiation Effects Steering Group (2006-2009), among other things.

Tim Oldham
Short Course Chairman
Dr. Patrick O’Neill, NASA Johnson Space Center, will present a detailed description of the radiation environment inside spacecraft. The free space (outside) solar and galactic cosmic ray and trapped Van Allen belt proton spectra are significantly modified as these ions propagate through various thicknesses of spacecraft structure and shielding material. In addition to energy loss, secondary ions are created as the ions interact with the structure materials. Nuclear interaction codes (FLUKA, GEANT4, HZTRAN, MCNPX, CEM03, and PHITS) transport free space spectra through different thicknesses of various materials. These “inside” energy spectra are then converted to Linear Energy Transfer (LET) spectra and dose rate – that’s what’s needed by electronics systems designers. Model predictions are compared to radiation measurements made by instruments such as the Intra-Vehicular Charged Particle Directional Spectrometer (IV-CPDS) used inside the Space Station, Orion, and Space Shuttle.

Introduction

- Stopping photons (X Ray / Bremmsstrahlung)
- Stopping particles (electrons, protons, neutrons, and heavy ions)
  - Earth’s atmosphere
  - Neutron monitors, sea-level single event effects
- Energy loss by ionization – Bethe-Bloch
- Particle and energy loss / creation by nuclear interaction – Spallation

Computer Models

- Simple Particle & Energy Loss – CRÈME 96
- Tracking the Created Particles
- Nuclear cross-sections for ion production - HZETRAN
- Monte Carlo Nuclear Models – FLUKA, GEANT, MCNPX

Each Natural Environment Has Its Own Shielding Issues

- Low Earth Orbit (LEO) – Inner Belt protons
- Middle Earth Orbit (MEO), Geosynch (GEO) – Outer Belt Electrons
- Deep Space - Galactic Cosmic Ray (GCR) and Solar Particle Events (SPE) heavy ions

Spacecraft Shielding Distributions and Actual “Inside” Radiation Model vs. Measurements

- Shuttle (STS), Space Station (ISS), Orion
- Tissue Equivalent Proportional Counter (TEPC), Charged Particle Directional Spectrometer (CPDS), Crew Passive Dosimeter (CPD)

Conclusion

- When are nuclear model shielding calculations necessary for single event effect (SEE) analysis?
Leif Scheick is the Principal Radiation Effects Engineer for the Radiation Effects Group of the Electronic Parts Engineering Office. Since 2000 he has provided radiation effects support for over twenty JPL missions including MER, JIMO, MRO, Juno, and Insight. He has been involved in both Single Event Effects and Total Dose testing and assurance of EEE devices for NASA missions. Leif’s research focuses currently on radiation effects on power devices, and he has contributed to research on radiation effects on non-volatile memory, SDRAMs and SRAMs, APSs and CCDs, and mixed signal devices. He received his B.S. in Physics from Wofford College in 1992 and did his graduate work in radiation physics in semiconductor devices at Clemson University. In 1996 he received a M.S. in Physics and in 1999 he received a Ph.D. in Physics, focusing on microdosimetric measurement using arrays of floating gates.

Dr. Leif Z. Scheick, Jet Propulsion Laboratory, will discuss the recent radiation effects in devices used in space power subsystems. The focus will be on the single-event and total dose effects that would affect power generation, distribution and monitoring (telemetry). Photovoltaic and radioisotope sources will be discussed in terms for power generation, along with electronics used in power management and distribution systems. Design and mitigation practices for highly reliable, radiation-resistant power systems will be presented. System level analysis approaches conclude the presentation.

**Power System Elements**

- **Sources**
  - Photovoltaic
  - MMRTG (Multi-Mission Radioisotope Thermoelectric Generator)
  - Alternatives

- **PMAD**
  - Conversion
  - Distribution
  - Telemetry

**Rad Effects**

- **Sources**
  - Photovoltaic
  - MMRTG

- **PMAD**
  - Conversion
    - DC/DC (Direct Current to Direct Current)
    - Power MOSFETs (Metal Oxide Silicon Field Effect Transistor)
  - Distribution
    - Power Management Bus (PMB)
    - Drivers
    - Switching Regulator Controller
    - Step-down Synch Switching Reg.
    - Boost/buck regulators
    - POL (Point of Load) regulators
    - Power MOSFETs (Metal Oxide Silicon Field Effect Transistor)
    - FPGAs (Field Programmable Gate Arrays)
    - ASICs (Application Specific Integrated Circuit)
    - PWM (Pulse Width Modulator)

- **Telemetry**
  - Op Amps (Operational Amplifiers)
  - Comparators
  - Voltage Reference
  - Analog to Digital Converters (ADCs)
  - Digital to Analog Converters (DACs)
  - Multiplexers

- **Open issues**
  - Monolithic vs hybrid

**Assurance**

- **SEE**
  - Mitigation
  - Technology selection

- **TID**
  - Mitigation
  - Technology selection

- **DDD**
  - Mitigation
  - Technology selection

- **Residual risk assessment**

- **Tools for mitigation**
  - SPICE
    - Available models
    - Best approaches

**Future tech**

- **Beyond silicon**
  - SiC (Silicon Carbide)
  - GaN (Gallium Nitride)
  - Alternate substrates
    - Graphene
    - Indium arsenide

- **Breaking Moore’s law**
  - nm and below tech

- **Cubesats and cubeprobes**

- **Mini-drones and micropower**

- **Super-systems and macropower**

**Conclusion**
Termence S. Lomheim, The Aerospace Corporation, will discuss the issues surrounding the design of optical payloads for use within the space radiation environment. Different types of optical payloads used, ranging from those typically employed for commercial Earth observation missions to the scientific payloads used for other missions will be explained. The system design of a payload and the concerns and various mitigation strategies for the detector chain, including the front end electronics, will be outlined. Lastly, detector degradation, including the behaviour of CCD, APS and hybrid detector technologies, will be related to system performance degradation to complete the presentation.

Introduction and Overview

Example Space Systems that Include Optical Payloads

Example Optical Payloads for Space Applications

Important Space Radiation Environments for Optical Payloads

Components and Materials Used in Optical Payloads

Technology-Driven Optical Payload Examples: Components to Subsystems
- Visible and Infrared Imaging Subsystems
- Telescope Subsystems
- Laser Communications Subsystems

Summary of Design Challenges and Important Needs for Future Optical Payloads from a Radiation-Tolerance Viewpoint

Concluding Remarks
Short Course Monday

NO CHARGE LEFT BEHIND: A REVIEW OF THE CHARGING PHENOMENON AND ASSOCIATED HAZARDS
Dr. Joe Mazur
The Aerospace Corporation

Dr. Joe Mazur, The Aerospace Corporation, will review the phenomenon of space and launch vehicle charging for the first time in an NSREC short course. He will describe the various charging environments and how they can couple with hardware to become a hazard to operations as determined through experiment, laboratory testing, and lessons from in-flight anomalies. There are many aspects to the mitigation of these hazards, and the course will discuss them and their roles in overall system design. The course will include charging concerns in less common environments such as satellite rendezvous and nuclear events and will conclude with a look ahead for charging issues for future systems.

Introduction
■ Definition of the charging phenomenon
■ Why charging is relevant to the NSREC community

Description of Charging Environments
■ Factory and laboratory
■ Atmosphere and clouds
■ Orbital

The Canonical Spacecraft Charging Illustration

What Are the Hazards from Charging and How Do We Know About Them?
■ Electrostatic discharge
■ Floating potential impacts
■ Special concerns for solar arrays and electric propulsion
■ Contaminants

Essentials of Mitigation Techniques
■ Environment specifications
■ General practices
■ Modeling of vehicle potentials
■ Laboratory simulation
■ Active and passive emitters

Issues with Mitigation Techniques
■ Tradeoffs between charging and other system needs
■ Importance of quantifying system susceptibilities
■ Material resistivity: pre-flight and after years on-orbit
■ Design complexities: self-shadowing and ram effects
■ Trapped charge or trapped heritage?

The Importance of Monitoring On-Orbit Environments and Effects
■ Inadvertent measurements
■ Charge and current monitors
■ Lessons for all systems

Charging in Unique Contexts
■ Satellite rendezvous
■ The moon and other airless bodies
■ Dust impacts
■ Nuclear weapons

Course summary and a look ahead for future systems

Joe Mazur received the A.B. degree in Physics in 1985 from the University of Chicago and the M.S. and Ph.D. degrees in Physics from the University of Maryland in 1987 and 1991 respectively. He was a Research Associate and Research Scientist at the University of Maryland until he joined The Aerospace Corporation in 1997 where he is currently an Associate Director of the Space Sciences Department. His major interests are advanced particle detectors, solar energetic particles, trapped particles in the Earth’s magnetosphere, and space environment effects on space systems. He has been a Co-investigator on 6 spaceflight missions including the Solar, Anomalous, and Magnetospheric Particle Explorer, the NASA/ESA Ulysses mission, and the Lunar Reconnaissance Orbiter. He is currently the Principal investigator on three missions including the NASA Van Allen Probes. Dr. Mazur is author/coauthor of over 80 papers in refereed journals.
The NSREC technical program will consist of contributed oral, poster papers, a data workshop, three invited presentations, 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:

- **Radiation Effects in Devices and Integrated Circuits**  
  Chair: Ivan Sanchez Esqueda, USC Information Sciences Institute

- **Hardness Assurance**  
  Chair: Steve Moss, The Aerospace Corporation

- **Single Event Effects: Devices and Integrated Circuits**  
  Chair: Norbert Seifert, Intel

- **Single Event Effects: Transient Characterization**  
  Chair: Sarah Armstrong, NAVSEA Crane

- **Space and Terrestrial Environments**  
  Chair: Stuart Huston, Atmospheric and Environmental Research, Inc.

- **Single Event Effects: Mechanisms and Modeling**  
  Chair: Kevin Warren, Vanderbilt University

- **Basic Mechanisms of Radiation Effects**  
  Chair: Marc Gaillard, CEA

- **Photonic Devices and Integrated Circuits**  
  Chair: Cedric Virmontois, CNES

- **Dosimetry**  
  Chair: Michael Gordon, IBM

- **Hardening By Design**  
  Chair: Ethan Cannon, The Boeing Corporation

Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session on Tuesday – Friday, Ballroom Salon G. The formal Poster Session will be held on Thursday from 1:45 to 4:45 PM and the authors will be available at that time to discuss their work. The Poster Session chair is David Hiemstra, MDA Corporation.

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 – Friday in the Ballroom Salons A-D. Authors will be available on Wednesday to discuss their work from 1:30 to 4:00 PM. A workshop record will be mailed to all registered conference attendees. The workshop chair is Keith Avery, Air Force Research Laboratory.

**INVITED SPEAKERS**

- **Meet John Adams – A Lively and Revolutionary Conversation with America’s Second President** George Baker, Performer and Lawyer

- **Brilliant Blunders: From Darwin to Einstein – Colossal Mistakes by Great Scientists that Changed Our Understanding of Life and the Universe** Mario Livio, Author & Astrophysicist, Space Telescope Science Institute

- **Witch City: Salem, Massachusetts and its Infamous Witch Trials** Emerson “Tad” Baker, Author & Professor, Salem State University

**WOMEN IN ENGINEERING**

- **Finding My Voice – 3 Things That I Learned to Say** Janet Barth, NASA/GSFC, Emeritus

**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 29, 2015. Detailed instructions for submitting a late-news summary are available on the NSREC web site at [www.nsrec.com](http://www.nsrec.com).
BALLROOM SALONS E - F

8:00 AM  OPENING REMARKS
  Mike Xapsos, NASA Goddard Space Flight Center, General Chairman

8:05 AM  AWARDS PRESENTATION
  Marty Shaneyfelt, Sandia National Laboratories, Radiation Effects Steering Group Chairman

8:35 AM  TECHNICAL SESSION OPENING REMARKS
  Ronald Lacoe, The Aerospace Corporation, Technical Program Chairman

SESSION A

8:40 AM  RADIATION EFFECTS IN DEVICES AND INTEGRATED CIRCUITS
  SESSION INTRODUCTION
  Chair: Ivan Sanchez Esqueda, USC Information Sciences Institute

A-1 8:45 AM  Interrupted PROGRAM and ERASE Operations for Characterizing Radiation Effects in Commercial NAND Flash Memories
  A. H. Roach, M. J. Gadlage, A. R. Duncan, J. D. Ingalls, M. J. Kay
  NAVSEA Crane

A technique of interrupting program and erase operations is used to extract analog information from the memory cells of commercial NAND Flash memories. Applications in radiation testing and characterization are discussed.

A-2 9:00 AM  Enhancement of Transistor-to-transistor Variability due to Total Dose in 65-nm MOSFETs
  S. Gerardin 1, M. Bagatin 1, D. Cornale 1, 2, L. Ding 1, S. Mattiazzo 1, A. Paccagnella 1, F. Faccio 2, S. Michelis 2
  1 University of Padova; 2 CERN

Device-to-device variation in bulk MOSFETs is investigated as a function of total ionizing dose. An enhancement in the variability of p-channel MOSFETs at high dose levels is discussed in the context of random dopant fluctuations.

A-3 9:15 AM  Impact of Electron Irradiation on Traps and $V_T$ Instability in AlGaN/GaN HEMTs
  T. Mohsin 1, Z. Zhang 1, P. Saunier 2, C. Lee 2, S. Ringel 1, A. Arehart 1
  1 The Ohio State University; 2 Qorvo Inc.

The impact of electron irradiation on AlGaN/GaN HEMTs is investigated. An observed radiation-induced increase in threshold voltage dispersion correlates with trap states at $E_C - 0.90$ eV. Radiation-insensitive traps at $E_C - 0.60$ eV dominate the dispersion.

A-4 9:30 AM  A Study of Gamma-Ray Exposure of Cu-SiO$_2$ Programmable Metallization Cells
  W. Chen, H. Barnaby, M. Kozicki, Y. Gonzalez-Velo, R. Fang, K. Holbert, S. Yu, W. Yu
  Arizona State University

Cu-SiO$_2$ based programmable metallization cells (PMCs) are a promising alternative to Ag-chalcogenide PMCs for their low power operation and CMOS-compatibility. The impact of TID on this technology is experimentally characterized and analyzed.
POSTER PAPERS

PA-1 Investigations on MGy Total Ionizing Dose Effects in CMOS Technologies
M. Gaillardin 1, P. Paillet 1, V. Goiffon 2, M. Martinez 1, S. Girard 3, M. Raine 1,
C. Marcandella 1, O. Duhamel 1, P. Magnan 2
1 CEA, DAM, DIF; 2 Universite de Toulouse; 3 Universite Jean Monnet

This work investigates MGy Total Ionizing Dose effects in CMOS technologies. Large TID-induced electrical shifts are observed in devices with thin dielectrics. Trapping and detrapping properties are discussed using dedicated irradiation/annealing experiments.

PA-2 Total Ionizing Dose Effects on Ge Channel pFETs with Raised Si0.55Ge0.45 Source/Drain
L. Wang 1, 2, E. X. Zhang 1, C. X. Zhang 1, G. X. Duan 1, R. D. Schrimpf 1,
D. M. Fleetwood 1, R. A. Reed 1, I. K. Samsel 1, J. Hachtel 1, M. L. Alles 1, L. Witters 3,
N. Collaert 3, D. Linten 3, J. Mitard 3, S. T. Pantelides 1, K. F. Galloway 1
1 Vanderbilt University; 2 Beijing Microelectronics Technology Institute; 3 IMEC

The TID response of Ge pFETs with raised SiGe source/drain is reported. Threshold voltage shifts and transconductance degradation during ON-bias irradiation are mainly due to NBTI. A non-monotonic leakage response is observed during irradiation.

PA-3 Effects of Proton-Induced Displacement Damage on Gallium Nitride Power Amplifier RF Performance
N. E. Ives, A. F. Witulski, R. D. Schrimpf, D. M. Fleetwood, R. W. Bruce, M. W. McCurdy,
E. X. Zhang, L. W. Massengill
Vanderbilt University

The effects of proton-induced displacement damage in GaN HEMTs on RF power amplifier circuit gain, stability, and output power are presented. The results are explained based on the device-level degradation.

PA-4 Evaluation of 1.5-T Cell Flash Memory Total Ionizing Dose Response
A. Sahu, J. W. Adams, L. T. Clark, K. E. Holbert, H. Navale, Y. Chen
Arizona State University

TID irradiation of 1.5T flash memories manifests failures indicating device damage and circuit marginalities. Sector erase failures limit radiation hardness, but read only operation allows TID exceeding 200 krad. The failures are analyzed by type.

9:45 – 10:10 AM
INDUSTRIAL EXHIBITS AREA/
BACK BAY CONFERENCE &
EXHIBIT CENTER

HARDNESS ASSURANCE

SESSION B
10:10 AM
SESSION INTRODUCTION
Chair: Steve Moss, The Aerospace Corporation
The Contribution of Low-Energy Protons to the Total On-Orbit SEU Rate


1 Sandia National Laboratories; 2 Vanderbilt University; 3 Swift Engineering & Radiation Services; 4 Brigham Young University; 5 BAE Systems; 6 NRL Consultant; 7 TRIUMF; 8 NASA Goddard Space Flight Center

We present experimental data and error rate predictions for many circuits from the 20-90 nm nodes to study the general importance of low-energy proton effects and to refine hardness assurance methods.

The Impact of Metal Line Reflections on Through-Wafer TPA SEE Testing

A. Khachatryan 1, N. J-H. Roche 2, N. A. Dodds 3, D. McMorrow 1, J. H. Warner 1, S.P. Buchner 1, R. A. Reed 4

1 Naval Research Laboratory; 2 George Washington University; 3 Sandia National Laboratory; 4 Vanderbilt University

Charge-collection experiments and simulations designed to quantify the effects of reflections from metallization during through-wafer TPA testing are presented. The results reveal a strong dependence on metal line width.

Investigating Pulsed X-Ray Induced SEE in Analog Microelectronic Devices

D. M. Cardoza 1, S. D. LaLumondiere 1, M. A. Tockstein 1, N. P. Wells 1, D. L. Brewe 2, K. M. Gaab 1, W. T. Lotshaw 1, S. C. Moss 1

1 The Aerospace Corporation; 2 Argonne National Laboratory

We investigate SETs and SELs generated by pulsed x-rays in analog devices. We compare these results with new and previously published laser and heavy ion results. We discuss the RHA implications of this test modality.

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

T. L. Turflinger 1, D. A. Clymer 2, L. W. Mason 2, S. Stone 2, J. S. George 1, M. A. Savage 3, R. Koga 1, E. R. Beach 2, K. D. Huntington 2

1 The Aerospace Corporation; 2 Lockheed-Martin Corp; 3 NAVSEA Crane

OP470 devices revealed SEDR events from protons only when gold-flashed lids faced the die surface. Proton on Gold fission fragments have sufficient LET and range. RHA implications and physics of these reactions are explored.

Hardness Assurance in Advanced Semiconductor Packaging with Krypton-85 Leak Testing

G. K. Lum 1, D. Beutler 2, D. Walters 3, W. P. Ballard 4

1 Lockheed Martin Space Systems Company; 2 MannaTech Engineering, LLC; 3 L3 Applied Technologies; 4 Sandia National Laboratories

Significant gain degradation was observed from $^{85}$Kr leak testing of a bipolar discrete. The implications for hardness assurance in advanced hermetic semiconductor packaging are raised.
Hydrogen Limits for Total Dose and Dose Rate Response
P. C. Adell 1, I. S. Esqueda 2, H. J. Barnaby 3, B. G. Rax 1
1 Jet Propulsion Laboratory; 2 Information Science Institute; 3 Arizona State University

Soaked-hydrogen irradiations show the H₂-limits for the total-dose response of bipolar technologies. We use a model to extrapolate experimental observations and generate an H₂ safe-operating-area for various total-dose conditions.

Schottky Diode Derating for Survivability in a Heavy-Ion Environment
M. C. Casey 1, E. P. Wilcox 2, J.-M. Lauenstein 1, A. D. Topper 2, K. A. LaBel 1
1 NASA Goddard Space Flight Center; 2 ASRC Federal Space and Defense, Inc.

The dependence of single-event failures in Schottky diodes on reverse voltage derating is discussed. Failure location and possible mechanisms are also discussed.

Evaluation and Application of U.S. Medical Proton Facilities for Single Event Effects Test
B. S. Wie 1, K. A. Label 2, T. L. Turflinger 3, A. D. Kostic 3, R. A. Reed 4, C. C. Foster 5, J. L. Wert 6, J. S. George 3
1 Integrity Applications Incorporated; 2 NASA Goddard Space Flight Center; 3 The Aerospace Corporation; 4 Vanderbilt University; 5 Foster Consulting Services, LLC; 6 The Boeing Company

We present the challenges of using new medical proton therapy cyclotrons for SEE tests in the 200 MeV regime. Solutions are discussed to utilize these facilities as a replacement for the Indiana University Cyclotron Facility.

Protons as a Screen for Displacement-Damage Sensitivity in Bipolar Junction Transistors
Vanderbilt University

The ratio of BJT gain degradation produced by ionization to that produced by displacement damage is analyzed for proton irradiation. Results show that protons can be used to screen for sensitivity to displacement damage.

Use of Proton SEE Data as a Proxy for Bounding Heavy-Ion SEE Susceptibility
R. L. Ladbury, J.-M. Lauenstein
NASA Goddard Space Flight Center

We examine use of proton SEE data to constrain heavy-ion SEE susceptibility. We discuss limitations due to short range proton recoils and develop an approach for using proton data to constrain device sensitive volumes.
PB-4  Sample-to-Sample Variability of Floating Gate Errors due to Total Ionizing Dose  
S. Gerardin 1, M. Bagatin 1, A. Bertoldo 1, A. Paccagnella 1, V. Ferlet-Cavrois 2  
1 University of Padova; 2 European Space Agency  
We studied sample-to-sample variability in the total-dose induced errors in NAND Flash Memories. Experimental data are modeled with statistical methods, and the accuracy of using a reduced number of samples is evaluated.

PB-5  Bayesian Inference Modeling of Total Ionizing Dose Effects on System Performance  
A. F. Witulski, Z. Diggins, N. Mahadevan, G. Karsai, E. Barth, R. Schrimpf, B. Sierawski, B. Pitt, R. Weller, M. Alles, R. Reed  
Vanderbilt University  
A probabilistic Bayesian model for determining the effects of radiation-induced component-level parameter shifts on system-level performance is presented for robots in radiation environments.

PB-6  Novel Method for In-Situ, Total Ionising Dose Measurement of Temperature Coefficients of Semiconductor Device Parameters  
J. Hofman 1, A. Holmes-Siedle 2  
1 Cobham RAD Solutions; 2 REM Oxford  
This work presents a new test method allowing in-situ measurement of total ionizing dose induced changes in temperature effects on semiconductor devices. Preliminary results of a pilot experiment on commercial PMOS transistors are presented.

PB-7  Software Reliability and the Effectiveness of Software Mitigation in Microcontrollers  
H. Quinn, T. Fairbanks, J. Tripp, G. Duran  
LANL  
We present information about software resilience and the effectiveness of software mitigation on microcontrollers and ARMs. This technique looks at the effect of SEUs and SETs on software failures.

PB-8  Analysis of Angular Dependence of Single-Event Latchup Sensitivity for Heavy Ion Irradiations of 0.18µm CMOS Technology  
L. Artola 1, N. Roche 2, N. Dodds 3, G. Hubert 1, A. Al Youssef 1, A. Khachatrian 2, P. McMarr 2, H. Hughes 2  
1 DESP/ECM, ONERA; 2 Naval Research Laboratory; 3 Sandia National Laboratories  
This paper presents the angular dependence of SEL occurrence in order to improve rate prediction and the interpretation of experimental cross sections. The analysis combines TCAD simulations and a prediction tool calibrated by electrical characterization.
We present a benchmark suite for radiation testing of field-programmable gate arrays (FPGAs) and microprocessors. Radiation results from several of these benchmarks are presented and can be used for comparing systems.

We show that, for avionic and accelerator applications, the hardness of the experimental and operational environments needs to be taken into account in order to avoid a significant underestimation of the SEL risk.

This study describes complications introduced by angular direct ionization events on space error rate predictions, proposes a methodology to extend existing error estimation, and illustrates these points using test data on a modern 28nm device.

We report on radiation-induced soft error rate improvements in the 2nd generation, 14nm high-k+metal gate bulk Tri-Gate technology over previous Tri-Gate and planar technology generations.
Bias Dependence of Single-Event Upsets in 16-nm FinFET D-Flip-Flops

B. Narasimham 1, S. Hatami 2, A. Anvar 1, D. M. Harris 2, A. Lin 1, J. K. Wang 1, I. Chatterjee 3, B. L. Bhuva 4, R. D. Schrimpf 4, R. A. Reed 4, M. W. McCurdy 4
1 Broadcom Corporation; 2 Harvey Mudd College; 3 University of Bristol; 4 Vanderbilt University

SEU cross-section of FinFET-based flip-flops increases exponentially with reduction in bias for low-LET particles. TCAD simulations show that weak variation of collected charge with supply voltage is responsible for this trend.

Multi-Cell Soft Errors at Advanced Technology Nodes

B. Bhuva 1, N. Tam 2, L. Massengill 1, D. Ball 1, I. Chatterjee 3, M. McCurdy 1, M. Alles 1
1 Vanderbilt University; 2 Marvell Technologies Group; 3 University of Bristol

Heavy-ion irradiation of bulk 16-nm FinFET SRAMs show that MCUs dominate the upset rates. TCAD simulations showing the spread of well-potential perturbation as a function of particle LET support the experimental data.

Frequency Dependence of Soft-Error Rates for Datapath Circuits

N. N. Mahatme 1, L. Rui 2, H. Wang 2, L. Chen 2, B. L. Bhuva 3, L. W. Massengill 3, S. Wen 4, R. Wong 4, K. Lilja 5
1 Freescale Semiconductor; 2 University of Saskatchewan; 3 Vanderbilt University; 4 CISCO Systems Inc.; 5 RobustChip

Heavy-ion irradiation of 28-nm datapath circuits shows that the cross-section decreases with frequency for low-LET particles and increases with frequency for higher-LET particles. Voltage dependence of this trend is evaluated.

The Role of Negative Feedback Effects on Single-Event Transients in SiGe HBT Analog Circuits

S. Jung 1, I. Song 1, N. E. Lourenco 1, M. A. Oakley 1, B. R. Wier 1, Z. E. Fleetwood 1, N. J. J. -H. Roche 2, A. Khachatrian 2, D. McMorrow 2, S. P. Buchner 2, J. H. Warner 2, P. Paki 3, J. D. Cressler 1
1 Georgia Institute of Technology; 2 Naval Research Laboratory; 3 Defense Threat Reduction Agency

We investigate the role of negative feedback effects on single-event transients in analog circuits utilizing SiGe HBT current mirrors.

2:50 – 3:15 PM
INDUSTRIAL EXHIBITS AREA/
BACK BAY CONFERENCE &
EXHIBIT CENTER

Heavy Ion SEE Testing of a 32nm RHBD DDRx SDRAM

M. Cabanas-Holmen, E. Cannon, J. Ballast, M. Carson, T. Amort
The Boeing Company

We have designed and fabricated a prototype radiation hardened DDR2 SDRAM in the IBM 32nm partially depleted SOI process, and present results from single event effects testing.
**POSTER PAPERS**

**PC-1**  
**Accurate Error Rate Prediction on SRAM-Based FPGAs: Proton and Neutron Radiation Test Experiments**  
L. Sterpone 1, M. Desogus 3, B. Du 1, D. Merodio Codinachs 2, C. Poivey 2, V. Ferlet-Cavrois 2, H. Wojciech 3, H. Quinn 4  
1 Politecnico di Torino; 2 European Space Agency; 3 Paul Scherrer Institute; 4 Los Alamos National Laboratories

The paper presents proton and neutron radiation tests of circuits implemented on Xilinx Virtex-5 SRAM- FPGAs. Experimental results are analyzed by a verification method predicting the Single Data Corruption Error Rate of the circuits.

**PC-2**  
**Neutron-Induced SEU and MCU Rate Characterization and Analysis of SOTB and Bulk SRAMs at 0.3V Operation**  
S. Hirokawa 1, R. Harada 1, M. Hashimoto 1, K. Sakuta 2, Y. Watanabe 2  
1 Osaka University; 2 Kyusyu University

We present measurement results of neutron-induced SEU and MCU in 0.3V SRAMs fabricated with 65nm SOTB and bulk devices and give an implication on MCU spatial patterns with Monte Carlo and circuit simulations.

**PC-3**  
**Single-Event Upset Characterization Across Temperature and Supply Voltage for a 20-nm Bulk Planar Technology**  
Vanderbilt University

Flip-flop alpha-particle single-event upsets are characterized over temperature and bias variations in a 20-nm bulk planar process. Cross sections vary up to 700% due to temperature dependence of carrier mobilities.

**PC-4**  
**A Comparison of the SEU Response of Planar and FinFET D Flip-Flops at Advanced Technology Nodes**  
P. Nsengiyumwa 1, N. Tam 2, M. McCurdy 1, T. W. Holman 1, B. L. Bhuvn 1, L. W. Massengill 1  
1 Vanderbilt University; 2 Marvell Semiconductor

Measurements show that 16-nm bulk FinFET flip-flops have considerably lower SEU cross-sections than their sub-32-nm planar counterparts. Results confirm the SEU improvement of FinFET over planar devices below 32-nm.
Investigation on MCU Clustering Methodologies for Cross-Section Estimation of SRAMs
A. L. Bosser 1, V. Gupta 2, R. Ferraro 2, A. Javanainen 1, H. Kettunen 1, H. Puchner 3, F. Saigne 2, A. Virtanen 1, F. Wrobel 2, L. Dilillo 4
1 University of Jyväskylä; 2 University of Montpellier; 3 LIRMM/University of Montpellier/CNRS; 4 Cypress Semiconductor

Various failure scenarios may occur during irradiation testing of SRAMs, which may generate different characteristic Multiple Cell Upset (MCU) error patterns. This work proposes a method based on spatial and temporal criteria to identify them.

Memory Latencies and Input Size Effects on Parallel Processors Reliability
D. Oliveira 1, L. Pilla 2, C. Lunardi 3, P. Navaux 1, L. Carro 4, P. Rech 1
1 UFRGS; 2 UFSC

We present data on the impact of memory latencies and data input size on processor performance and reliability. Data from extensive radiation testing experiments are analyzed and discussed for different implementations of various parallel algorithms.

Prediction of Proton Single Event Burnout Rate in STRIPFET Devices
S. Siconolfi 1, J. Mekki 2, P. Oser 2, G. Spiezia 2, G. Hubert 1, J.-P. David 1
1 ONERA The French Aerospace Lab; 2 CERN

This paper presents a proton SEB prediction model for device characterization. Calculated SEB cross section in STRIPFETs is compared to proton data from PSI, showing good agreement in order of magnitude.

An Investigation of the SET Response of Devices and Differential Pairs in a 32-nm SOI CMOS Technology
1 Georgia Institute of Technology; 2 Sandia National Laboratories; 3 Applied Physics Laboratory; 4 Naval Research Laboratory; 5 Defense Threat Reduction Agency

The single-event effect (SEE) response of devices and differential pairs in a 32-nm SOI CMOS technology are explored using laser-induced carrier injection and TCAD simulation.

Single-Event Characterization of Bang-Bang All-Digital Phase-Locked Loops (ADPLLs)
Y. P. Chen 1, L. W. Massengill 1, B. L. Bhuvan 1, W. T. Holman 1, W. H. Robinson 1, T. D. Loveless 2, A. F. Witulski 1, N. J. Gaspard 3
1 Vanderbilt University; 2 University of Tennessee; 3 Altera Corp.

The SEU vulnerability of a bang-bang ADPLL is investigated through fault injection experiments and circuit simulations. SEUs in the digital loop filter result in the worst-case error response, often requiring phase reacquisition.
Heavy Ion SEE Testing of Multi-GHz 32nm RHBD Analog/Mixed Signal Macros
E. Cannon, M. Cabanas-Holmen, J. Mackler, M. Yao, T. Amort
The Boeing Company

We performed at-speed SEE testing on multi-gigaHertz RHBD Analog/Mixed Signal macros, including SerDes and PLL, using custom designed test chips, carefully designed test setups, and high speed test equipment.

Single-Event Effects in a W-Band (75-110 GHz) Radar Down-Conversion Mixer Implemented in 90 nm, 300 GHz SiGe HBT Technology
S. Zeinolabedinzadeh 1, I. Song 1, N. E. Lourenco 1, A. S. Cardoso 1, N. J. -H. Roche 2, 3, A. Khachatrian 2, 4, D. McMorrow 2, S. P. Buchner 2, J. H. Warner 2, P. Paki 5, J. D. Cressler 1
1 Georgia Tech; 2 Naval Research Laboratory; 3 The George Washington University; 4 Sotera Defense; 5 Defense Threat Reduction Agency

This paper investigates single-event effects in a W-band (75-110 GHz) SiGe HBT down-conversion mixer intended for use in a space-based remote sensing radar system.

An Investigation of Single-Event Effect Modeling Techniques for a SiGe RF Low-Noise Amplifier
1 Georgia Institute of Technology; 2 The George Washington University; 3 Sotera Defense; 4 Naval Research Laboratory; 5 CFD Research Corporation; 6 Defense Threat Reduction Agency

The impact of transient modeling approaches on simulation fidelity is evaluated for an L-band, SiGe low-noise amplifier (LNA) to establish best practices for predicting SEE sensitivity within space-based radar and communications systems.

SEU and SET of 65nm Bulk CMOS Flip-Flops and Their Implications for RHBD
Y. Zhao, L. Wang, S. Yue, D. Wang, X. Zhao, Y. Sun, D. Li, F. Wang, X. Yang, H. Zheng, J. Ma, L. Fan
Beijing Microelectronics Technology Institute

Heavy ion results of 65nm CMOS testchips were analyzed in both LET and proposed time domains. The SEU and SET performance of various DFFs were compared and discussed, concluding practical implications for RHBD.

Impact of Stacked-Layer Structure on SEE Rate of SRAMs
V. Gupta 1, A. Bosser 2, G. Tsiligiamnis 3, A. Mohammadzadeh 4, A. Javanainen 2, A. Virtanen 2, H. Puchner 5, F. Wrobel 6, F. Saugne 6, L. Dilillo 7
1 Universite Montpellier - LIRMM/IES; 2 University of Jyvaskyla; 3 Jet Propulsion Laboratory; 4 ESA; 5 Cypress Semiconductor; 6 Universite Montpellier - IES; 7 Universite Montpellier/ CNRS - LIRMM

We present experimental data from long-range heavy-ion and low-energy proton radiation testing of a 90nm SRAM consisting of two stacked layers. Results are discussed and impact on proton SEE rate is investigated.
PC-15  Comparative Analysis of Photo Flash Induced Latch-Up, Photoemission Detection, Substrate Mitigation, and Heavy Ion SEL Correlation
J. F. Salzman 1, R. Roybal 1, W. Vonbergen 1, T. Vigilant 1, H. Chen 2, K. Chen 2
1 Texas Instruments; 2 Brookhaven National Laboratory

Photo flash induced latchup in CMOS devices using photoemission measurements were used to determine latchup mitigation effectiveness using P+ epi substrates on several devices, and correlated to Heavy ion induced SEL in the same devices.

PC-16  The Dependence of Single-Event Latchup on Charge Injection, Applied Bias and Strike Location Using a Pulsed Laser
1 Naval Research Laboratory; 2 Foster Consulting Services, LLC; 3 Airbus Group Innovations; 4 Analog Devices

Focused pulsed laser light is used to investigate single event latchup in an analog-to-digital converter (AD9140) through the generation of charge collection spectra and their dependence on bias, laser intensity and strike location.

PC-17  COTS-Based Computing for Space Applications - The HiRel European Space Agency Program and Its Results
C. Albanese 1, M. Alderighi 2, F. Casini 1, S. Esposito 3, L. Giganti 4, M. L. Esposti 4, C. Monteleone 5, M. Violante 3
1 Sanitas EG; 2 National Institute for Astrophysics; 3 Politecnico di Torino; 4 Thales Alenia Space Italia s.p.a.; 5 European Space Agency

The abstract describes the HiRel European Space Agency Program, which resulted in a high-performance COTS-based computer for space applications. The architecture of the computer and the results of its validation are discussed.

PC-18  Evaluating Multi-Gigabit Transceivers (MGT) for Use in High Energy Physics Through Proton Irradiation
M. Cannon 1, M. Wirthlin 1, A. Camplani 2, M. Citterio 2, C. Meroni 2
1 Brigham Young University; 2 Italian Institute of Nuclear Physics (INFN)

The paper summarizes the radiation test results of Xilinx 7-Series Multi-Gigabit Transceivers (MGT) operating in a 180 MeV proton beam to test the suitability in High Energy Physics experiments.

PC-19  Single-Event Effect Performance of a Conductive-Bridge Memory EEPROM
D. Chen 1, E. Wilcox 2, M. Berg 2, H. Kim 2, A. Phan 2, M. Figueiredo 3, K. LaBel 1
1 NASA Goddard Space Flight Center; 2 ASRC Space & Defense, AS&D Inc.; 3 Orbital Science Corp.

We investigate the SEE susceptibility of a CBRAM-based EEPROM. The part is vulnerable to SEFIs during standby, read, and write/read operation modes. We also observed SEUs evident of cell corruption during write cycles.
Silicon Carbide Power Device Performance under Heavy-Ion Irradiation
J.-M. Lauenstein 1, M. C. Casey 1, A. D. Topper 2, A. M. Phan 2, E. P. Wilcox 2, K. A. LaBel 1
1 NASA Goddard Space Flight Center; 2 ASRC Federal Space and Defense, AS&D, Inc.

Heavy-ion induced degradation and catastrophic failure in SiC power MOSFETs and Schottky diodes are examined to provide insight into the challenge of single-event effect hardening of SiC power devices.

Characterization of Single-Event Transients in Sub-Threshold Circuits
J. R. Ahlbin 1, M. J. Gadlage 2, P. Gadfort 3, S. Stansberry 2
1 USC - Information Sciences Institute; 2 NAVSEA Crane, IN; 3 US Army Research Lab

Direct measurements of SETs from a 65nm circuit designed specifically to operate at subthreshold voltages are presented. Alpha data shows pulse widths that range from nanoseconds to microseconds while operating well below the nominal voltage.

Charge Collection Mechanisms of Ge-Channel Bulk pMOSFETs
I. K. Samsel 1, E. X. Zhang 1, A. L. Sternberg 1, R. A. Reed 1, D. M. Fleetwood 1, M. L. Alles 1, R. D. Schrimpf 1, D. Linten 2, J. Mitard 2, L. Witters 2, N. Collaert 2
1 Vanderbilt University; 2 IMEC

Single-event transients in SiGe MOS devices with ultrathin quantum well channels reverse polarity for source and drain strikes. No polarity reversal is found in similar devices with thick Ge channels, confirming TCAD predictions.

Impact of Cumulative Irradiation Degradation and Circuit Board Design on the Parameters of ASETs Induced in Discrete BJT-Based Circuits
N. Roche 1, 2, A. Khachatrian 1, 3, J. Warner 1, S. Buchner 1, H. Hughes 1, P. McMarr 1, 3, D. McMorrow 1
1 Naval Research Laboratory; 2 The George Washington University; 3 Sotera Defense Group

Circuit parameters and configuration are very important when studying the synergistic effects of total dose/SET. A method combining dynamic parameter and spectrum analysis which lead to a better understanding of this complex phenomenon is explored.

A Comparison of Single-Event Transients in Pristine and Irradiated AlGaN/GaN HEMTs Using Pulsed Laser Light to Generate Carriers via Two-Photon Absorption
S. P. Buchner 1, A. Khachatrian 2, N. J.-H. Roche 3, A. D. Koehler 1, T. J. Anderson 1, K. D. Hobart 1, B. Weaver 1, D. P. McMorrow 1
1 Naval Research Laboratory; 2 Sotera Defense Group; 3 George Washington University

Pulsed laser light is used to investigate single-event transients in pristine and irradiated AlGaN/GaN HEMTs via two-photon absorption whereby free carriers are produced in the GaN buffer but not in the AlGaN barrier layer.
Frequency Trends Observed in 32nm SOI Flip-Flops and Combinational Logic

R. C. Quinn 1, J. S. Kauppila 1, T. D. Loveless 2, J. A. Maharrey 1, J. D. Rowe 1, M. W. McCurdy 1, M. L. Alles 1, B. L. Bhuva 1, R. A. Reed 1, K. Lilja 3, L. W. Massengill 1

1 Vanderbilt University; 2 University of Tennessee at Chattanooga; 3 Robust Chip, Incorporated

32 nm SOI combinational logic data show a linear single-event sensitivity with frequency, but flip-flops show a reciprocal relationship. We attribute the latter to a frequency-dependent flip-flop temporal window of vulnerability.

Charge Collection Mechanism in GaAs MOSFETs

K. Ni 1, E. Zhang 1, R. D. Schrimpf 1, R. A. Reed 1, D. M. Fleetwood 1, A. L. Sternberg 1, S. Ren 2, T.-P. Ma 2, L. Dong 3, J. Zhang 3, P. D. Ye 3

1 Vanderbilt University; 2 Yale University; 3 Purdue University

Two-photon laser induced current transients are investigated for GaAs MOSFETs. The gate oxide does not eliminate gate transients and charge enhancement is observed. The collected charge increases with gate bias.

A Novel Uniform Vertical Inverter Chains (UniVIC) SEMT Test Structure for Heavy-Ion-Induced Charge Sharing Measurement

P. Huang, S. Chen, J. Chen, B. Liang, Y. Chi

National University of Defense Technology

The UniVIC SEMT, a new test structure for charge sharing measurements, is introduced. Heavy-ion experiments reveal that fewer than 30 percent of single events can bring about charge sharing in 65 nm technologies.

END OF TUESDAY SESSIONS
**Meet John Adams – A Lively and Revolutionary Conversation with America’s Second President**

*George Baker, Performer and Lawyer*

In this one-man show, George Baker portrays the character of President John Adams. Through stories and with song, dressed in clothes he would have worn as President of the United States from 1797 – 1801, George Baker as “President John Adams” presents his views of the nation, history and family life in a humorous and inspiring talk. This unique performance will not only provide insights into the early history of the United States, of which events in Boston played a crucial role, but will entertain you. Mr. Baker has performed throughout the country, including at the Dwight D. Eisenhower Presidential Library in Kansas, the George H. W. Bush Presidential Library in Texas, the Harry S. Truman Presidential Library in Missouri, and was featured as John Adams on National Public Radio’s *Studio 360*.

John Adams was born in Braintree, Massachusetts in 1735 and practiced law in Boston until 1774 when he was chosen to be one of the five delegates from Massachusetts to the Continental Congress meeting in Philadelphia. In 1776, he was the Congress’ most strenuous advocate for American independence from Great Britain. Later he served as ambassador from the Continental Congress to Paris, Holland and London and was Vice President in the administration of President George Washington. In 1796, he was elected President of the United States. Mr. Baker’s portrayal of the second president of the United States will provide a late eighteenth century perspective of life in early America.

*George Baker* is a graduate of Columbia College and Columbia Law School. He practices law in New Canaan, Connecticut. In 2008, George created a one-man show to represent the humor and patriotism of President John Adams. Since then, his performances have taken place across the United States at venues large and small.

**SPACE AND TERRESTRIAL ENVIRONMENTS**

**SESSION INTRODUCTION**

*Chair: Stuart Huston, Atmospheric and Environmental Research, Inc.*

**E-1**

**Recent Updates to the AE9/AP9/SPM Radiation Belt and Space Plasma Specification Model**

*W. R. Johnston¹, T. P. O’Brien², S. L. Huston³, G. P. Ginet⁴, T. B. Guild²*

¹Air Force Research Laboratory; ²Aerospace Corp.; ³Atmospheric and Environmental Research, Inc.; ⁴MIT Lincoln Laboratory

The AE9/AP9/SPM radiation belt and space plasma specification model has been recently updated with Version 1.20. We review these updates of flux maps and features, discuss validation results, and summarize pending improvements.
E-2 A New Model of Outer Belt Electrons for Dielectric Internal Charging (MOBE-DIC)

A. Hands 1, K. Ryden 1, C. Underwood 1, D. Rodgers 2, H. Evans 2

1 University of Surrey; 2 European Space Agency

The outer electron belt poses a significant radiation hazard to spacecraft due to internal charging effects. We present a new model to characterise the worst-case environment based on data from the Giove-A spacecraft.

POSTER PAPERS

PE-1 Design and Calibration of the New Space Environment In-Situ Suite (SEISS) Space Weather Instruments for the NOAA GOES-R Satellites

B. K. Dichter 1, G. E. Galica 1, J. O. McGarity 1, S. Tsui 1, M. Golightly 1, C. Lopate 2, J. J. Connell 2

1 Assurance Technology Corporation; 2 University of New Hampshire

New instruments have been designed to meet the near real time, expanded, space weather needs for the NOAA GOES-R program. We present the rationale, design and calibration technique for the full suite of instruments.

PE-2 Dose Measured on-Board INTEGRAL after More than 12 Years in Space

A. Claret 1, P. Laurent 1, A. Sauvageon 1, V. Savchenko 2

1 IRfu/SAp, CEA Saclay; 2 APC

This paper presents the dose measurements performed on-board the INTEGRAL satellite after more than 12 years of successful operations in space, and comparison to predictions derived from sectorial analysis and dose profiles.

PE-3 Terrestrial Muon Flux Measurement at Low Energies for Soft Error Studies

E. Blackmore 1, M. Stukel 1, M. Trinczek 1, C. Slayman 2, S.-J. Wen 2, R. Wong 2

1 Triumf; 2 Cisco Systems

A large volume detector has been used to measure the stopping muon rate under different conditions of location, altitude, shielding and weather to determine the terrestrial soft error rate due to direct ionization of muons.

PE-4 Characterization of Atmospheric Muons at Sea Level Using a Cosmic-Ray Telescope

T. Saad Saoud 1, S. Moindjie 1, J.-L. Autran 1, D. Munteanu 1, V. Malherbe 2, G. Gasiot 2, P. Roche 2

1 Aix-Marseille University; 2 STMicroelectronics

We designed, built and operated a portable fully automatic cosmic-ray telescope to characterize atmospheric charged particles. Experimental data and simulation results are reported for the characterization of the muon flux at sea level.
Investigation of Alpha Emissivity as a Function of Time
F. Wrobel 1, A. Kaouache 1, F. Saigne 1, A. D. Touboul 1, R. D. Schrimpf 2, J.-L. Autran 3, O. Bruguier 1
1 Universite de Montpellier; 2 Vanderbilt University; 3 Universite d’Aix-Marseille

We present benefits and drawbacks of the metrics used for alpha pollutant investigations. Measurements of the specific activities and the alpha emissivity are used to predict an increase of the SER during the device lifetime.

Sub-LET Threshold SEE Cross Section Dependency with Ion Energy
R. Garcia Alia 1, C. Bahamonde 2, M. Brugger 1, V. Ferlet-Cavrois 3, S. Hoeffgen 4, A. Menicucci 3, S. Metzger 4, M. Muschitiello 3, E. Noordeh 5, G. Santin 3
1 CERN; 2 University of Utah; 3 European Space Agency; 4 Fraunhofer INT; 5 York University

Sub-threshold LET SEU data for the ESA Monitor are analysed from a broad range of facilities, covering an energy interval of 10-1500 MeV/amu. Results are contrasted with simulations and discrepancies are discussed.

Single Event Measurement and Analysis of Antimony Based n-Channel Quantum-Well MOSFET with High-k Dielectric
M. Barth 1, H. Liu 1, J. H. Warner 2, B. R. Bennett 2, D. McMorrow 2, N. Roche 3, P. Paillet 4, M. Gaillardin 4, S. Datta 1
1 The Pennsylvania State University; 2 Naval Research Laboratory; 3 The George Washington University; 4 CEA, DAM, DIF

Ion-induced, time-resolved charge-collection measurements for n-channel InAsSb quantum-well (QW) MOSFETs are reported for the first time. The data reveal a charge enhancement process. The dynamics of this process are explained using TCAD simulations.

Sensitive Volume and Extreme Shifts in Floating Gate Cells Irradiated with Heavy Ions
M. Bagatin 1, S. Gerardin 1, A. Paccagnella 1, A. Visconti 2, M. Bonanomi 2, M. Calabrese 2, L. Chiavarone 2, V. Ferlet-Cavrois 3
1 University of Padova; 2 Micron Technology; 3 ESA - ESTEC

Floating gate cells in flash memories were irradiated with heavy ions at large angles. The shape of the sensitive volume and the average and extreme values of threshold voltage distributions are discussed.
**New Insights on Mechanisms of Low-Energy Proton-Induced SEUs via Energy Straggle Elimination**

N. Dodds 1, P. Dodd 1, M. Shaneyfelt 1, F. Sexton 1, J. Martinez 1, J. Black 1, R. Reed 2, M. McCurdy 2, J. Pellish 3, P. Marshall 4, K. Rodbell 5, M. Gordon 5

1 Sandia National Laboratories; 2 Vanderbilt University; 3 NASA Goddard Space Flight Center; 4 NRL Consultant; 5 IBM

We present low-energy proton SEU data in which energy straggle has been made negligible by removing the SOI SRAM’s substrate. The removal of this prevalent error source allows deeper insight into SEU mechanisms.

**SEB Hardened Power MOSFETs with High-K Dielectric**

X. Wan 1, 2, S. Ren 2, D. Liu 1, W. Zhou 1, J. Xu 1, H. Bo 1, E. X. Zhang 3, D. M. Fleetwood 3, T. P. Ma 2

1 Tsinghua University; 2 Yale University; 3 Vanderbilt University

2D-simulations of the SEB hardness of power MOSFETs are carried out with a calibrated structure. The effects of incorporating high permittivity gate dielectric layers and increasing channel doping concentration are investigated.

**Impact of the Radial Ionization Profile of Proton on SEU Sensitivity for Nano-Scale Devices**

G. Hubert 1, P. Li Cavoli 1, C. Federico 2, L. Artola 1, J. Busto 3

1 The French Aerospace Lab.; 2 LDA, IEAv; 3 CCPM

The impact of the radial ionization profile of protons on SEU sensitivity for nano-scale devices using coupled GEANT4 and MUSCA-SEP3 simulations is presented. The approach is compared with experimental results on a 65 nm memory.

**Electron Induced SEUs: Microdosimetry in Nanometric Volumes**

C. Inguimbert 1, R. Ecoffet 2, D. Falguère 1

1 ONERA; 2 CNES

Experimental electron induced SEU cross-sections are analysed using microdosimetry calculations performed on nanoscale volumes. The roles of different mechanisms potentially at the origin of the observed SEUs are analyzed.

**Generic Analytic Expression of Heavy Ion SEU Cross Section Derived from Monte-Carlo Diffusion-Based Prediction Code**

F. Wrobel 1, A. D. Touboul 1, V. Pouget 1, L. Dilillo 1, R. Ecoffet 2, E. Lorfevre 2, F. Bezerra 2, M. Brugger 3, R. Alia Garcia 3, F. Saigne 1

1 Universite Montpellier; 2 CNES; 3 CERN

An analytical formula linking the heavy ion SEU cross-section and the LET based on a physical approach is presented. Calculated SEU cross-sections are in good agreement with experimental data for 150 nm, 90 nm and 65 nm technologies.
PF-5  Estimation of Single-Event Induced Collected Charge for Multiple Transistors Using Analytical Expressions
T. R. Assis 1, K. Ni 1, J. Kauppila 1, B. L. Bhuva 1, R. D. Schrimpf 1, L. W. Massengill 1, S.-J. Wen 2, R. Wong 2, C. Slayman 2
1 Vanderbilt University; 2 Cisco Systems

The Ambipolar-Diffusion-with-Cutoff model is extended to estimate the single-event induced collected charge for advanced transistors. The model includes parasitic-bipolar and charge sharing effects. Results indicate good agreement with published data.

PF-6  An Improved Particle-Level Charge Transport Model for the Simulation of Radiation-Induced Current Pulses in Bulk CMOS Technology
V. Malherbe 1, 2, G. Gasiot 1, J.-L. Autran 2, P. Roche 1
1 STMicroelectronics; 2 Aix-Marseille University

A particle-level stochastic algorithm for the simulation of radiation-induced currents in bulk CMOS is presented. The model is derived from physical equations and accurately reproduces TCAD pulses. Comparisons with previous models are performed.

PF-7  Temperature Dependence of MCU Sensitivity in 65 nm CMOS SRAM
A. B. Boruzdina 1, A. V. Sogoyan 1, A. A. Smolin 2, A. V. Ulanova 1, M. S. Gorbunov 2, A. I. Chumakov 1, D. V. Boychenko 1, 3
1 National Research Nuclear University (NRNU) MEPhI; 2 Scientific Research Institute of System Analysis Russian Academy of Sciences; 3 Specialized Electronic Systems

The temperature dependence of MCUs in a 65 nm CMOS SRAM is investigated from 300 to 400K. Experimental results show upset multiplicity increasing with increasing temperature. The physical mechanisms are analyzed using device simulations.

PF-8  Two-Photon Absorption Induced Single-Event Effects: Correlation Between Experiment and Simulation
J. M. Hales 1, 2, N. J. J.-H. Roche 1, 3, A. Khachatryan 1, 4, D. McMorrow 1, S. Buchner 1, J. H. Warner 1, N. C. Hooten 4, 5, R. A. Reed 4, R. D. Schrimpf 4
1 Naval Research Laboratory; 2 Sotera Defense Solutions; 3 George Washington University; 4 Vanderbilt University; 5 Dynetics Inc.

Charge density simulations utilizing nonlinear-optical beam propagation software, coupled with a simple RPP approach to approximate charge collection in a bulk silicon diode, exhibit good correlation with experimental transient charge-collection measurements.

11:50 AM – 1:30 PM
GLOUCESTER/BACK BAY CONFERENCE AND EXHIBITION CENTER

LUNCH - INDUSTRIAL EXHIBITS
INTRODUCTION

Chair: Keith Avery, Air Force Research Laboratory

W-1  Heavy Ion Single Event Effects Measurements of Xilinx Zynq-7000 FPGA
    M. Amrbar, F. Irom, S. M. Guertin, G. R. Allen
    Jet Propulsion Laboratory

Heavy ion single-event effect measurements on Xilinx Zynq-7000 are reported. Susceptibility to Single-Event latch up, single event upsets of BRAM, configuration bits and on chip memory of the processor were investigated.

W-2  Neutron SEE Testing of the 65nm SmartFusion2 Flash-Based FPGA
    D. Dsilva, J.-J. Wang, N. Rezzak, N. Jat, C.-K. Huang
    Microsemi

SmartFusion2 Flash-based Reprogrammable FPGAs are Neutron beam tested. Results confirm immunity of SEL and configuration upsets with an elevated temperature of 85-95 ºC. SEU is discussed for the Fabric Logic, Globals & SRAM.

W-3  Heavy-Ion Induced SETs in 32nm SOI Inverter Chains
    J. A. Maharrey 1, J. S. Kauppila 1, R. C. Quinn 1, T. D. Loveless 2, E. X. Zhang 1,
    W. T. Holman 1, B. L. Bluova 1, L. W. Massengill 1
    1 Vanderbilt University; 2 University of Tennessee at Chattanooga

A large data set of heavy-ion induced single-event transients has been collected for 32nm partially-depleted silicon-on-insulator inverter chains across various bias voltages, transistor variants, ion energies and angles of incidence.

W-4  Impact of Temperature and Vcc Variation on 20nm Kintex UltraScale FPGAs Neutron Soft Error Rate
    P. Maillard, M. Hart, J. Barton, P. Jain, J. Karp
    Xilinx, Inc.

The single-event response vs. temperature and Vcc supply voltage of the 20nm Kintex UltraScale FPGA is characterized using a 68 MeV proton beam as proxy for atmospheric neutron. SEU and MBU results are presented.
**W-5**  SEE Testing of the Intersil ISL71840SEH 16-Channel Analog Multiplexer  
N. W. van Vonno, L. G. Pearce, K. S. Bernard, E. J. Thomson  
Intersil  

We report the results of destructive and nondestructive heavy ion SEE testing of the Intersil ISL71840SEH hardened 16-channel analog multiplexer together with a brief discussion of its functionality, electrical specifications and fabrication process.

**W-6**  Single-Event Effects Testing of the Intersil ISL72027SEH CAN Bus Transceiver  
N. W. van Vonno, L. G. Pearce, E. J. Thomson  
Intersil  

We report the results of destructive and nondestructive single-event effects testing of the Intersil ISL72027SEH Controller Area Network (CAN) transceiver together with a brief discussion of its electrical specifications and fabrication process.

**W-7**  SET and SEFI Characterization of the 65 nm SmartFusion2 Flash-Based FPGA under Heavy Ion Irradiation  
N. Rezzak, D. Dsílva, J.-J. Wang, C.-K. Huang, N. Jat  
Microsemi  

SET and SEFI characterization of the SmartFusion2 flash-based FPGA under heavy ion irradiation is performed for the first time and presented. Functional blocks such as the PLL and Microcontroller subsystem are characterized and presented.

**W-8**  Heavy Ions Induced Single Event Upsets Testing of the 28 nm Xilinx Zynq-7000 All Programmable SoC  
L. A. Tambara 1, F. L. Kastensmidt 1, N. H. Medina 2, V. A. P. Aguiar 2, M. A. G. Silveira 3  
1 Universidade Federal do Rio Grande do Sul (UFRGS); 2 Universidade de Sao Paulo (USP); 3 Centro Universitario da FEI  

SEUs induced by heavy ions are investigated in the 28 nm Xilinx Zynq-7000 All Programmable SoC. The experiment was performed in a Brazilian facility located at the Universidade de São Paulo, Brazil.

**W-9**  Radiation Effects Characterization of a 3.125Gbps 90nm SerDes IP  
A. L. Wilson, S. Zarev  
Cobham Semiconductor Solutions  

A 3.125Gbps SerDes fabricated in a 90nm technology has been characterized for radiation effects. The device is SEL immune, an error rate of < 1.61E-12 errors/bit, and 100 krad(Si) TID tolerant.

**W-10**  Heavy Ion SEU Test Data for 32nm SOI Flip-Flops  
R. C. Quinn 1, J. S. Kauppila 1, T. D. Loveless 4, J. A. Maharrey 1, J. D. Rowe 1, M. L. Alles 1, B. L. Bluva 1, R. A. Reed 1, W. T. Holman 1, M. Bounasser 3, K. Lilja 3, L. W. Massengill 1  
1 Vanderbilt University; 2 University of Tennessee at Chattanooga; 3 Robust Chip, Incorporated  

Heavy ion SEU cross section data are presented for 32nm SOI flip-flop test chips. Data are shown for hardened and unhardened flip-flops across test facility, beam tune, angle of incidence, and clock frequency.
W-11  Compendium of Current Single Event Effects for Candidate Spacecraft Electronics for NASA
M. V. O'Bryan 1, K. A. LaBel 2, D. Chen 2, M. J. Campola 2, M. C. Casey 2, J.-M. Lauenstein 2, J. A. Pellish 2, R. L. Ladbury 2, M. D. Berg 1
1 ASRC Federal Space and Defense, AS&D, Inc.; 2 NASA Goddard Space Flight Center

NASA/GSFC presents 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-12  2015 Compendium of Recent Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory's Radiation Effects Group
Jet Propulsion Laboratory, Pasadena

This paper reports heavy ion, proton, and laser induced SEE results for a variety of microelectronic devices targeted for possible use in JPL spacecraft. The compendium covers devices tested from August 2012 through February 2015.

W-13  Compendium of Current Total Ionizing Dose and Displacement Damage for Candidate Spacecraft Electronics for NASA
A. J. Boutte 1, D. J. Cochran 2, M. J. Campola 1, D. Chen 1, M. C. Casey 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 Goddard Space Flight Center; 2 ASRC Federal Space and Defense, AS&D, Inc.

Total ionizing dose and displacement damage testing is performed to characterize and determine the feasibility of candidate electronics for NASA spacecraft and program use.

W-14  Single Event Upset Characterization of the Zynq-7000 ARM® Cortex™-A9 Processor Unit Using Proton Irradiation
D. M. Hiemstra, V. Kirischian
MDA

Proton induced SEU cross-section of the Zynq-7000 ARM® Cortex™-A9 Processor Unit is presented. Upset rates in the space radiation environment are estimated.

W-15  Guide to the 2014 IEEE Radiation Effects Data
D. M. Hiemstra
MDA

The 2014 Workshop Record has been reviewed and a table prepared to facilitate the search for radiation response data by part number, type, or effect.

W-16  Predicting Optocoupler Life with Radiation Damage in Various Circuits
D. M. Hiemstra, J. Brelski
MDA

This paper shows the effectiveness of using generic proton displacement damage test results to predict the radiation degradation of optocouplers across different circuit applications. Test results are provided for three lots of the 4N49.
W-17 Floating Gate Dosimeter Measurements at 4M Lunar Flyby Mission
J. Cesari 1, A. Barbancho 1, A. Pineda 1, G. Ruy 2, H. Moser 2
1 Integrated Circuits Malaga S.L.; 2 LuxSpace Sarl

The radiation results from two Floating Gate sensors during the 4M lunar flyby mission are presented. 216 hours of data from the spacecraft is analyzed and compared with the expected results from simulations.

W-18 TID Radiation Effects on 20 nm UTBB and 14 nm FINFET Technology
1 Naval Research Laboratory; 2 Sotera Defense Solutions; 3 Vanderbilt University; 4 IBM

20 nm UTBB and 14 nm FINFETs were irradiated and have significant TID damage in terms of threshold voltage shifts and leakage current. Buried oxide charge has a causal relationship in producing these effects.

W-19 Electrical Mode Influence on TID Sensitivity of Integrated and Hybrid DC-DC Converters
L. N. Kessarinskii, D. V. Boychenko, A. Y. Borisov
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

Total dose experimental results for different types of voltage regulators is presented and analyzed. The worst irradiation cases are revealed.

W-20 Proton and Heavy Ion Sensitivity of Commercial Reference Voltage and Voltage Regulator Devices
R. Koga
The Aerospace Corporation

Aerospace presents observations of proton and heavy-ion induced single event effects in selected voltage reference and low-dropout regulator devices.

W-21 Terrestrial Neutron Induced Failures in Commercial SiC Power MOSFETs at 27C and 150C
A. Akturk 1, R. Wilkins 2, J. McGarrity 1
1 CoolCAD Electronics LLC; 2 Prairie View A&M University

Experimental investigation of neutron induced single event failures in silicon carbide (SiC) power MOSFETs at room temperature and 150C is presented. The cross sections for failures at high temperature are presented for the first time.

W-22 Leakage Current Degradation of Gallium Nitride Transistors Due to Heavy Ion Tests
B. D. Olson, J. D. Ingalls, C. H. Rice, C. C. Hodge, P. L. Cole, A. R. Duncan, S. E. Armstrong
NAVSEA Crane

Commercial gallium nitride high-electron mobility transistors are tested at Texas A&M University cyclotron. Degradation of gate and drain currents is characterized.
W-23  Heavy Ion Testing of Commercial GaN Transistors in the Radio Frequency Spectrum  
S. E. Armstrong 1, H. Bradley 2, K. Bole 3, P. L. Cole 1, C. H. Rice 1, J. D. Ingalls 1,  
C. C. Hedge 1, B. D. Olson 1, W. Shedd 2, E. Johnson 2, J. Staggs 2, A. R. Duncan 1  
1 NAVSEA Crane; 2 Air Force Research Laboratory  
Commercial gallium nitride high-electron mobility transistors are tested in the radio frequency spectrum at heavy ion facilities to explore space environment stresses on these emerging technologies.

W-24  Ionizing Radiation Effects in Non-Radiation-Tolerant Commercial Video Cameras  
E. Simova, P. A. Rochefort  
Canadian Nuclear Laboratories Limited  
A set of commercially available video cameras were irradiated with gamma- and X-rays at various dose rates. Image quality and camera performances were analyzed with respect to both total absorbed dose and dose rates.

W-25  Proton Effects in a Commercially-Available Charge Injection Device Imager  
B. C. Fodness 1, C. Beam 2, S. Bhaskaran 2, Z. Ninkov 1, D. A. Thompson 3  
1 Rochester Institute of Technology; 2 Thermo Fisher Scientific; 3 Exelis Inc.  
CID technology has been widely used in radiation applications. The technology has excelled in ground-based applications. A radiation hardened CID imager has been irradiated to investigate its viability for use in space applications.

W-26  Test Results Obtained on the Low and High Energies Heavy Ion Test Facilities  
A. Kozitionov, V. Anashin  
Branch of JSC UIRSC-ISDE  
The paper presents test results of electronic components obtained on low and high energy heavy ion facilities. Also the purpose of the study was to demonstrate the availability of high-energy facilities in Russia.

W-27  Vanderbilt Pelletron - Low Energy Protons and Other Ions for Radiation Effects on Electronics  
M. W. McCurdy 1, M. H. Mendenhall 2, R. A. Reed 1, B. R. Rogers 1, R. D. Schrimpf 1  
1 Vanderbilt University; 2 National Institute of Standards and Technology  
The Vanderbilt Pelletron produces low energy (<4 MeV) protons and other ions for radiation effects on electronics, both displacement damage and total ionizing dose effects, facilitated with a vacuum test chamber and dosimetry.

W-28  Radiation Test Results for Common Cubesat Microcontrollers and Microprocessors  
S. M. Guertin, M. Amrbar, S. Vartanian  
Jet Propulsion Laboratory  
SEL, SEU, and TID results are presented for microcontrollers and microprocessors of interest for small satellite systems such as the TI MSP430F1611 and MSP430F1612, Microchip PIC24F256GA110 and dsPIC33FJ256GP710, and the Atmel AT91SAM9G20.
W-29  **Radiation Effects Evaluation of a Commercial 180nm Ferroelectric Memory Technology for Harsh Environments**
Texas Instruments

Total ionizing dose, single-event effect, and high temperature results from a new non-volatile 1Mbit FRAM are reported. The FRAM devices were manufactured in an analog-friendly 180nm CMOS process optimized for harsh-environments.

W-30  **Single Event Effects in COTS Ferroelectric RAM Technologies**
Z. Zhang 1, 2, Z. Lei 1, Z. Yang 3, X. Wang 3, B. Wang 3, J. Liu 3, Y. En 1, H. Chen 1, B. Li 2
1 China Electronic Product Reliability and Environmental Testing Research Institute (CEPREI); 2 South China University of Technology; 3 Institute of Modern Physics, Chinese Academy of Sciences

At least six SEE types were observed in FeRAMs under heavy ions and pulsed laser. Test techniques confirmed that the majority of errors were caused by anomalies in peripheral circuitry. No voltage effect was observed.

W-31  **Heavy Ion Single Event Effects Measurements of 512Mb ISSI SDRAM**
F. Irom, M. Amrbar
Jet Propulsion Laboratory

Heavy ion measurements on 512Mb ISSI SDRAM are reported. Susceptibility to single event latchup (SEL), single bit upsets (SBUs), double bit upsets (DBUs), multiple bit upsets (MBUs) and single effect functional interrupts (SEFI) were investigated.

W-32  **Proton Displacement Damage Measurements in Commercial Optocouplers**
F. Irom, G. R. Allen, B. G. Rax
Jet Propulsion Laboratory

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

W-33  **Compendium of Single-Event Latchup and Total Ionizing Dose Test Results of Commercial Digital to Analog Converters**
F. Irom, S. G. Agarwal
Jet Propulsion Laboratory

This paper reports single-event latchup and total ionizing dose results for a variety of digital-to-analog converters targeted for possible use in NASA spacecraft. The compendium covers devices tested over last 15 years.

W-34  **Low Dose Rate Testing of ADXL327 Accelerometer for a Mars Mission**
M. Alvarez-Alonso 1, J. J. Jimenez 1, D. Escribano 1, P. Manzano 1, I. Arruego 1, V. Apestigue 1, M. Gonzalez-Guerrero 1, I. Martin 1, D. M. Gonzalez-Castaño 2
1 INTA; 2 USC, Spain

A low dose rate Total Ionizing Dose test has been performed on Analog Devices ADXL327 Accelerometer. Results show its suitability for Mars missions, being unaffected up to 9.4 krad, biased or unbiased.
W-35  **ELDRS Characterization up to 300 Krad of Texas Instruments High Speed Amplifiers, LM7171 and LM6172**  
*K. Kruckmeyer, T. Trinh*  
*Texas Instruments*  

The LM7171 was tested to 300 krad and the LM6172 was tested to 200 krad at 10 mrad/s. Testing to 300 krad took one year. Both products were ELDRS “free”.

W-36  **Experimental Investigation of SELs in SiT8003 MEMS-Oscillators**  
*A. S. Tararaksin, L. N. Kessarinskiy, A. A. Pechenkin, A. V. Demidova, A. V. Yanenko, D. V. Boychenko, A. Y. Nikiforov*  
*National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)*  

SEEs in SiT8003 MEMS-oscillator were investigated. Irradiation was provided with ion-cyclotron and picosecond focused laser. SEL, SEU were observed. Threshold LET, saturation cross-section were estimated. High SEE sensitivity of SiT8003 is shown.

4:00 PM  **END OF WEDNESDAY SESSIONS**
Brilliant Blunders: From Darwin to Einstein – Colossal Mistakes by Great Scientists that Changed Our Understanding of Life and the Universe

Mario Livio, Author & Astrophysicist, Space Telescope Science Institute

Astrophysicist and award-winning author Dr. Mario Livio analyzes ruinous errors of five great scientific minds in the wake of their most prominent discoveries, and how those errors have not only propelled scientific breakthroughs, but provide insights into the operation of the human mind. In this talk, Dr. Livio will scrutinize the various types of blunders made and attempts to identify their causes. Summoning Charles Darwin, Lord Kelvin, Linus Pauling, Fred Hoyle, and Albert Einstein, Dr. Livio argues there is no progress without lessons in humility, and blunders are part and parcel of progress in science and other creative enterprises. These thinkers succumbed to moments of fear, pride, stubbornness, and doubt common to all mere mortals, to the benefit of elucidating the evolution of life and the universe. Two-time Nobel prize-winning chemist Pauling’s flub of basic chemistry catalyzed the discoveries of Watson and Crick; Hoyle, a cosmologist who displayed a pigheaded, almost infuriating refusal to give up his thoroughly refuted steady state theory, energized advanced studies of how we exist in space with his controversial ideas; and Einstein, the embodiment of genius, refused to give up on his cosmological constant, the most famous fudge factor in the history of science. With humor and precision, Dr. Livio reminds us: “Even the most impressive minds are not flawless; they merely pave the way for the next level of understanding.”

Mario Livio is an internationally known astrophysicist at the Space Telescope Science Institute (STScI), the institute which conducts the scientific program of the Hubble Space Telescope, and will conduct the scientific program of the upcoming James Webb Space Telescope. He received his Ph.D. in theoretical astrophysics from Tel Aviv University in Israel, was a professor in the Physics Dept. of the Technion-Israel Institute of technology from 1981 until 1991, and joined STScI in 1991. He has published more than 400 scientific papers on topics ranging from Dark Energy and cosmology to black holes and extrasolar planets. He is a Fellow of the American Association for the Advancement of Science. Dr Livio is also the author of five popular science books, including “The Golden Ratio” (for which he received the “Peano Prize” and the “International Pythagoras Prize”) and “Is God A Mathematician?”. Livio’s recent book, “Brilliant Blunders”, was on the Bestsellers List of the New York Times, and was selected by the Washington Post as one of the “2013 Best Books of the Year.”
SESSION G 9:25 AM
BASIC MECHANISMS OF RADIATION EFFECTS
SESSION INTRODUCTION
Chair: Marc Gaillardin, CEA

G-1 9:30 AM
Total Ionizing Dose (TID) Effects in Extremely Scaled Ultra-Thin Channel Nanowire (NW) Gate-All-Around (GAA) InGaAs MOSFETs
S. Ren 1, M. Si 2, K. Ni 3, X. Wan 1, J. Chen 3, S. Chang 1, X. Sun 1, E. Zhang 3, R. A. Reed 3, D. M. Fleetwood 3, P. Ye 2, S. Cui 1, T.-P. Ma 1
1 Yale University; 2 Purdue University; 3 Vanderbilt University

InGaAs NW GAA MOSFETs exhibit superior radiation hardness compared to planar devices and FinFETs, benefitting from lower gate-oxide electric fields. Channel thickness and forming gas anneal can strongly affect NW device radiation hardness.

G-2 9:45 AM
Detailed Characterization of the Radiation Response of Multijunction Solar Cells
R. J. Walters 1, R. Hoheisel 2, S. R. Messenger 3, D. Scheiman 1, P. P. Jenkins 1
1 Naval Research Laboratory; 2 The George Washington University; 3 University of Maryland Baltimore County

The response of triple-junction solar cells to proton irradiation is analyzed using electroluminescence (EL). This analysis allows the dark current of each individual subcell to be determined providing insight into the radiation response mechanisms.

G-3 10:00 AM
Drain Current Collapse in 65nm pMOS Transistors after Exposure to Grad Dose
L. Ding 1, 2, S. Gerardin 1, 2, M. Bagatin 1, S. Mattiazzo 1, D. Bisella 1, 2, A. Paccagnella 1, 2
1 University of Padova; 2 INFN, Padova, Italy

TID response of 65 nm pMOS transistors was studied by X-ray exposure up to 1 Grad(SiO2). Radiation induced narrow channel effect and localized damage in gate oxide could be the two degradation mechanisms.

G-4 10:15 AM
Modeling Radiation-Induced Scattering in Graphene
I. S. Esqueda 1, C. D. Cress 2
1 University of Southern California; 2 Naval Research Laboratory

In this paper we analyze and model TID-induced carrier scattering effects in graphene using a fundamental transport theory that applies to low-dimensional materials with non-parabolic bands and quasi-ballistic transport properties.

POSTER PAPERS
PG-I
Performance and Breakdown Characteristics of Irradiated Vertical Power GaN P-I-N Diodes
M. P. King 1, A. M. Armstrong 1, G. Vizkeley 1, R. M. Fleming 1, J. Campbell 1, W. R. Wampler 1, I. C. Kiziyalli 2, D. P. Bour 2, O. Aktas 2, H. Nie 2, D. Disney 2, J. Wierer, Jr 1, A. A. Allerman 1, M. W. Moseley 1, R. J. Kaplar 1
1 Sandia National Laboratories; 2 Avogy Inc.

Electrical performance and defect characterization of vertical GaN PiN diodes following proton irradiation is investigated. Post-irradiation, large bias results in increased leakage before breakdown. Proton damage decreases device breakdown voltage but remains above 1300V.
PG-2  Single Ion Displacement Effects in III-V Heterojunction Bipolar Transistors  
G. Vizkelethy, E. Bielejec, D. B. King, G. A. Patrizi  
Sandia National Laboratories  

Gain degradation of III-V HBTs due to single ions was measured. HBTs were irradiated with 24 MeV oxygen ions and discrete steps in gain degradation attributed to displacement damage from single ions were observed.

PG-3  Sub-Micron Resolution of Localized Ion Beam Induced Charge Reduction in Silicon Detectors Damaged by Heavy Ions  
E. C. Auden, J. L. Pacheco, B. L. Doyle, E. Bielejec, G. Vizkelethy  
Sandia National Laboratories  

Displacement damage reduces ion beam induced charge (IBIC) through recombination at midgap defects. IBIC reduction can be resolved over sub-micron regions of a silicon detector damaged by as few as 1,000 heavy ions.

PG-4  Radiation Induced Molecular Switching Events in Nanoelectronic Circuits  
A. W. Bushmaker 1, D. Walker 1, C. Mann 1, V. Oklejas 1, A. R. Hopkins 1, M. R. Amer 2, S. B. Cronin 2  
1 The Aerospace Corporation; 2 The University of Southern California  

We measure electrical properties of carbon nanotube field effect transistors exposed to proton and gamma radiation. Single event effects are observed and attributed to interaction of the device with the surrounding ionized atmosphere.

PG-5  Neutron and Co-60 Gamma Irradiation Effects on Hexagonal Boron Nitride Structures  
S. A. Francis 1, J. Petrosky 1, J. McClory 1, B. Barnett 1, M. Snure 2  
1 Air Force Institute of Technology; 2 Air Force Research Laboratory  

Hexagonal boron nitride interface characteristics with silicon substrates are evaluated following gamma and neutron irradiation. Electrical and optical measurements indicate negligible displacement damage occurs, while hole trapping at the hBN-Si interface dominates radiation response.

PG-6  The Effects of Ionizing Radiation on TaOx-Based Memristors  
B. D. Tierney, H. P. Hjalmarson, M. L. McLain, D. R. Hughart  
Sandia National Laboratories  

The irradiation of tantalum oxide memristors is simulated. Tunneling transport through device interfaces is considered and transport characteristics are compared with recently published experimental data of memristor devices subjected to pulsed ionizing radiation.
Possible Physical Mechanism for the ELDRS Absence in SiGe Transistors
V. S. Pershenkov, A. S. Bakerenkov, V. V. Belyakov, V. V. Shurenkov, A. S. Rodin, V. A. Felitsyn
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

The possible physical mechanism of ELDRS effect elimination in silicon-germanium (SiGe) bipolar transistors is described. The mechanism is connected with bandgap narrowing in HBTs base region due to Ge content.

3D Time Dependent Model of Internal Charging, Comparison with Experiments
P. Sarrailh 1, T. Paulmier 1, B. Dirassen 1, D. Rodgers 2, G. Santin 2, F. Cipriani 2
1 Onera - The French Aerospace Lab; 2 ESA/ESTEC

A new model of dielectric conductivities has been implemented in SPIS-IC. It allows modeling the 3D time dependent behavior of the charge and potential inside payload. The results have been compared to dedicated experiments.

Pixel Pitch and Particle Energy Influence on the Dark Current Distribution of Neutron Irradiated CMOS Image Sensors
J.-M. Belloir 1, V. Goiffon 1, P. Magnan 1, C. Virmontois 2, O. Gilard 2, M. Raine 3, O. Duhamel 3, M. Gaillardin 3, P. Paillet 3
1 ISAE; 2 CNES; 3 CEA

The influence of both the pixel pitch and the incident particle energy on the dark current distribution of CMOS Image Sensors induced by non-ionizing interactions is explored using an empirical model.

On-Site Regeneration Technique for Hole-Assisted Optical Fibers Used in Nuclear Facilities
S. Girard 1, A. Boukenter 1, T. Robin 2, E. Marin 1, A. Ladaci 1, I. Reghioua 1, A. Morana 1, D. Di Francesca 1, S. Rizzolo 1, C. Cangialosi 1, I. Planes 1, C. Marcandella 3, P. Paillet 3, M. Gaillardin 3, M. Raine 3, N. Richard 3, B. Cadier 2, Y. Ouerdane 1
1 Universite de Saint-Etienne; 2 iXFiber; 3 CEA, DAM, DIF

This study focus on an innovative procedure allowing to regenerate highly irradiated optical fibers used in nuclear facilities by recovering the fiber transmission acting only from one of the two fiber ends.
Equilibrium Degradation Levels in Irradiated Erbium-Doped Fiber Amplifiers
F. Mady, J.-B. Duchez, Y. Mebrouk, M. Benabdesselam
University of Nice Sophia Antipolis

We show that local EDFA degradation can be tuned reversibly across equilibrium levels determined by local pump power and dose rate, while the dose is cumulated. This remarkable property inspires a physical, validated degradation model.

Multi-MGy Radiation Hardened CMOS Image Sensor: Design, Characterization and Total Ionizing Dose Tests
V. Goiffon 1, F. Corbiere 1, S. Rolando 1, M. Estrebeau 1, P. Magnan 1, B. Avon 1, J. Baer 1, M. Gaillardin 2, R. Molina 1, P. Paillet 2, S. Girard 3, A. Chabane 1, C. Marcandella 2
1 Universite de Toulouse; 2 CEA, DAM, DIF; 3 Universite de Saint-Etienne

The radiation hardness of a radiation-hardened-by-design CMOS Image Sensor is validated up to several MGy(SiO2) (>100 Mrad) of TID. The perspectives in terms of further improvements and applications are discussed.

Radiation Effects in CCD on CMOS Devices: First Analysis of TID and DDD Effects
O. Marcelot 1, V. Goiffon 1, M. Raine 2, O. Duhamel 2, M. Gaillardin 2, R. Molina 1, P. Magnan 1
1 ISAE; 2 DAM, DIF, CEA

A first study focused on radiation effects in CCD on CMOS image sensors manufactured using 0.18 µm technology is presented. Three different designs are used, and performances such as CTI and dark current are studied.

Modeling TID Effects in Mach-Zehnder Interferometer Silicon Modulators for HL-LHC Data Transmission Applications
S. Seif El Nasr-Storey 1, 2, F. Bouef 3, C. Baudot 3, S. Detraz 1, J. M. Fedeli 4, D. M. Marini 5, L. Olantera 1, G. Pezzullo 1, C. Sigaud 1, C. Soos 1, J. Troska 1, F. Vasey 1, L. Vivien 5, M. Zeiler 1, M. Ziebell 5
1 CERN; 2 University of Bristol; 3 ST Microelectronics; 4 CEA-LETI; 5 Universite Paris Sud

High-speed Mach-Zehnder interferometer silicon modulators were exposed to a total ionizing dose of 1.3 MGy. A physical model to describe the effect of ionizing radiation on the modulators has been developed.

Single Event Upset Sensitivity of D-Latches of Infrared Image Sensors for Low Temperature Applications down to 77K
L. Artola 1, G. Hubert 1, O. Gilard 2, S. Ducret 3, F. Perrier 3, M. Boutillier 2, P. Garcia 4, G. Vignon 4, B. Baradat 2, N. Ricard 3
1 DESP/ECM, ONERA; 2 CNES; 3 Sofradir; 4 TRAD

This paper presents an investigation, based on experimental testing and simulations, of Single Event Upset susceptibility of D-latches of infrared image sensors for low temperatures down to 77K considering layout variations.
Effects of Radiation on Noise Performance in Solid-State Photomultipliers
Radiation Monitoring Devices, Inc.

Solid-state photomultiplier is a viable alternative to photomultiplier tubes for nuclear and space instruments. Noise terms such as dark noise, after-pulsing, and their radiation sensitivity affects the detector performance for harsh environment applications.

Development of Optical Frequency-Domain Reflectometry Based Sensors for Nuclear Environments
S. Rizzolo 1, 2, 3, E. Marin 1, A. Boukenter 1, Y. Ouerdane 1, M. Cannas 2, J. Perisse 4, S. Bauer 3, J.-R. Mace 5, C. Marcandella 6, P. Paillet 6, S. Girard 1

1 Universite de Saint-Etienne; 2 Universita degli studi di Palermo; 3 AREVA Centre Technique; 4 AREVA NP; 5 AREVA NP; 6 CEA-DAM-DIF

OFDR-based radiation tolerant sensors are tested during irradiation up to 1 MGy level to investigate on mixed temperature and radiation effects. Rayleigh based sensors radiation responses reveal promising performances for their employment in harsh environments.
Witch City: Salem, Massachusetts and its Infamous Witch Trials
Emerson “Tad” Baker, Author & Professor, Salem State University

In 1692 more than 150 people were accused of witchcraft, and 25 died in the Salem witch trials, by far the largest witch hunt in American history. In this presentation, drawn from his recent book A Storm of Witchcraft: The Salem Trials and the American Experience, Emerson Baker explores why the tragedy unfolded as it did, and also sets the trials in the broader context of American history from the 1620s to present. Between roughly 1400 and 1750 about 100,000 people in Europe and her colonies were accused of witchcraft, and about half of them were executed for the crime. Some outbreaks in Europe lasted years and resulted in the deaths of hundreds of victims. By these standards, Salem is not even a large outbreak.

So why is Salem known around the world as “Witch City?” The Salem witch hunt was a critical moment for the fading Puritan government of Massachusetts Bay, whose attempts to suppress the story of the trials and erase them from memory only fueled the popular imagination. Baker argues that the trials marked a turning point in colonial history from Puritan communalism to Yankee independence, from faith in collective conscience to skepticism toward moral governance. The government’s failure to protect the innocent at Salem can be seen as the beginning of American’s distrust of government. It should come as no surprise that the grandchildren and great grandchildren of people involved in the witch trials would help lead the fight for American independence.

Emerson “Tad” Baker is a professor of History and former dean of the Graduate School at Salem State University. He is the award-winning author of many works on the history and archaeology of early New England, including The Devil of Great Island: Witchcraft and Conflict in Early New England. Baker received his BA from Bates College, his MA from the University of Maine and his Ph.D. in History from William and Mary. He has been an advisor for PBS-TV’s The American Experience, and as on-camera expert for the PBS series Colonial House. The Portland Press Herald says “By almost any measure, Emerson W. Baker’s new history, A Storm of Witchcraft, is a masterpiece.”

GaAs Displacement Damage Dosimeter Based Diode Dark Currents
J. H. Warner 1, S. R. Messenger 2, C. D. Cress 1, R. J. Walters 1
1 Naval Research Laboratory; 2 University of Maryland Baltimore County

GaAs diode dark currents are correlated with displacement damage dose (DDD) for proton irradiation. The dark currents vary linearly with DDD making it a perfect candidate for a displacement damage dosimeter.
## Characterization of a Large Area Thinned Silicon Microdosimeter for Space and Particle Therapy


1 University of Wollongong; 2 Australian Nuclear Science and Technology Organization; 3 University of Oslo; 4 SINTEF; 5 National Institute of Radiological Science

A 20µm-thick silicon microdosimeter with 9600 micro-sized sensitive volumes has been developed for use in microdosimetry in space and particle therapy. Its characterization and utility in a high energy 12C field is presented.

## Capacitive-Based Dosimetry of Co-60 Radiation using Fully-Depleted Silicon-on-Insulator Devices

Y. Li, W. Porter, R. Ma, M. A. Reynolds, B. J. Gerbi, S. J. Koester

University of Minnesota

The capacitance-based sensing of Co-60 gamma radiation is demonstrated using fully-depleted silicon-on-insulator variable capacitors. The capacitance change vs. dose was 0.18%/Gy with low variability between devices and independent of dose.

## The Role of Static Charge in Ultra-Low Alpha Particle Emissivity Measurements

M. S. Gordon, K. P. Rodbell, C. E. Murray, B. D. McNally

1 IBM, TJ Watson Research Center, Yorktown Heights, NY; 2 XIA, LLC, Hayward, CA, USA

The effect on the alpha particle emissivity of static charge on insulating samples is described for measurements made in an ultra-low background ionization detector. Methods to reduce the influence of static charge are given.

## Neutron Spectra Unfolding Employing Particle Swarm Optimization

X. L. Luo, Y. K. Wang, G. F. Liu, J. Yang, Z. L. Hu

National University of Defense Technology

Neutron spectra unfolding of both 241Am-Be and 252Cf sources has been accomplished utilizing the particle swarm optimization algorithm. The unfolded spectra agree well with the reference spectra, thus demonstrating the effectiveness of this novel approach.

## 3D Silicon Microdosimetry and RBE Studies in Different Energies of 12C Heavy Ion


1 University of Wollongong; 2 Australian Nuclear Science and Technology Organization; 3 SPA-BIT; 4 National Institute of Radiological Science; 5 Australian National University

A 10µm thick 3D SOI microdosimeter has been developed and studied for LET change of 70MeV and 4.2GeV carbon ions traversing thin protective layers used for shielding electronic devices and in thick targets.
PI-3  Energy Dependent Efficiency in Low Background Alpha Measurements and Impacts on Accurate Alpha Characterization  
H. Kawasaki 1, B. M. Clark 2, T. Nishino 1, M. S. Gordon 3  
1 Senju Metal Industry Co. Ltd; 2 Honeywell, USA; 3 IBM  

A difference in low alpha measurements was observed between AS1950 proportional counter and the XIA Ultra-Lo 1800 ionization chamber. The energy dependent efficiency was evaluated. Implications of instrument design bias on measurement results is presented.

10:30 – 10:55 AM  BREAK  
ATRIUM FOYER  

SESSION J  
HARDENING BY DESIGN  
SESSION INTRODUCTION  
Chair: Ethan Cannon, The Boeing Corporation  

J-1  High Performance Low Power Pulse-Clocked TMR Circuits for Soft-Error Hardness  
C. Ramamurthy, S. Chellappa, V. Vashisht, A. Gogulamudi, L. T. Clark  
Arizona State University  

A TMR pulse-clocked, self-correcting, low power AES IC with 64Gb/s throughput providing spatial separation of constituent circuits is presented. Fault injection simulation and experimental proton beam testing prove the resulting SEE hardness.

J-2  Efficient Mitigation of SET Induced Harmonic Errors in Ring Oscillators  
J. Agustin 1, M. Lopez-Vallejo 1, L. W. Massengill 2  
1 Technical University of Madrid; 2 Vanderbilt University  

We present a radiation-tolerant ring-oscillator based on the variation of its duty cycle. It masks the harmonic frequencies caused by SETs in ring-oscillators thanks to its singular asymmetric design without area overhead.

J-3  Optimization of SiGe HBT RF Switches for Single-Event Transient Mitigation  
I. Song 1, S. Jung 1, N. E. Lourenco 1, Z. E. Fleetwood 1, M.-K. Cho 1, N. J. Roche 2, A. Khachatrian 2, J. H. Warner 2, S. P. Buchner 2, D. McMorrow 2, P. Paki 3, J. D. Cressler 1  
1 Georgia Institute of Technology; 2 Naval Research Laboratory; 3 Defense Threat Reduction Agency  

An SET-hardened SiGe HBT-based RF switch was designed and fabricated. Two-photon absorption laser experiments were used to optimize the switch core configuration in order to reduce both transient peaks and durations.
Radiation Hardening of Voltage References Using Chopper Stabilization


1 Vanderbilt University; 2 Silicon Laboratories, Inc.; 3 The University of Tennessee at Chattanooga

A technique for enhancing the precision of voltage references in an ionizing radiation environment is presented and demonstrated. Chopper offset cancellation is used to mitigate the effect of radiation-induced mismatch.

A Novel 65nm Radiation Tolerant Flash Configuration Cell Used in RTG4 Field Programmable Gate Array

J.-J. Wang, N. Rezzak, C.-K. Huang, D. Dsilva
Microsemi Corporation

This paper describes the configuration cell of flash-based FPGA RTG4 and explains its function and radiation characteristics. A subtle and unique retention issue was found and resolved through studying physical mechanisms and experimenting.

POSTER PAPERS

PJ-1 Hardening of a Charge Pump Circuit to Total Ionizing Dose Radiation

D. M. Mitchell, P. Eaton, W. Burke, D. Allum, R. Marquez

1 Microelectronics Research Development Corporation; 2 Air Force Research Laboratories

A new charge pump circuit has been designed, fabricated and tested that uses radiation hardening techniques to mitigate unwanted circuit response changes to total ionizing dose (TID) radiation.

PJ-2 An Investigation of the Use of Inverse-Mode SiGe HBTs as Switching Pairs for SET-Hardening of RF Mixers


1 Georgia Institute of Technology; 2 Naval Research Laboratory; 3 Defense Threat Reduction Agency

The SET-mitigation capability of inverse-mode SiGe HBTs in large-signal operation was investigated in a down-conversion mixer using a through-wafer, two-photon absorption pulsed-beam laser experiment.

PJ-3 Single Event Upset Mitigation in Memory Elements Using a Double Modular Redundancy Architecture

F. Smith
Nelson Mandela Metropolitan University

A circuit is proposed to provide single event upset (SEU) mitigation in memory elements in a double modular redundancy (DMR) architecture. Proton tests suggests its efficiency in eliminating SEUs compared to TMR and unmitigated designs.
**PJ-4**  Analyzing the Effectiveness of a Novel Frame-Level Redundancy Scrubbing Technique for SRAM-Based FPGAs  
J. Tonfat 1, P. Rech 1, H. Quinn 2, F. Kastensmidt 1, R. Reis 1  
1 PGMICRO, UFRGS; 2 Los Alamos National Laboratory  

This work analyses the effectiveness to correct neutron-induced soft errors of a novel scrubbing technique using internal frame redundancy with minimum energy consumption overhead and also improves the MTTR.

**PJ-5**  Using Classical Reliability Models and Single Event Upset (SEU) Data to Determine Optimum Implementation Schemes for Triple Modular Redundancy (TMR)  
M. D. Berg 1, H. S. Kim 1, C. M. Seidleck 1, A. M. Phan 1, K. A. LaBel 2, J. Pellish 2, M. J. Campolla 2  
1 ASRC Federal Space and Defense, AS&D, Inc.; 2 NASA Goddard Space Flight Center  

Space applications are complex systems that require intricate trade analyses for optimum implementations. We focus on a subset of the trade process, using classical reliability theory and SEU data, to illustrate appropriate TMR scheme selection.

**PJ-6**  Selective Software Techniques to Detect Neutron-Induced Soft Errors in Processors with Minimum Overhead  
E. Chielle 1, G. S. Rodrigues 1, F. L. Kastensmidt 1, S. Cuenca-Asensi 2, L. A. Tambara 1, P. Rech 1, H. Quinn 3  
1 Universidade Federal do Rio Grande do Sul; 2 University of Alicante; 3 Los Alamos National Laboratory  

A selective software-based technique to detect soft errors at low costs is proposed. Simulation and neutron induced SEE tests show high fault coverage at performance and memory overheads inferior to duplication.

**12:15 PM**  END OF CONFERENCE
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 2015 will be held in Boston, Massachusetts, July 13 – 17, 2015 at the Marriott Copley Place. Mike Xapsos and his 2015 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 3D Plus, Atmel, BAE Systems, Boeing, Cobham Semiconductor Solutions, Honeywell, International Rectifier, Intersil Corporation, Northrop Grumman, Sandia National Laboratories, 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 2016 will be held in Portland, Oregon, July 11 – 15, 2016 at the The Double Tree and Portland Convention Center. The conference chair is Robert Reed of Vanderbilt University. Véronique Ferlet-Cavrois of ESA/ESTEC will be chair of the 2017 NSREC, which is planned for New Orleans, Lousiana. Ronald Lacoe, The Aerospace Corporation, has been named the 2018 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.
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 2015), 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 website [www.nsrec.com](http://www.nsrec.com). The deadline for submission of papers is the Friday before the Conference (July 10, 2015). 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 2015 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
- **Pascale Gouker**, Associate Editor, MIT Lincoln Laboratory  
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- **Heather Quinn**, Associate Editor, Los Alamos National Laboratory  
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- **Hugh Barnaby**, Associate Editor, Arizona State University  
  Email: hburnaby@asu.edu
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 2015 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 (2015) 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 16, from 4:45 - 6:30 PM in Ballroom Salons E - F. All conference attendees and spouses are encouraged to attend. We will discuss the 2015 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

2014 NSREC OUTSTANDING CONFERENCE PAPER AWARD

Hardness Assurance for Proton Direct Ionization-Induced SEEs Using a High-Energy Proton Beam

2014 MERITORIOUS CONFERENCE PAPER

Upsets in Phase Change Memories due to High-LET Heavy Ions Impinging at an Angle
S. Gerardin, M. Bagatin, A. Paccagnella, A. Visconti, M. Bonanomi, S. Beltrami, and V. Ferlet-Cavrois

2014 OUTSTANDING STUDENT PAPER AWARD

On the Transient Response of Best-of-Breed Complementary (nnp+pnp) SiGe HBT BiCMOS Technology

2014 OUTSTANDING DATA WORKSHOP PRESENTATION AWARD

Compendium of Single Event Effects, Total Ionizing Dose, and Displacement Damage for Candidate Spacecraft Electronics for NASA

2014 RADIATION EFFECTS AWARD

The 2014 Radiation Effects Award was presented to Janet L. Barth, NASA GSFC - retired, during the opening ceremonies of the 2014 conference. Janet’s citation reads “For contributions to understanding the space radiation environment and to the development of flight-qualified spacecraft systems.”

2015 RADIATION EFFECTS AWARD

The winner of the 2015 Radiation Effects Award will be announced Tuesday morning, July 14. 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.

2016 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2016 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 Sylvain Girard, Member-at-Large for the Radiation Effects Steering Group. Sylvain can be reached at sylvain.girard@univ-st-etienne.fr or +33 477 915 812.
BOSTON… Bean Town. Home of the Boston Marathon, the Boston Tea Party, the Boston Common, the Freedom Trail, Harvard, MIT, and the “Big Dig”, Boston is a compact city with a charm and history unlike any other. Dating back 385 years (that’s “old” in the U.S.), it was founded by colonists seeking freedom and a better life. Freedom continued to be on the Bostonian forefront when the events leading to the American Revolution occurred here, including the argument over the tea tax that caused the Boston Tea Party in 1773. During the protest, colonists dressed as Native Americans and then raided three British ships, dumping their cargo of tea into the harbor. In 1775, it was here that the famous ride was made to warn that “The British are coming!” … and the next day was the start of the American Revolution.

Today, Boston has become the quintessential all-American city with architecturally distinct buildings, ethnic culture and food, and a fabulous neighborhood ambience. With one of the most active city-centers in the country, the locals keep the atmosphere fresh and edgy – there’s always something to do, some place to go and interesting people to meet. The NSREC welcomes you to Boston this summer…the most delightful time to be there!

The Boston Marriott Copley Place is the host hotel, located in the heart of the Back Bay, an officially recognized neighborhood in Boston. Most famous for its Victorian brownstone homes, the Back Bay is one of the best preserved examples of 19th century urban design in the U.S. This area is also the home of some of the best shopping in the city, including both neighborhood boutique shopping (Newbury and Boylston Streets) and major shopping center shopping (Prudential Center and Copley Place malls).

The 2015 IEEE NSREC will provide breakfasts and refreshments at breaks during the NSREC Short Course and Technical Sessions. For those attendees at the Short Course on Monday, a lunch will be provided. These meals and refreshments are for registered conference attendees only. Please see the schedule for times and locations.

The Marriott has contracted with FedEx Office to operate a full-service business center that can handle photocopying, faxing, computer printer access, shipping/receiving, laminating, graphic design, equipment rental and shipping/receiving. They are open Monday through Friday from 7:30 AM - 6:30 PM and Saturday/Sunday from 10:00 AM - 4:00 PM. Guests can have 24-hour access for internet access, computer printing and photocopying. Costs associated with FedEx Office may be paid by credit card (preferred) or put on your room account (only during office hours).

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

Notes: You must register for the conference before a side meeting room can be reserved! All audio/visual equipment and refreshments must be coordinated directly with the hotel and are the responsibility of the attendee hosting the meeting.
The 2015 Conference is offering child-care reimbursement of up to $400 per family as a pilot program 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 2015. 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 babysitting 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 31, 2015). If the report is not received by that date, no reimbursement will be made. All reimbursements will be made after the conference.

To apply, an attendee must register for the conference technical sessions, and then complete the application form to request reimbursement for child care. The application must be received no later than June 6, 2015. 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 2015 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 12. 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](http://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 June 26, 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

All conference registration will take place on the fourth floor of the Marriott. If you have not yet registered, go to “On-Site Registration” at the Registration B Counter. If you have already registered, go to “Pre-Registration” on the fourth floor foyer to pick up your prepared packets.

ON-SITE REGISTRATION HOURS

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<tr>
<td>Sunday, July 12</td>
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</tr>
<tr>
<td>Monday, July 13</td>
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<tr>
<td>Tuesday, July 14</td>
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<tr>
<td>Wednesday, July 15</td>
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<td>Thursday, July 16</td>
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</tr>
<tr>
<td>Friday, July 17</td>
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CONFERENCE CANCELLATION

A $50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 12, 2015, 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.
The host hotel for the 2015 NSREC is the 4-star Boston Marriott Copley Place, conveniently located in the Back Bay area with multiple subway stations within a couple blocks. This 38-story tower is attached by sky bridge to the Prudential Center, which includes not only office buildings but also over 50 shops and 25 restaurants, cafes and food shops. Just steps away in this Copley Square neighborhood, you’ll find the famous and historic Old South Church, Trinity Church and Boston Public Library – all well worth visiting. All of the other fabulous sites of Boston are easily accessible via public transportation. There are so many things to do and restaurants to experience that it will be hard to set priorities!

Marriott hotel amenities include one restaurant, one cocktail lounge, 24-hour health club (complimentary to hotel guests), concierge, business center, lobby ATM, parking garage, and Starbucks. The 1147 guest rooms are comfortably furnished in typical Marriott contemporary design. All rooms are non-smoking and feature large windows with dramatic views, individual climate control, flat-screen TV with video-on-demand and cable, MP3 player, wireless internet at a fee, work desk, coffee maker, mini-refrigerator, hairdryer, iron and ironing board, multiple phones with voice mail, one king or two double plush beds, a safe, and room service.

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

<table>
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<th>Rate Type</th>
<th>Rate</th>
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<tr>
<td>NEGOTIATED GROUP RATE</td>
<td>$239.00 single/double per night</td>
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<tr>
<td>GOVERNMENT PER DIEM</td>
<td>$210.00 single/double* per night</td>
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Taxes will be added to all rates listed above. There is no additional charge for children 18 years of age and under when sharing a room with an adult and utilizing existing beds. A charge of $20.00 + tax per night will be added for each third and fourth adult in the room (19 years of age and older).

*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.

The preferred method to make reservations is by using the weblink: resweb.passkey.com/go/IEEEENSREC. The first step is to click on the drop-down box to choose “attendee rate” or “government rate”. Then enter your arrival and departure dates and follow the prompts. Based on availability, you will be given the opportunity to choose a standard room or an upgrade to a room with a view of the Charles River.

Reservations can also be made by calling Marriott Reservations toll-free at 877-901-2079 within the U.S. or Canada. To get the special rates, advise the agent of the following group name: IEEE NSREC. Both the group rate and U.S. government rate will be listed under this name.
All rooms 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 June 12, 2015. 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!

Please be certain to notify the hotel of any change to your arrival or departure dates. When you check into the hotel, be sure to verify your departure date. Any cancellation must be made by no later than 6:00 PM on the day prior to your scheduled arrival. If the cancellation is made by that time, then any deposit will be refunded.

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**AIRPORT AND TRANSPORTATION INFORMATION**

Boston Logan International Airport is located about 4 miles “as the crow flies” from the Marriott. However, due to the waterways and complex street layout, it is closer to 9 miles on land and will normally take between 15-30 minutes, depending on traffic. During rush hour, it could be longer. Taxis to the Marriott are based on time and distance so will normally cost between $30.00 - $40.00 one way.

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

1) Super Shuttle offers “shared” transfer service from the airport to the Marriott at $16.00 one way, per person, plus gratuity. There is no discount for a roundtrip. Advance reservations are required!

   Super Shuttle airport hours: 7:00 AM - 11:00 PM
   Tollfree: 800-258-3826
   reservations.supershuttle.com/Default.aspx?content=Landmark

2) Or you can consider the MBTA’s Silver Line bus service from any airport terminal to the Airport “T” Station. Then, take the blue line “T” train to the State Station. Change to the orange line and take that to the Back Bay Station. Cross the street, go up the escalator to the Prudential Shopping Center and follow the signs to the Marriott. [www.massport.com/logan-airport/to-and-from-logan/public-transportation](http://www.massport.com/logan-airport/to-and-from-logan/public-transportation)

3) Another option is the Back Bay Logan Express bus which operates from all airport terminals on a set schedule (every 20 minutes during the day), going to the Copley “T” Station (two blocks from the Marriott) and then to the Hynes Convention Center (three blocks from the Marriott). Current fare is $5 per person.

PARKING AND DRIVING DIRECTIONS

There are no discounts for parking at the Marriott so note the following options. The Marriott’s daily valet parking is at $53 per night, including in/out privileges, OR you can use “public” off-site parking at around $37 per day with no in/out privileges. Parking in Boston can be hard to find and maneuvering the streets can be confusing, so we suggest that you use public transportation. However, if you do choose to rent a car and drive from the airport, the following are the driving directions.

Airport to Marriott: Follow signs for Boston/Sumner tunnel. Pay the toll and stay in the right lane in the tunnel. Follow signs for Exit 26/Storrow Drive. After you emerge from the tunnel, take the second left exit to Copley Square/Back Bay. At the first light, turn right onto Beacon Street. Follow Beacon St. for 4 blocks and make a left on to Exeter Street. After 5 lights, Exeter St. ends at Huntington Avenue. Turn right onto Huntington Avenue. At the first light, under the sky bridge, make a U-turn to the left. The hotel entrance will be immediately on your right.

GETTING AROUND TOWN

Public transportation in Boston is excellent and is the recommended mode of transport…aside from walking.

BOSTON PUBLIC TRANSPORTATION

The Massachusetts Bay Transportation Authority (MBTA) operates subway and bus routes throughout the city, with commuter rail and boat service rounding out its services. The Marriott Copley Place sits in the middle of three T (subway) stations: Back Bay (the closest), Copley and Prudential. From those stations, you can get almost anywhere in the city!! User-friendly ticket kiosks and route maps are available at all stations. Please note that the Government Center station will be closed until March 2016. This closure affects both the Green and Blue Line stops for this station. www.mbta.com

SIGHTSEEING TRANSPORTATION

Trolley and Duck tours depart from designated locations near the Marriott. These are an excellent way to see and get around the city!!

BOSTON DUCK TOURS

These tours are on W.W. II-era amphibious landing vehicles that travel both land and river to show you the major sites and neighborhoods of the city. This is a fun way to learn your way around the city on a sunny summer day. Commentary is provided on board. In 80 minutes, you will get a good overview of Boston history, see the Boston landmarks, and have the chance to quack at pedestrians. Tours depart from the Prudential Center, which is connected to the Marriott. Although there are a couple routes offered, only the 80-minute tour departs from the Huntington Avenue location. www.bostonducktours.com/tour.aspx

“Charlie River” and the Boston Skyline
Courtesy of the Greater Boston Convention & Visitors Bureau, Boston Duck Tours
THE TROLLEY
Similarly, the Trolley offers another way to tour the city, but it is different in that it allows you to “jump off” at any stop and then “jump back on” to continue the circle route of the city. Special “theme” routes are offered, as well, just in case you have some specific interests. Your ticket also allows you admission discounts to some attractions.

www.trolleytours.com/boston/?gclid=CLiU3e6-7MMCFQiuQodJawAuw

BICYCLES AND WALKING
Many restaurants, shopping centers, and attractions are within walking distance of the Marriott. In fact, this is one of the most “walkable cities” in the country with something new to discover at every turn. For those who want to cover a bit more territory, bicycles are available to rent for daily use near the hotel.

www.cityofboston.gov/bikes/share.asp

CAR RENTAL
All major car companies have rental stations at Logan International Airport but again, you’ll then have to deal with the high daily parking rates once you drive into the city. It may be better to consider renting a car ONLY on the day(s) that you might actually need the vehicle. You’ll find a Dollar-Rent-A-Car desk inside the Marriott Copley Place. And nearby, you will also find Hertz at the Park Plaza and Enterprise in the Prudential Center.
The 2015 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 2015 NSREC Industrial Exhibits will be in Gloucester/Back Bay Conference and Exhibition Center on Tuesday and Wednesday. Conference breaks will be hosted in the Exhibit Area on Tuesday and Wednesday along with a light lunch on Wednesday (for registered attendees only). NSREC badges must be worn at all times.

Tuesday evening, the exhibitors will host the Industrial Exhibits Reception featuring complimentary drinks along with 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:

David Hansen  Phone: 858-503-3416
Maxwell Technologies, Inc.  Email: dhansen@maxwell.com

Or visit the 2015 NSREC Industrial Exhibits web site: www.nsrec.com/exhibit.htm
Industrial Exhibits

EXHIBITORS

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Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2015 NSREC.

NSREC INDUSTRIAL EXHIBITS

MARRIOTT COPLEYS PLACE

GLOUCESTER/BACK BAY CONFERENCE AND EXHIBITION CENTER

EXHIBIT HALL HOURS

TUESDAY, JULY 14
9:30 AM – 4:00 PM
9:45 AM MORNING BREAK
2:50 PM AFTERNOON BREAK
6:00 PM – 7:30 PM
RECEPTION
COCKTAILS

WEDNESDAY, JULY 15
9:30 AM – 2:00 PM
10:20 AM MORNING BREAK
11:50 AM LIGHT LUNCH (for registered attendees only)
2015 IEEE NSREC Technical Sessions and Short Course Registration Form

REGISTRATION FEES (in U.S. dollars)

Late fee REQUIRED if payment received after June 12, 2015

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 12, 2015, 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 26, 2015.

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 12, 2015. 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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Early</th>
<th>Late</th>
<th>Number</th>
<th>Attending Cost</th>
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</thead>
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<tr>
<td><strong>A Trip to Lowell</strong> Tuesday, July 14</td>
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<tr>
<td>Adult (17 yrs+)</td>
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<tr>
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<tr>
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<tr>
<td>Infant (0-3 yrs)</td>
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<tr>
<td><strong>JFK Library and Faneuil Hall</strong> Thursday, July 16</td>
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<td>Adult (18 yrs+)</td>
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<tr>
<td>Teen (13-17 yrs)</td>
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</tbody>
</table>

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 ________________________________

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Mail or Fax this form and your remittance to:

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P.O. Box 398
Castle Rock, CO 80104

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

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 26, 2015.
Boston is one of the oldest cities in the United States and is a unique combination of historic and modern sites and green open areas. As the center of the American Revolution, the city is filled with monuments highlighting its role in American independence. Being one of the most walkable American cities, you will enjoy leisurely strolls through areas such as the Back Bay and the Esplanade Park that borders the Charles River. Of course, Boston is also the home to many premiere colleges and universities, museums and shops … all perfect for exploring.

The conference committee has designed a social program that will allow you to explore Massachusetts by both land and sea. Boston and the surrounding areas, called “The Hub,” are divided into an array of neighborhoods and squares that reflect the diversity of the area. The Marriott is located between historic Copley Square, with its stunning 19th century architecture, and the Fenway neighborhood’s Kendall Square, which is best known as the home of the Red Sox at Fenway Stadium. The Massachusetts Bay Transport Authority (MBTA), called “the T” by locals, make Cambridge’s most famous squares, the culturally diverse Central Square and Harvard Square, a short ride from the hotel.

Join your colleagues for a dessert reception in the Ballroom Salon G on the Marriott’s fourth 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.
On Tuesday morning, you’ll depart from the Marriott at 9:30 AM to visit the American Textile History Museum in Lowell, MA. Located on the Merrimack River, Lowell is a historic mill town that is most noted as being “the cradle of the American Industrial Revolution.” By 1850, Lowell had grown to be the largest industrial complex in the U.S., entirely due to textile production. Today’s Textile Museum highlights this historically important industry through a number of collections and exhibits, including:

- **Exhibits:** The permanent exhibit at the museum is called “The Textile Revolution.” This exhibit follows American textiles from the pre-American revolutionary and pre-Industrial Revolution times when most textiles and garments were made by hand through modern times with highly industrialized textiles processes and modern fabrics. The newest pieces in the collection include the U.S. Olympic “sharkskin” swimming suits and parts of the astronaut suits used for extravehicular activities.

- **Collections:** The highlight of the museum is the clothing collection, which includes clothing manufactured and worn in America from the 1800s to present times. The museum has a comprehensive collection of textiles from a Jacquard-woven portrait of Christopher Columbus to hand woven linens. There is also one of the largest textile samples of American hand weavers and manufacturers. Finally, the museum has a collection of machinery used to make textiles, including carding machines, looms and spinning machines.

For the first hour, docents will be spread throughout the museum to explain and guide everyone through the exhibits. After that, you are free to explore the museum on your own or you can take the short walk to the charming town of Lowell for some shopping and lunch (on your own). Another option would be to discover the area around the museum which is a National Historic Park, operated by the National Park Service. It covers about ½ square mile and includes attractions such as the Boott Cotton Mill and Museum, the Mill Girl and Immigrants Boardinghouse, the Lowell Canal System and the Merrimack River Walkway. The historic and downtown areas are pedestrian friendly, although trolley service is available around the historic park.

The bus will depart at 2:45 PM for the return transfer to the Marriott.
A special breakfast will be held in the Suffolk room on the third floor of the Marriott 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. We will be hosting guest speakers who will discuss their early career in radiation effects and why they continue to practice professionally. 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.

One of the most unique experiences in New England is a good, old fashioned island clambake! (See the inside back brochure cover, page 74.) The NSREC Social will be just that … a Boston-style clambake on beautiful Thompson Island, four miles from downtown … lightyears from the hustle and bustle of the city. Coaches will take you from the Marriott to the pier where everyone boards a chartered ferry for the short 30-minute cruise.

Thompson Island is a 204-acre nature preserve and it’s the only private island in the harbor. You can explore the island on groomed nature trails or lounge on the hammocks and Adirondack chairs. You can play sand pit volleyball, softball, bocce ball, horseshoes, corn hole, soccer, Frisbee … need we go on? A DJ will play music in the background, livening things up as the evening progresses.

The menu includes clam chowder, steamers, Maine lobster, grilled chicken, vegetarian lasagna, sides, and apple or blueberry pie. Of course, libations (alcoholic and non) will be available throughout the evening.

By no later than 10:00 PM, the chartered ferry must leave the island to return you to the pier, where coaches will transfer everyone back to the Marriott. This event provides you with the opportunity to socialize with other conference attendees and guests, regardless of whether you choose to be physically tested (all those games!!) or pleasantly relaxed (love those hammocks!)

A light jacket or sweater might be in order if the temperature cools down in the evening. Tickets are not included in the conference registration so be sure to purchase them with your registration. Due to the size of the chartered ferry boat, SPACE IS LIMITED so buy your tickets early!!
The John F. Kennedy Presidential Library and museum is dedicated to the personal and political life and death of the 35th president of the United States. Located at Columbus Point in Dorchester, MA, the site of this library is both historic and beautiful – a must see in Boston! But the exhibits inside are even more fascinating … most notable are a permanent exhibit on the space race and a temporary exhibit on the Cuban missile crisis. A short film about President Kennedy’s life is also available.

From the library, you then go to Faneuil Hall for shopping and lunch (on your own). Faneuil Hall is one of America’s oldest marketplace and meeting halls. The market was built in 1742 and it immediately became a gathering place for commerce as well as cultural and political matters. For instance, a number of revolutionary patriots gave speeches at Faneuil Hall. Today, Faneuil Hall is more known for shops, eateries, and very talented street performers. This is truly one of the most entertaining places to grab a quick lunch, browse and people-watch on a warm summer day!

You will leave the hotel at 10:00 AM for the short half-hour drive to the JFK Library. You’ll have about an hour and a half to explore the Library and the surrounding grounds, including a small beach. At about 12:30 PM, you’ll then depart the JFK Library to Faneuil Hall where you can enjoy lunch and shopping for a couple hours. The buses will leave at 2:45 PM; arriving back at the Marriott around 3:00 PM.

A special lunch will be held in the Suffolk room on the third floor of the Marriott for Women in Engineering and is sponsored by the IEEE NPSS society. This event is open to women attendees and is a chance to meet and socialize with each other. This lunch will also include a short talk by Janet Barth from NASA Goddard Space Flight Center. For more information, please contact Kay Chesnut, kay.c.chesnut@boeing.com.

Young Professionals are also encouraged to attend.

Note: Tickets are required so check the box for this lunch when you register for the conference.
Janet L. Barth (M’89-SM’96) has been active in the radiation effects community for nearly 40 years. She retired from NASA’s Goddard Space Flight Center (GSFC) in 2014 and continues to support NASA programs as an Emeritus Scientist. At her retirement, she was the Chief of the Electrical Engineering Division where she was responsible for the delivery of spacecraft and instrument avionics to NASA’s science missions, including, the Solar Dynamics Observatory, the SWIFT Burst Alert Telescope, the Lunar Reconnaissance Orbiter, the Global Precipitation Measurement mission, and the Magnetospheric Multiscale Mission. She also directed the development of microwave and optical communications systems and suborbital avionics systems at NASA’s Wallops Flight Facility.

Ms. Barth’s IEEE Nuclear and Radiation Effects Conference (NSREC) roles include reviewing papers, chairing technical sessions, teaching the Short Course in 1997 and serving as the Guest Editor of the Transactions on Nuclear Science from 1998-2000, the Technical Program Chairwoman in 2001, and the General Conference Chairwoman in 2006. She is a regular participant in the European Radiation and its Effects on Components and Systems (RADECS) Conference and has served as a session co-chair, the NSREC Liaison to the RADECS Conference Technical Committee in 2001, and a Short Course instructor at the 2009 RADECS Conference. She was an elected member-at-large on the Radiation Effects Steering Group (RESG) from 2002-2004. Ms. Barth has also been active on the Nuclear and Plasma Sciences Society (NPSS) Administrative Committee (AdCom), serving as an elected member for RESG 2007-2010, NPSS Vice-president 2011-2012, and NPSS President 2013-2014. She continues to serve on the AdCom as the Past-president and as the representative for the IEEE Women in Engineering (WIE) organization.

Dave Bushmire, our nationally certified fitness instructor, will be inserting a thirty minute full body stretching session to his aerobics class. The class will begin with thirty minutes of low impact aerobics followed by a stretching session designed to increase your flexibility and range of motion, decrease joint pain, back pain and chance of falling, while reducing stress, depression and fatigue. You will learn a set of stretches that can be done daily to enjoy an active and happy life style.

As in prior conferences, the classes will be held from 6:00 to 7:00 AM on Tuesday, Wednesday and Thursday in the Tremont Room on the first floor of the Marriott.

### 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@etccic.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.
GENERAL INFORMATION

There is plenty to do and see in Boston and the surrounding communities. The city is home to the American Revolution, a world-famous symphony and the Boston Red Sox! Historic sites, museums, noteworthy architecture, charming neighborhoods, beautiful parks, an active waterfront, and intriguing tours are all available, along with great dining and entertainment, as well.

Boston is surrounded by a number of nearby communities, including Brookline, Cambridge, Lexington and Concord. Cambridge and Brookline are accessible to Boston by both trains and buses. Lexington and Concord are a short car ride away. So, if you run out of things to do in Boston, which you probably won’t, there is much more to see and do in the surrounding areas.

ACTIVITIES WITHIN BOSTON AND CAMBRIDGE AREA

THE SHOPS AT PRUDENTIAL CENTER

The Marriott is attached by sky-bridge to The Shops at the Prudential Center; a destination for shopping and dining. The center features more than 70 nationally and locally renowned retailers and dining venues, all connected via over-the-street walkways. [www.prudentialcenter.com](http://www.prudentialcenter.com)

SKYWALK OBSERVATORY

The Skywalk Observatory is on top of the Prudential Tower, a huge office building within the Prudential Center. The Observatory provides a 360° view of Boston and is especially worthwhile on a sunny day! Visit early in the week in order to get a “bird’s eye view” of your location in the city as well as the location of other sites to visit. It is open 10 AM to 10 PM daily in the summer. [www.prudentialcenter.com/shop_detail.html?id=64](http://www.prudentialcenter.com/shop_detail.html?id=64)

FENWAY PARK

Fenway Park, the home of the Boston Red Sox, is only one mile from the Marriott. If you have ever wanted to sit on top of the Green Monster, then you really should take one of the walking tours of the park. If you’re a true fan, you may want to consider buying tickets to the New York Yankees/Red Sox games on July 10-11-12. Unfortunately, during the rest of the week, the Sox will be traveling. Keep in mind, if you want tickets for the Yankees/Red Sox games, the tickets will sell out quickly. [boston.redsox.mlb.com/bos/ballpark/tour.jsp](http://boston.redsox.mlb.com/bos/ballpark/tour.jsp)

MUSEUM OF FINE ARTS

The Museum of Fine Arts is considered one of the most comprehensive art museums in the world with over 450,000 works of art. It is less than a mile away from the conference hotel. While the museum covers a wide range of artistic time period, its Art of the Americas collection has recently gone through a renovation with its own dedicated wing. During NSREC, there will also be temporary exhibit of Gordon Parks’s photography titled “Back to Fort Scott.” [www.mfa.org](http://www.mfa.org)

BOSTON PUBLIC LIBRARY (BPL)

The Boston Public Library is both a municipal library system (the second largest in the US with over 23 million items) and a specific building. It is the building, just a block from the Marriott, that you DO need to visit!! Also known as the McKim Building, this structure is not only architecturally elegant, but ALSO a museum for special exhibits of the BPL’s 1.7 million rare books, manuscripts and maps collection. Well worth seeing!! [www.bpl.org/central/walkmckim.htm](http://www.bpl.org/central/walkmckim.htm)

Copley Square and Boston Public Library

Courtesy of the Greater Boston Convention & Visitors Bureau, Leise Jones Photography
Local Activities

FREEDOM TRAIL
The Freedom Trail is a 2.5-mile, red-lined walking tour of the Beacon Hill region of Boston. The tour has 16 sites that are significant to the American Revolution, including meeting houses, churches, and cemeteries. For the more physically active tourist, the Freedom Trail can be a great run through history. www.thefreedomtrail.org/#sthash.gUwEGYcK.dpuf

Fittingly behind Revere’s statue, at the end of the Mall, sits the Old North Church

THE CHARLES RIVER ESPLANADE
The Esplanade is located near the conference hotel and is an excellent place to take a bike ride, a run or a stroll. The park runs between Storrow Drive and the Charles River. Access to the park is available near the Massachusetts Avenue Bridge and Beacon Street. The Hatch Memorial Shell on the Esplanade is the location for the famous Boston Fourth of July Pops concert and is frequently used in the summer for community concerts and movies.

ISABELLA STEWART GARDNER MUSEUM
While alive, Isabella Stewart Gardner was one of foremost female patrons of the arts. The museum was established by Gardner in 1903. Its building was designed to look like a 15th-century Venetian palace. Besides the art museum, its Café G is a local favorite for lunch in the summer. www.gardnermuseum.org/home

NEWBURY STREET
Newbury Street, in the Back Bay neighborhood of Boston, is a mile-long stretch of brownstones that have been converted into shops and restaurants. It is frequently seen in TV shows and movies that are shot in Boston. Lower Newbury, near the Public Gardens, houses the high-end boutiques with the shops becoming less expensive as you head toward Massachusetts Avenue. Newbury Street is a must see for shoppers!
The Public Garden and Boston Common are located in downtown Boston and are a quick stroll from the Marriott Copley Place. While the original use of the Public Garden was as a botanical garden, the Common was originally a cow pasture. These days, most people know the Public Garden from the children’s story “Make Way for Ducklings.” There is a statue of the ducks and a duck pond dedicated to that story. The Public Garden also includes a number of statues of revolutionary war heroes, including George Washington. The Common is the southernmost end of the Freedom Trail and is across Beacon Street from the Massachusetts State House. During the summer months, the Common also hosts the Commonwealth Shakespeare Company and the Boston Lyric Opera.

The Boston Museum of Science is located on the Charles River and is a short train ride from the Marriott. Its permanent collections are good for kids and adults alike, including exhibits on wind farms; the live animal care center with 120 different species such as tamarins and cooters; and flying micro-robots. The museum has a planetarium, laser shows, an IMAX theater and a 4-D Film theater for those who want a multi-sensory experience.

Looking for some live entertainment? The hotel is only a short distance from the theater district where you can take in a number of live performances. For example, the Charles Playhouse features the iconic Blue Man group and their visually stunning blend of music, percussion, comedy, art and science that is sure to be a unique experience. The Playhouse also features “Shear Madness”, seven time winner of The Boston Globe “Best Comedy of the Year” award and America’s longest running comedy ever.

Fort Independence is located on Castle Island in the Boston Harbor but is connected to the mainland for easy access. Originally built by the English in 1634, they abandoned the island during the Revolutionary War. The fort structure, re-built several times, became an American stronghold after the Revolutionary War and has found many uses since. It is now a worthy historical fortress to explore and you will immediately see the importance of this crucial location. Or…if the historical significance is not your interest, you can simply walk around the island and enjoy the ocean views.

Did someone say “chocolate???” The fabulous Taza Chocolate is made across the river in Somerville, MA. Taza makes stone-ground, Mexican-style organic dark chocolate. While a little bit off the beaten path, the factory tour is well worth taking time to visit.

The Massachusetts Institute of Technology (MIT) Museum highlights the many scientific and technological discoveries that MIT University has made over the years. The exhibits include recent work from MIT graduates, artificial intelligence robots designed at MIT and the original cathode-ray tubes computers. It is located across the river in Kendall Square in Cambridge, MA.
HARVARD UNIVERSITY &
HARVARD SQUARE

Nearby Harvard Square is the home of the Ivy-league Harvard University, which is America’s oldest institution of higher learning. Established in 1636 in Cambridge, MA, the campus hosts tree-lined quads and red brick buildings, making it a wonderful place to spend a summer afternoon. Tours of the university are available, including tours led by Harvard students (www.trademarktours.com). After a tour of the university, spend time relaxing in the surrounding area, Harvard Square. The square is an eclectic mix of street performers, public chess tables, coffee shops and high-end retailers. This is a great place to have a coffee, play a chess game and people watch.

Shops along Massachusetts Avenue in Harvard Square, Cambridge.

ARNOLD ARBORETUM OF
HARVARD UNIVERSITY

The Arnold Arboretum is located in Jamaica Plain, which is one of the five neighborhoods in Boston. The park was designed by Frederick Law Olmsted and is part of the Emerald Necklace series of parks in Boston. The collection has nearly 15,000 plants including a large collection of the ligneous species from North America and eastern Asia. While the arboretum is train accessible, driving might be a simpler option.

arboretum.harvard.edu

CAPE COD

Cape Cod is the peninsula near the Rhode Island border. It consists of a series of towns and villages that cater to tourists looking for relaxing beach vacations. Each of the 15 towns has its own character and charm so there is a town for every personality! A good portion of the cape has private and public beaches, although the water is often cold year round. Cape Cod can be reached by car or ferry.

CAPE ANN

Cape Ann is the rockier cousin of Cape Cod and is 30 minutes north of Boston. Within the area, the city of Gloucester and the town of Rockport are both worth a visit. While there are white sand beaches with sand dunes on Cape Ann, many are the distinctive New England rock beaches. Much of the commercial lobstering is done on Cape Ann so this is one of the best places to get fresh lobster!

CITIPASS

Boston CitiPASS is a discounted admission pass to the city’s top attractions. One rate allows you admission to four of the following: New England Aquarium, Museum of Science, Boston Museum of Fine Arts, and either the Skywalk Observatory OR the Harvard Museum of Natural History. New rates go into effect on March 1 @ $49 for those 12 years of age and older and $36 for children from 3-11 years.

www.citypass.com/boston

WEATHER AND CLOTHING

Typical summertime weather in Boston can be delightful with the ocean breezes helping to keep the humid temperatures under control. The evenings can be cool and may require a light sweater. Pop up thunderstorms are common, so you may want to include an umbrella in your bag. July’s average high temperatures are around 82 °F (27.8 °C) with overnight lows above 66 °F (18.9 °C).
2015 Conference Committee

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Matthew Kay, NAVSEA Crane
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The 2016 IEEE Nuclear and Space Radiation Effects Conference will be held July 11 - 15 at the The Double Tree and Portland Convention Center, Portland, Oregon. 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 11, 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**
PROCEDURE FOR SUBMITTING SUMMARIES
Authors must conform to the following requirements:

1. Prepare a single Adobe Acrobat file consisting of a cover page and an informative two to four page summary describing results appropriate for 12-minute oral or 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 2016). 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.

PORTLAND, OREGON
In Portland, it’s easy to find limitless recreation, fabulous food and drink and flourishing culture. Portland is located approximately 70 miles from the Pacific coast in a beautiful setting between the Willamette and Columbia Rivers. Also, Portland is a short drive to a variety of activities including the Willamette valley wineries, Mount Hood, and spectacular ocean beaches. With no sales tax, Portland is a haven for shoppers. 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. Portland’s big city excitement and with small town charm make it one of the favorite destinations in the West.

Mt. Hood, Courtesy of Julia Grieve & Travel Portland
How to Enjoy a New England Clambake

- Take a ferry cruise to the island
- Find a private island
- View the Boston skyline
- Explore
- Try some activities
- Relax with a drink
- Eat lobster
- Eat side dishes
- Enjoy the evening

Photos credit: http://thompsonisland.org/
AIRPORT TO MARRIOTT

Follow signs for Boston/Sumner tunnel. Pay the toll and stay in the right lane in the tunnel. Follow signs for Exit 26/Storrow Drive. After you emerge from the tunnel, take the second left exit to Copley Square/Back Bay. At the first light, turn right onto Beacon Street. Follow Beacon St. for 4 blocks and make a left on to Exeter Street. After 5 lights, Exeter St. ends at Huntington Avenue. Turn right onto Huntington Avenue. At the first light, under the sky bridge, make a U-turn to the left. The hotel entrance will be immediately on your right.

AIRPORT SHUTTLES

1) Super Shuttle offers “shared” transfer service from the airport to the Marriott at $16.00 one way, per person, plus gratuity. There is no discount for a roundtrip. Advance reservations are required! Super Shuttle airport hours: 7:00 AM - 11:00 PM. Tollfree: 800-258-3826

reservations.supershuttle.com/Default.aspx?content=Landmark

2) MBTA’s Silver Line bus service from any airport terminal to the Airport “T” Station. Then, take the blue line “T” train to the State Station. Change to the orange line and take that to the Back Bay Station. Cross the street, go up the escalator to the Prudential Shopping Center and follow the signs to the Marriott.


3) Back Bay Logan Express bus which operates from all airport terminals on a set schedule (every 20 minutes during the day), going to the Copley “T” Station (two blocks from the Marriott) and then to the Hynes Convention Center (three blocks from the Marriott). Current fare is $5 per person.


MASSACHUSETTS BAY TRANSIT AUTHORITY (MBTA)

The Massachusetts Bay Transportation Authority (MBTA) operates subway and bus routes throughout the city, with commuter rail and boat service rounding out its services. The Marriott Copley Place sits in the middle of three T (subway) stations: Back Bay (the closest), Copley and Prudential. From those stations, you can get almost anywhere in the city!! User-friendly ticket kiosks and route maps are available at all stations. Please note that the Government Center station will be closed until March 2016. This closure affects both the Green and Blue Line stops for this station.

www.mbta.com