RADECS 2019 MONTPELLIER

30th anniversary

European Conference on

Radiation and its Effects on Components & Systems

September 16-20th, 2019

Montpellier, France

www.radecs2019.org

CONFERENCE SCHEDULE

Monday

08:00 Registration

09:00 Introduction

09:10 **Short Course** Part I

10:25 Break

11:00 **Short Course** Part II

12:00 Short Course Lunch

13:30 **Short Course** Part III

14:30 **Short Course** Part IV

15:30 Break

16:00 **Short Course** Part V

17:00 End of sessions

17:10 Short Course Exam

17:40

18:30 Welcome Cocktail

20:30

Tuesday

08:00 Registration

09:00 Conference Opening

09:40 **Session C** Single Event Effects: Mechanisms & Modelling

10:30 Break

11:00 **Session C** Single Event Effects: Mechanisms & Modelling

12:30 Lunch

14:00 **Session A** Basic Mechanisms of Radiation Effects

14:50 **Session E** Photonics, Optoelec. & Sensors

15:25 Break

15:55 **Session E** *(cont'd)* Photonics, Optoelectronics & Sensors

17:00 End of sessions

17:10 End of sessions

18:30 Industrial Exhibit Reception

21:30

10:00 **Industrial exhibit** 17:00

Wednesday

08:00 Registration

08:30 *Invited talk* **Mars missions and the search for traces of life**

09:30 **Session B** Radiation Effects on Devices & ICs

10:35 Break

11:05 **Session B** Radiation Effects on Devices & ICs

12:20 Lunch

13:30 **Women in Engineering**

14:10 **Session I** Facilities and Dosimetry

15:00 **Poster Session**

17:30 End of sessions

09:00 **Industrial exhibit** 17:00

Thursday

08:00 Registration

08:30 *Invited talk* **30 years of parabolic flights at CNES**

09:30 **Session D** Single Event Effects: Devices & ICs

10:50 Break

11:15 **Session F** Hardening Techniques

12:20 Lunch

14:00 **Session F** *(cont'd)* Hardening Techniques

14:45 **Radiation Effects Data Workshop**

16:15 **RADECS General Assembly**

17:30 End of sessions

18:30 30th Anniversary Gala Dinner

09:00 **Industrial exhibit** 16:00

Friday

08:30 Registration

09:00 **Session G** Radiation Hardness Assurance

10:05 Break

10:35 **Session H** Radiation Environments

11:55 Closing Remarks

12:10 End of Conference

14:00 Technical visits

16:00

WELCOME

Welcome to RADECS 2019

The RADECS conference is the European annual forum on the effects of radiation on electronics and optoelectronics devices and systems where scientists and engineers exchange on the latest progresses and results about radiation effects on electronics.

RADECS 2019, the 30th anniversary edition of the RADECS conference, is organized by the Institute of Electronics and Systems (IES), a joint research unit of the University of Montpellier and the French National Center for Scientific Research (CNRS), under the technical sponsorship of the RADECS association and the IEEE Nuclear & Plasma Sciences Society, with the support of the 123 Events agency.

While celebrating the heritage of the past three decades of RADECS conferences, the theme of this year's conference is "Prepare for the next decade" with the ambition to explore the technical challenges that will drive the radiation effects scientific community and industry over the coming years. The conference includes a full-day short-course, technical sessions, a data workshop, and an industrial exhibition.

The RADECS 2019 Committee is pleased to welcome you to Montpellier, where the RADECS story began 30 years ago, a city that combines a typical South of France atmosphere with a rich medieval downtown and a modern metropolis known for its innovation and scientific activities. Within a few kilometers, the countryside around Montpellier offers many cultural activities and various landscapes from beaches to vineyards and garrigue. We hope you will enjoy the city and its area as well as the technical and social programs we have put together.

Vincent Pouget
RADECS 2019 General Chair

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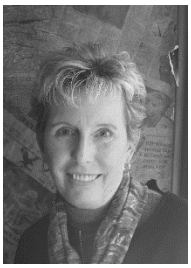

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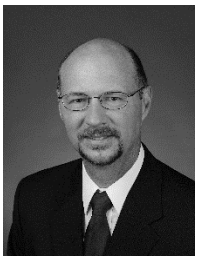

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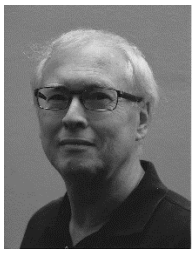
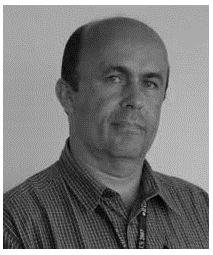


Dan Fleetwood
IEEE Guest Editor
Vanderbilt University



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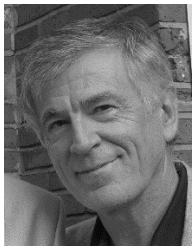

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1.2.3. EVENTS
La signature de vos évènements

Isabelle Saunier
Laure Escarment
123 Events
Organization support

CONTENTS

SHORT COURSE PROGRAM - MONDAY

Einstein Auditorium, Level 0

9:00 **SHORT COURSE INTRODUCTION**
Frédéric Wrobel, University of Montpellier, Short Course Chair

Prepare for the next decade!

This short course is intended for beginners as well as experts in the field. Basic and main concepts will be presented before focusing on various effects and technologies that are, and will be in the next decade, at play. It will cover displacement damage and ionizing dose effects for both silicon devices and emerging technologies. The issue of low energy protons for single event effects will be also addressed for space and high altitude environments. In addition, a talk on the complex challenges of mitigation techniques in FPGAs will be given. Finally, RHA strategies for aerospace systems will be presented.

Part I 09:10 **OVERVIEW OF THE MAIN CONCEPTS OF RADIATION EFFECTS AND THEIR EVOLUTION OVER THE 30 YEARS OF RADECS CONFERENCES**

Philippe Paillet, CEA

Philippe Paillet (M'97–SM'04–F'18) received his Master's degree in Electrical Engineering from the Université Aix-Marseille I, France, in 1989 and his PhD degree in Electrical Engineering from the Université Montpellier II, France, in 1995. He joined the Commissariat à l'Energie Atomique (CEA) in Arpajon, France in 1995, and is now a CEA International Expert. Philippe has been involved in numerous programs developing radiation-hardened electronic and optoelectronic technologies, characterizing the physical mechanisms responsible for radiation response of components and ICs, modeling the effects of radiation in MOS technologies and creation of radiation-induced defects, and developing hardness assurance approaches. Philippe has authored or co-authored more than 200 publications, articles, short courses and book chapters, including three Best Papers at RADECS, two Meritorious Paper Awards at NSREC, one Best Paper Award at HEART, and five Outstanding Paper Awards at NSREC. He is currently serving as Vice-president of the RADECS Association and RADECS Liaison to the IEEE Radiation Effects Steering Group.

Abstract **-** An overview of the main concepts of radiation effects in electronic and optoelectronic devices and circuits will be provided. These main effects include both destructive and non-destructive events, and the underlying degradation mechanisms will be briefly introduced. Depending on the type of incoming particle (photon, proton, neutron, heavy ion) and the target technology or device, non-destructive effects can range from transient perturbation of electrical or optical parameters (Single-Event Upsets, Single Event Transients, photocurrents, etc…) to permanent degradation (Total Ionizing Dose induced charge trapping in insulators, Displacement Damage Dose in semiconductor materials). As a celebration of the 30-years of RADECS conferences, these main concepts will be presented with an emphasis on the historical perspective, and of the attention they drew at the conference since 1989.

Contents

- Total Ionizing Dose Effects in insulators
  Charge trapping; Effects on elementary device response (V_{th} shifts, Device Leakage, etc…); Evolution with scaling
- Displacement Damage in semiconductor bulk
  Concepts of DDD and NIEL; main effects; and Simulation of displacement cascade generation and anneal
- Single-Event Effects in devices and ICs
  Destructive and non-destructive events; Charge generation and collection; Impact on device operations; Influence of scaling

10:25 **BREAK**

Part II **TID EFFECTS, BORDER TRAPS, AND 1/*f* NOISE IN EMERGING TECHNOLOGIES**

11:00 **Dan Fleetwood, Vanderbilt University**

Daniel M. Fleetwood received his B. S., M. S., and Ph. D. degrees in Physics from Purdue University in 1980, 1981, and 1984. Dan joined Sandia National Laboratories in Albuquerque, New Mexico, in 1984, and was named a Distinguished Member of the Technical Staff in the Radiation Technology and Assurance Department in 1990. In 1999 he accepted a position as Professor of Electrical Engineering at Vanderbilt University in Nashville, Tennessee. In 2000, he was also named a Professor of Physics, in 2001 he was appointed Associate Dean for Research of the Vanderbilt School of Engineering, and in 2003 he was named Chair of the Electrical Engineering and Computer Science Department. Dan is the author of more than 500 publications on radiation effects in microelectronics, 12 of which have been recognized with Outstanding Paper Awards. These papers have been cited nearly 20,000 times. In 2009, he received the IEEE Nuclear and Plasma Sciences Society's Merit Award, which is the society's highest individual technical honor. Dan is a Fellow of both the Institute for Electrical and Electronics Engineers and The American Physical Society, and a member of ASEE, Phi Beta Kappa, and Sigma Pi Sigma.

Abstract - This course will present a brief overview of total-ionizing-dose (TID) effects, and illustrate how 1/*f* noise measurements can provide significant insights into the responses of MOS devices and GaN-based HEMTs, with a focus on emerging technologies. Noise measurements are especially helpful when coupled with current-voltage and/or charge-pumping measurements, and/or first-principles theory calculations. Border traps are near-interfacial oxide traps that exchange charge with the underlying silicon on the time scales of measurements; their effects have become increasingly important for highly-scaled MOS devices. 1/*f* noise is quite sensitive to border traps in these devices. In GaN-based HEMTs, 1/*f* noise is sensitive to both total-ionizing-dose and displacement-damage effects. Examples will also be shown for SiC-based MOSFETs and other emerging MOS technologies (e.g., graphene, black phosphorus, MoS_2).

Contents

- TID in Isolation Oxides
  Leakage, V_{th} shifts
- Oxide and Border Traps
  Effects on TID Response, Microstructure
- Low-frequency noise
  Background, Measurements, Carrier Number Fluctuation Model, Defect Microstructure, Kinetics – Dutta-Horn Model, Illustrative Examples

12:00 **SHORT COURSE LUNCH** – *Level 3*

Part III **LOW ENERGY PROTONS - WHERE AND WHY "RARE EVENTS" MATTER**

13:30 **Kenneth P Rodbell, IBM Research**

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

Abstract **-** Upsets due to direct ionization from protons were first predicted in 1988 and then experimentally realized in 2007 for both low energy protons (1 MeV) and neutrons (1 – 10 MeV). For terrestrial applications, secondary - low energy protons, generated during collision events, may cause upsets, especially in cells further away from the initial strike location than their heavier spallation-fragment cousins. However, in space and high altitude environments, this direct ionization mechanism may be more important due to the large flux of primary high energy protons impinging on nearby spacecraft (and local device) shielding. In this short course a brief review of the relevant literature will be followed by a discussion of the sensitivity to direct ionization of typical CMOS devices. It will be shown that a significant number of low energy protons are generated, as a result of cosmic radiation spallation events, and suggests that track structures and exact device hit locations need to be understood and effectively modeled, especially for modern devices. Finally, the rate of multiple cell upsets, and hence multiple bit upsets, in these environments will be explored, with possible mitigation techniques discussed.

Contents

- SOI versus Bulk
- Proton direct ionization (PDI)
- Angle of incidence, SOI and MBUs
- LEP SEUs and reliability testing
- Elastic scattering

Part IV **RADIATION EFFECTS AND MITIGATION TECHNIQUES IN FPGAS: THE COMPLEXITY CHALLENGE**

14:30

Luis Entrena, University Carlos III of Madrid,
Miguel Aguire, University of Sevilla

Luis Entrena received the Industrial Engineering degree from Universidad de Valladolid (Spain) in 1988 and the PhD degree in Electronic Engineering from Universidad Politécnica de Madrid (Spain) in 1995. From 1990 to 1993 he was with AT&T Microelectronics at Bell Labs (USA). From 1993 to 1996 he was Technical Project Leader at TGI (Spain). In 1996 he joined Universidad Carlos III de Madrid (Spain), where he is currently Full Professor and has previously served as Head of the Electronic Technology Department and Director of the Postgraduate Program in Electrical Engineering. He has published over 150 papers in international journals and conferences and holds a patent for the invention of the Redundancy Addition and Removal synthesis method. He has collaborated with industry in many space projects and missions involving the use of FPGAs. His current research interest include FPGA-based high performance computing and mitigation of radiation effects in FPGAs, microprocessors and SoCs.

Miguel A. Aguirre (Mí90, PhD'94) obtained the Master degree in 1990, in Electrical and Electronic Engineering by the Universidad de Sevilla, Spain. He obtained the PhD degree in 1994 in the Universidad de Sevilla, and since 2016 is Full Professor, in the same University. He was teaching digital microelectronics design in the Electronic Engineering Department of the Universidad de Sevilla. He is the author of more than 20 publications in Journals of the IEEE and more than 100 international conferences, and an endless list of industrial projects and research competitive projects. His field of interest is related with tools for dependable design of integrated circuits and FPGAs, and mitigation techniques for radiation effects in electronic devices and systems. In the field of FPGAs he has been working in FT-UNSHADES system in both, Virtex version and Brave, SRAM-FPGA. At the end of 2018, the University has retired him due to health problems, and now he is in the way of recovery and collaborates in several actions related to RADECS. His work is now continued by Dr Hipolito Guzman Miranda.

Abstract - FPGAs are increasingly being used to implement digital systems because of their versatility, performance per watt and NRE cost reduction. Today they are regularly found in space equipment. At the ground level, they are entering the high-performance computing market and are expected to be massively deployed in data centers, where neutron sensitivity may be a concern. Furthermore, modern FPGAs are complex devices that include a wide variety of resources and interfaces, and their complexity is expected to increase in the future. As a result, radiation hardness assurance is challenging. This course will provide an up-to-date overview of radiation effects on major FPGA technologies, sensitivity evaluation methods and mitigation techniques and tools. Available space-grade devices will be presented and compared with COTS FPGAs, which are also making their way with the aid of user-implemented mitigation techniques.

Contents

- Introduction to FPGAs
- Radiation effects and mitigation techniques in FPGAs
- Radiation-hardened FPGAs
- Sensitivity evaluation
- Mitigation techniques for COTS FPGAs

15:30 **BREAK**

SHORT COURSE PROGRAM - MONDAY

Part V **RADIATION HARDNESS ASSURANCE: EVOLVING FOR NEW SPACE**

16:00

Michael Campola, NASA/GSFC,
Jonathan Pellish, NASA

Michael Campola is employed at the Goddard Space Flight Center (GSFC) as the National Aeronautics and Space Administration's Radiation Effects and Analysis Group (REAG) Leader. Michael received a B. S. degree in Engineering Physics from Embry-Riddle Aeronautical University, and the M. S. degree in Electrical Engineering from Arizona State University. Michael joined the Flight Data Systems and Radiation Effects Branch at NASA Goddard Spaceflight Center in 2007, working on flight projects and research to capture system level radiation response. He has worked on programs and projects such as Magnetospheric MultiScale (MMS) Mission, Landsat 8, ICESat-2, and Transiting Exoplanet Survey Satellite (TESS), which are currently operational on orbit. He is a member of the Institute for Electrical and Electronics Engineers.

Dr. Jonathan "Jonny" Pellish is employed at the Goddard Space Flight Center (GSFC) as the National Aeronautics and Space Administration's Electrical, Electronic, and Electromechanical (EEE) Parts Manager, responsible for workforce stewardship and coordinating Agency-wide discipline technical activities in the EEE parts and radiation effects engineering communities. Jonny is also the deputy manager for the NASA Electronic Parts and Packaging (NEPP) Program, which is operated by GSFC for the NASA Office of Safety and Mission Assurance. Dr. Pellish received the B.S. degree in physics from Vanderbilt University in 2004, and the M.S. and Ph.D. degrees in electrical engineering from Vanderbilt University in 2006 and 2008. From 2007–2008 Jonny held an IBM Ph.D. Fellowship, which included a co-op position at the IBM Austin Research Laboratory. Jonny has authored or co-authored over 60 refereed publications in addition to numerous conference and workshop presentations. He is a member of the American Institute of Aeronautics and Astronautics and the Institute for Electrical and Electronics Engineers.

Abstract **-** Dr. Jonathan Pellish, NASA Electronic Parts Manager, and Mr. Michael Campola, NASA Goddard Space Flight Center (GSFC), will present radiation hardness assurance (RHA) strategies that engineers and scientists can apply to a wide range of aerospace systems, with a focus on how to manage aggressive system scaling for smaller platforms. During the past decade, numerous small satellites have been launched into space, with dramatically expanded dependence on advanced commercial-off-the-shelf (COTS) technologies and systems required for mission success. While the radiation effects vulnerabilities of small satellites are the same as those of their larger, traditional relatives, revised approaches are needed for risk management because of differences in technical requirements and programmatic resources. While moving to COTS components and systems may reduce direct costs and procurement lead times, it undermines many cost-reduction strategies used for conventional RHA. Limited resources are accompanied by a lack of radiation testing and analysis, which can pose significant risks—or worse, be neglected altogether. Small satellites have benefited from short mission durations in low Earth orbits with respect to their radiation response, but as mission objectives grow and become reliant on advanced technologies operating for longer and in harsher environments, requirements need to reflect the changing scope without hindering developers that provide new capabilities.

Contents

- New Space and SmallSat Considerations
- The Natural Space Radiation Environment Hazard
- Radiation Effects on Micro-Electronics
- Hardness Assurance, as a Discipline, with its Challenges
    - New Technologies
    - New Architectures
    - Unbound Risks
- Building Smart Requirements
- Risk Acceptance and Guidance

17:00 End of Short Course

SHORT COURSE PROGRAM - MONDAY

17:10 **SHORT COURSE EXAM** (30 min)

At the end of the short course, there will be a short quiz for attendees who want to evaluate their understanding about the talks. Attendees who pass the exam will receive a certificate.

To participate, please note that you need to:

- Be registered to the short course
- Have your own laptop with internet connection (Wi-Fi provided by conference)
- Register to the IWantECTS website prior to the conference

TECHNICAL PROGRAM - TUESDAY

Pasteur Auditorium, Level 1

9:00 **CONFERENCE OPENING REMARKS**
Vincent Pouget, IES-CNRS, General Chair

9:30 **TECHNICAL PROGRAM INTRODUCTION**
Françoise Bezerra, CNES, Technical Program Chair

09:40 **SESSION C**
SINGLE EVENT EFFECTS: MECHANISMS & MODELLING
Chairs: Heather Quinn (LANL) & Magali Haussy (Thales Alenia Space)

C-1 09:45 **Angular Sensitivity of Neutron-Induced Single-Event Upsets in 12-nm FinFET SRAMs with Comparison to 20-nm Planar SRAMs**
T. Kato[1], H. Matsuyama[1]
1. Socionext Inc., Japan
Neutron-induced single-event upsets are studied in 12-nm FinFET SRAMs with varying incidence angle. Comparison with 20-nm planar SRAMs reveals different angular sensitivities of multiple-cell upsets. Parasitic bipolar effects are likely a key mechanism underlying this.

C-2 10:00 **The Pion Single Event Effect Resonance and its Impact in an Accelerator Environment**
A. Coronetti[1], R. Garcia Alia[1], M. Cecchetto[1], W. Hajdas[2], D. Soderstrom[3], A. Javanainen[3], F. Saigne[4]
1. CERN, France
2. PSI, Switzerland
3. Jyvaskylan Yliopisto, Finland
4. Universite de Montpellier, France
The pion SEU and SEL cross-section is experimentally investigated and is found to be higher than that of protons above 100 MeV (resonance). Numerical simulations are proposed to study the different nuclear interactions involved.

C-3 10:15 **Cross-Calibration of Various SEE Test Methods Including Pulsed X-rays and Application to SEL and SEU**
G. Augustin[1], M. Mauguet[1], N. Andrianjohany[1], N. Chatry[1], F. Bezerra[2], E. Capria[3], M. Sander[3], K. Voss[4]
1. TRAD, France
2. CNES, France
3. ESRF, France
4. GSI, Germany
Correlations are established between heavy ions, X-rays and simulations using charge measurements on a photodiode. These results are then used to performed comparative SEU and SEL tests on integrated circuits.

10:30 **BREAK**

C-4 11:00

Heavy Ion Nuclear Reaction Impact on SEE testing: from Standard to Ultra-High Energies

V. Wyrwoll[1], R. Garcia Alia[2], K. Roed[3], P. Fernandez Martinez[2], M. Kastriotou[2], M. Cecchetto[2], N. Kerboub[2], M. Tali[4], F. Cerutti[2]

1. CERN/University of Oslo, Switzerland
2. CERN, Switzerland
3. University of Oslo, Norway
4. CERN/ESA/University if Jyvaskyla, Switzerland

Monte Carlo (MC) simulations and experimental data of high energy protons and heavy ions in a broad energy range have been studied focusing on the sub-LET threshold region for Single Event Latch-up (SEL) cross section.

C-5 11:15

Pulsed Laser-Induced Single-Event Transients in InGaAs FinFETs with Sub-10-nm Fin Widths

K. Li[1], E. Zhang[1], S. Bonaldo[2], A. Sternberg[1], J. Kozub[1], M. Reaz[1], L. Ryder[1], K. Ryder[1], H. Gong[1], S. Weiss[1], R. Weller[1], A. Vardi[3], J. Alamo[3], R. Reed[1], D. Fleetwood[1], R. Schrimpf[1]

1. Vanderbilt University, USA
2. University of Padova, Italy
3. Massachusetts Institute of Technology, USA

The single-event transient response and charge collection mechanisms are investigated for InGaAs FinFETs on InP with sub-10-nm fin widths. The dependences on fin width, VDS, VGS, and laser energy are consistent with wider-fin devices.

C-6 11:30

Rad-Ray: A new Simulation Tool for the Analysis of Heavy Ions-induced SETs on ICs

L. Sterpone[1], F. Luoni[2], S. Azimi[1], B. Du[1]

1. Politecnico di Torino, Italy
2. GSI, Germany

We present Rad-Ray, a tool for simulating the passage of heavy ions particles through the silicon matter of modern Integrated Circuits and generating the transient voltage pulse response. Heavy ions radiation campaigns demonstrated comparable results.

C-7 11:45

Impact of electrical stress and neutron irradiation on reliability of Silicon Carbide power MOSFET

K. Niskanen[1], A. Touboul[1], R. Germanicus[2], A. Michez[1], A. Javanainen[3], F. Wrobel[1], J. Boch[1], V. Pouget[1], F. Saigne[1]

1. IES, University of Montpellier, France
2. CRISMAT LAMIPS, France
3. RADEF, Finland

Effects of electrical stress and neutron irradiation to Single Event Burnout (SEB) sensitivity and breakdown voltage degradation of silicon carbide power MOSFETs was studied. Different SEB behavior between stressed and fresh devices was observed.

C-8 12:00

Single-Event Transient Space Characterization in 28nm SOI Technologies and below

C. Lecat-Mathieu de Boissac[1], F. Abouzeid[1], V. Malherbe[1], J.-M. Daveau[1], G. Gasiot[1], P. Roche[1], J-L. Autran[2], T. Thery[1]

1. STMicroelectronics, France
2. IM2NP, France

A Single-Event Transient study was performed on two FDSOI technology nodes, embedding a novel characterization structure and with the help of Monte-Carlo simulations

C-9 12:15

Single Event Latchup Cross Section Calculation from TCAD Simulations - Effect of the Doping Profiles and Anode to Cathode Spacing

S. Guagliardo[1], F. Wrobel[1], Y. Aguiar[1], J. Autran[2], P. Leroux[3], F. Saigné[1], V. Pouget[1], A. Touboul[1]

1. IES, University of Montpellier, France
2. Aix-Marseille University, France
3. Leuven University, Belgium

In this paper SEL cross sections were calculated from TCAD simulations varying doping profiles and anode-to-cathode spacing values. We found that doping profiles variation has a stronger impact on SEL sensitivity then variation of spacing.

POSTER PAPERS

PC-1 **An Improved Approach for Quantitative Pulsed-Laser Single-Event Effects Testing Using Two-Photon Absorption**

J. Hales[1], A. Khachatrian[1], J. Warner[1], S. Buchner[1], D. McMorrow[1]
1. U.S. Naval Research Laboratory, USA

Quantitative pulsed-laser testing using two-photon absorption is challenging due to its complicated dependence on laser pulse parameters. This work focuses on an accurate, yet simplified, approach for enabling such quantitative testing.

PC-2 **Atmospheric Neutron Radiation Response of III-V Binary Compound Semiconductors**

J. Autran[1], D. Munteanu[2]
1. Aix-Marseille University, France
2. CNRS, France

This works examines the radiation response of III-V binary compound semiconductors subjected to high energy atmospheric neutrons. Production of neutron-induced secondary products and implications for single event effects are carefully analyzed and discussed.

PC-3 **Heavy-Ion Microbeam Studies of Radiation-Sensitive Regions of SiC VD-MOSFETs**

C. Martinella[1], T. Ziemann[2], K. Voss[3], R. Garcia Alia[4], Y. Kadi[4], U. Grossner[2], A. Javanainen[5]
1. CERN, University of Jyväskylä, Switzerland
2. APS - ETH Zurich, Switzerland
3. Material Research Department at GSI, Germany
4. CERN, Switzerland
5. RADEF, Finland

Micro-probe experiments allow a micrometer-accurate localization of the radiation-sensitive regions in SiC VD-MOSFETs, providing useful information for the comprehension of basic phenomena of Single Event Effects in SiC commercial technologies.

PC-4 **Behavior of Damaged Sites Introduced by SEGR in Silicon Carbide Power MOSFETs**

Y. Nakada[1], S. Kuboyama[1], E. Mizuta[1], H. Shindou[1], A. Takeyama[2], T. Ohshima[2]
1. JAXA, Japan
2. National Institutes for Quantum and Radiological Science and Technology, Japan

It was found that the behavior of damage sites introduced by SEGR in SiC vertical power MOSFETs were essentially different from the one observed in corresponding Si devices, although the electrical behavior was similarly modeled.

PC-5 **Comparative Analysis of Upset-Multiplicity Occurrences due to Flash X-rays and Pulsed Neutrons in Commercial SRAMs**

C. Qi[1], W. Chen[2], Y. Wang[1], G. Wang[2], R. Li[2], X. Bai[2], X. Jin[2]
1. Peking University, China
2. Northwest Institute of Nuclear Technology, China

Upset bursts in 65-nanometer commercial SRAMs due to flash X-rays and pulsed neutrons are successfully distinguished from the experimental point of view, by an approach of analyzing upset-multiplicity occurrences.

PC-6 **SEU Prediction for Very Integrated Circuits based on Advanced Physical Considerations**

N. Rostand[1], G. Hubert[1], S. Martinie[2]
1. ONERA, France
2. CEA/LETI, France

Charge deposit morphology and advanced physical features are part of the new challenges in SET modelling for SEU prediction. In this paper, we address them with a novel simulation flow.

PC-7 **Standard Verification Flow Compatible Layout-Aware Fault Injection Technique for Single Event Effects Tolerant ASIC Design**

I. Danilov[1], A. Khazanova[1], A. Balbekov[1], M. Gorbunov[1]
1. Scientific Research Institute of System Analysis, Russian Academy of Sciences (SRISA), Russian Federation

We propose a layout-aware fault injection technique for Single Event tolerant integrated circuits design. Being fully compatible with standard verification flow, the proposed technique is applied to AES crypto cores implemented with TMR.

PC-8 **Engineering TID modeling for the SEE and performances evaluations of integrated CMOS circuits at cryogenic temperatures**

L. Artola[1], S. Ducret[2], G. Hubert[1]
1. ONERA, France
2. Sofradir, France

This paper presents a TID modeling approach based on Cobalt60 irradiations of CMOS transistors. The TID models were developed for the investigation of logic and sequential gates performances (SEE and delay) at cryogenic temperatures.

PC-9 **Analysis of Radiation-induced SETs in 3D VLSI Face-to-Back LUTs**

L. Sterpone[1], L. Bozzoli[1], C. De sio[1], B. Du[1], S. Azimi[1]
1. Politecnico di Torino, Italy

In this work we propose a new method for evaluating the radiation-induced Single Even Transients on 3D FPGA's Look-Up Table. Experimental analysis performed on a 15-nm 3D LUT provide effective static and dynamic error rate.

PC-10 **A Statistical Method for MCU Extraction Without Layout Information**

X. Wang[1], L. Ding[1], Y. Luo[1], W. Chen[1], F. Zhang[1], X. Guo[1]
1. Northwest Institute of Nuclear Technology, China

A statistical method was proposed to extract physical LSBs and MCUs from SEU data without layout information. Application of the method on a SRAM demonstrated its effectiveness to extract the shapes and rates of MCUs.

PC-11 **New Approach of Single Event Latchup Modeling Based on TCAD Simulations and Design of Experiment Analysis**

D. Truyen[1], L. Montagner[1]
1. MICROCHIP, France

This work presents a predictive SEL modeling based on physical simulations and DOE analysis. The model is built from layout and process inputs and evaluates SEL risk by estimating the LET threshold and holding voltage

PC-12 **A mathematical model to predict microprocessors fault tolerance under proton and neutron irradiation**

L. Reyneri[1], A. Serrano-cases[2], Y. Morilla[3], S. Cuenca-asensi[2], A. Martínez-Álvarez[2]
1. Politecnico di Torino, Italy
2. University of Alicante, Spain
3. Centro Nacional de Aceleradores (Universidad de Sevilla, CSIC, JA), Spain

Mathematical model to predict microprocessors fault tolerance under accelerated radiation campaigns. Model built using radiation data from CNA's Cyclotron (Spain) and LANSCE (USA). An ARM-SoC device were used to assess the model over different applications.

PC-13L **Measurement of Single-Event Upsets in 65-nm Bulk SRAMs Under Irradiation of Spallation Neutrons at J-PARC MLF**

J. Kuroda[1], S. Manabe[1], Y. Watanabe[1], K. Ito[2], L. Wang[3], M. Hashimoto[2], S. Abe[4], M. Harada[5], K. Oikawa[5], Y. Miyake[6]

1. Department of Advanced Energy Engineering Science, Kyushu University, Japan
2. Department of Information System Engineering, Osaka University, Japan
3. Department of Information System Engineering, Osaka University and is currently with School of Systems Engineering, Kochi University of Technology, China
4. Research Group for Radiation Transport Analysis, Japan Atomic Energy Agency, Japan
5. Materials and Life Science Division, J-PARC Center, Japan
6. The Muon Science Laboratory, High Energy Accelerator Research Organization (KEK) and the Materials and Life Science Division, Japan Proton Accelerator Research Complex Center, Muon Section, Japan

A neutron irradiation test of 65-nm bulk SRAMs was performed using the spallation neutron source at J-PARC MLF. The experimental SEU data were compared with our previous data measured at different neutron source facilities.

12:30 **LUNCH** - *Level 3*

14:00 **SESSION A**
BASIC MECHANISMS OF RADIATION EFFECTS
Chairs: Christophe Inguimbert (ONERA) & Yago Gonzalez Velo (ASU)

A-1 **TID Mechanisms and Low-frequency Noise in 28 nm MOSFETs Irradiated to Ultra-high Doses**
14:05

S. Bonaldo[1], S. Mattiazzo[1], C. Enz[2], A. Baschirotto[3], D. Fleetwood[4], A. Paccagnella[1], S. Gerardin[1]

1. University of Padova, Italy
2. EPFL - Ecole Polytechnique Fédérale de Lausanne, Switzerland
3. University of Milano Bicocca, Italy
4. Vanderbilt University, USA

TID mechanisms at ultra-high doses are investigated in 28 nm pMOSFETs and nMOSFETs through DC and low-frequency noise measurements. The TID sensitivity depends on channel-length, channel-width, and bias condition.

A-2 **TID Response of PMOS Bulk Si FinFETs: Bias, Fin Width and Orientation Dependence**
14:20

Z. Ren[1], X. An[1], G. Li[1], G. Chen[1], M. Li[1], G. Yu[2], Q. Guo[2], X. Zhang[1], R. Huang[1]

1. Peking University, China
2. Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, China

The TID response of PMOS bulk Si FinFETs with two fin widths and two orientation is experimentally investigated under four irradiation bias conditions. The bias and orientation dependence of TID response are demonstrated firstly.

A-3 **The Sensitive Region of Displacement Damage in LPNP induced by Various Charged Particles**
14:35

X. Li[1], J. Yang[1], P. Li[1], X. Sun[1], L. Dong[1]

1. Harbin Institute of Technology, China

The sensitive region of displacement damage in LPNP induced by various charged particles was investigated. Experimental results show that the displacement damage can be equivalent based on the radiation sensitive region of Si/SiO2 interface.

POSTER PAPERS

PA-1 **Simulation of Single Particle Displacement Damage in Si1-xGex alloys – Interaction of Primary Particles with the Material and Generation of the Damage Structure**

T. Jarrin[1], A. Jay[2], M. Raine[1], N. Mousseau[3], A. Hémeryck[4], N. Richard[1]
1. CEA, DAM, DIF, France
2. ISAE-SUPAERO, Université de Toulouse, France
3. Université de Montréal, Canada
4. LAAS/CNRS, France

Primary interaction simulation with neutrons and collision cascades starting with Si and Ge Primary Knock-On Atoms are performed on Si1-xGex alloys using Monte-Carlo (MC) and Molecular dynamics (MD) codes.

PA-2 **Comparison of X-Ray and Proton Irradiation Effects on the Characteristics of InGaN/GaN Multiple Quantum Wells Light Emitting Diodes**

L. Wang[1], B. Li[1], X. Zhang[1], N. Liu[2], Q. Yuan[3], N. Liu[4], M. Liu[1], B. Li[1], J. Gao[1], Y. Huang[1], J. Yang[5], X. Li[5], J. Luo[1], Z. Han[1], X. Liu[1]
1. Key Laboratory of Silicon Device Technology, Institute of Microelectronics, Chinese Academy of Sciences, China
2. Guangdong Institute of Semiconductor Industrial Technology, Guangzhou, Guangdong 510650, China
3. Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China
4. Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China
5. Harbin Institute of Technology, Harbin city, China

Different from proton, X-ray irradiation increased the external quantum efficiency of GaN-LEDs from original 56.7% to 61.8%. ABC model fittings revealed the Shockley-Read-Hall and radiative recombination rates were both found to be improved after irradiation.

PA-3 **Effect of Low Temperatures Irradiation on NPN Bipolar Junction Transistors**

J. Dardié[1], J. Boch[2], A. Michez[2], C. Guasch[2], S. Bouisri[2], F. Saigné[2], F. Bezerra[3], J. Favre[4]
1. TMI-Orion & IES, France
2. IES, University of Montpellier, France
3. CNES, France
4. TMI-Orion, France

The effect of dose on NPN bipolar junction transistors is investigated for irradiation performed at low temperatures. Degradation of forward-Gummel curves and current gain is shown and discussed in terms of physical mechanisms.

PA-4 **Impact of High-Energy Proton Irradiation on MoS2 Films and Its Field Effect Transistors**

H. Zhu[1], L. Wang[1], J. Shi[1], X. Huang[1], Z. Zheng[1], G. Xiong[1], B. Li[1], J. Luo[1], Z. Han[1], X. Liu[1]
1. Institute of Microelectronics, Chinese Academy of Sciences, China

Sulfur vacancies introduced by proton irradiation in MoS2 film cause multilayer MoS2 to be decoupled, resulting in a indirect-to-direct bandgap transition. Unlike the irradiation-introduced interface states, sulfur vacancies can improve the performance of MoS2 devices.

PA-5 **Proton Effect Test Compare to ZnO Thin Film Transistors with Different Active Layer Structures**

Y. Kim[1], J. Jeong[2], G. Lee[2]
1. KOMAC, Korea, Republic of
2. Chungnam National University, Korea, Republic of

We investigated the ZnO TFTs with different structures of active layer after high dose proton irradiation. For the ZnO NRs, an anomalous hump was disappeared, and their performance was dramatically improved than the ZnO film.

PA-6 **Mutual Influence Mechanism of Displacement Damage and Total Ionizing Dose Effect of Lateral PNP Bipolar Transistors**

Y. Liu[1], C. He[2], W. Chen[3], C. Wang[3], X. Jin[3], X. Bai[3], J. Li[3]
1. Northwest Institute of Nuclear Technology; Xi'an Jiaotong University, China
2. Xi'an Jiaotong University, China
3. Northwest Institute of Nuclear Technology, China

The interaction between DD effect and TID effect of GCLPNP transistors is studied by neutron and gamma irradiation experiments with different sequences. The mechanisms of the effects are explored by charge separation methodology on GCLPNPs.

PA-7 **Estimation of Residual Radionuclides Induced Electron Radiation Damage in SiC after HANARO Neutron Irradiation**

K. Lee[1], B. Park[1]
1. Korea Atomic Energy Research Institute, Korea, Republic of

The DPA value for SiC is calculated by using PHITS code to estimate the electron radiation damage, based on the radioactivity data of neutron induced residual radionuclides in SiC after irradiation with HANARO neutrons.

PA-8 **Modeling Radiation Damage to Pixel Sensors in the ATLAS Detector**

J. Zahreddine[1]
1. Laboratoire de Physique Nucleaire et de Hautes Energies (LPNHE), Sorbonne University, Paris-Diderot Sorbonne Paris Cite, CNRS/IN2P3, France

A model of pixel digitization is presented including radiation damage effects to the ATLAS pixel sensors. Thorough description of setup, and predictions for basic pixel cluster properties, alongside early studies with LHC Run-2 proton-proton collision data are presented.

PA-9 **A Direct Evidence of the Annealing Effect of Ionization Damage on Displacement Damage in NPN Transistors**

J. Yang[1], G. Lv[1], L. Dong[1], X. Li[1]
1. Harbin Institute of Technology, China

In this paper, based on the sequential irradiation of 40 MeV Si ions and Co-60 gamma ray, a direct evidence of the annealing effect of ionization damage on displacement damage in NPN transistors is investigated.

PA-10L **A Theoretical Approach for Analyzing Radiation Effects in Si/SiO2 MOSFETs**

N. Harmon[1], S. Mcmillan[2], J. Ashton[3], M. Flatté[2], P. Lenahan[3]
1. University of Evansville, USA
2. University of Iowa, USA
3. Pennsylvania State University, USA

Near zero-field magnetoresistance (NZFMR) spectroscopy has potential for providing chemical/physical information on radiation damage in 3D integrated circuits. We model NZFMR in Si/SiO2 MOSFETs by including spin-dependent recombination and hyperfine interactions in stochastic Liouville equations.

14:50 **SESSION E**
PHOTONICS, OPTOELECTRONICS & SENSORS
Chairs: Matthieu Beaumel (SODERN) & Jeffrey Warner (NRL)

E-1 **Combined temperature and radiation effects on radiation sensitive single-mode optical fibers**
14:55 C. Campanella[1], A. Morana[1], S. Girard[2], A. Guttilla[3], F. Mady[3], M. Benabdesselam[3], H. Desjonqueres[4], C. Monsanglant-Louvet[4], C. Balland[4], E. Marin[2], Y. Ouerdane[2], A. Boukenter[2], S. Lesoille[5]
1. Laboratoire Hubert Curien, France
2. Université de Saint Etienne, France
3. Université de Nice, France
4. Institut de Radioprotection et de Sûreté Nucléaire, France
5. Agence Nationale pour la gestion des Déchets Radioactifs, France
We analyzed the simultaneous response to radiation and temperature exposure of radiation-sensitive optical fibers in the framework of the CERTYF project in order to build a predictive model based on intrinsic and extrinsic optical parameters.

E-2 **Radiation-response of Fiber Bragg Gratings at Low Temperatures**
15:10 A. Morana[1], S. Girard[1], E. Marin[1], L. Lablonde[2], T. Robin[3], M. Lancry[4], A. Boukenter[5], Y. Ouerdane[1]
1. Université Jean Monnet, France
2. iXblue, France
3. iXblue, Finland
4. Institut de Chimie Moléculaire et des Matériaux d'Orsay, Université Paris Sud, France
5. Université Jean Monnet, France
The radiation-resistance of different types of gratings was investigated at -120°C up to the accumulated dose of 100 kGy(SiO2). The temperature sensitivity of these gratings was evaluated at low temperatures, before and after irradiation.

15:25 **BREAK**

E-3 **Simulating charge deposition by cosmic rays inside astronomical imaging detectors**
15:55 D. Lucsanyi[1], T. Prodhomme[1]
1. ESA, ESTEC, Netherlands
Accurate and fast modelling of spurious images generated by solar and galactic cosmic rays in imaging detectors is critical for Space Astronomy missions. We present a novel cosmic ray model validated against test data.

E-4 **Annealing effects on Radiation hardened CMOS Image Sensors Exposed to Ultra High Total Ionizing Doses**
16:10 H. Dewitte[1], S. Rizzolo[1], P. Paillet[2], F. Corbiere[1], R. Molina[1], A. Chabane[1], P. Magnan[1], S. Girard[3], A. Boukenter[3], T. Allanche[3], C. Muller[3], C. Monsanglant-louvet[4], M. Osmond[4], H. Desjonqueres[4], J. Mace[5], P. Burnichon[6], J. Baudu[6], A. Saraviaflores[7], S. Catherin[7], V. Goiffon[1]
1. ISAE-SUPAERO, France
2. CEA, France
3. Université de Lyon, France
4. IRSN, France
5. AREVA, France
6. OPTSYS, France
7. Andra, France
We discuss the annealing effects and degradation on CMOS image sensors (CIS) after total ionizing doses of up to 1 MGy(SiO2), through the analysis of the CIS electronics behaviors and the dark current evolutions.

E-5 16:25 **Displacement damage effects in InGaAs photodiodes produced by electrons, protons and neutrons irradiations**

C. Inguimbert[1], T. Nuns[1], J. Barbero[2], J. Moreno[3], S. Ducret[4], A. Nedelcu[4], B. Galnander[5], E. Passoth[5]
1. ONERA, France
2. ALTER, Spain
3. ALTER TECHNOLOGY, Spain
4. SOFRADIR, France
5. The Swetberg Laboratory, Sweden

Different InGaAs photodiodes have been irradiated with electrons, protons, neutrons and gamma. The increase of the dark current has been analyzed and the damage factors have been compared with the NIEL scaling.

E-6 16:40 **High Displacement Dose Effects in Radiation Hardened CMOS Image Sensors**

S. Rizzolo[1], A. Le Roch[1], F. Corbiere[1], P. Paillet[2], M. Gaillardin[2], P. Magnan[1], V. Goiffon[1]
1. ISAE SUPAERO, France
2. CEA, France

MGy radiation tolerant CIS are exposed to neutron fluences beyond 1014 cm-2 and their performance characteristics are studied to evaluate the capability of this technology to be used in a high displacement damage dose environment.

E-7 16:55 **Phosphorus Versus Arsenic: Role of the Photodiode Doping Implant in CMOS Image Sensor Dark Current and Random Telegraph Signal.**

A. Leroch[1], C. Virmontois[2], P. Paillet[3], J. Belloir[2], P. Magnan[4], V. Goiffon[4]
1. ISAE-SUPAERO /CNES, France
2. CNES, France
3. CEA, France
4. ISAE-SUPAERO, France

Proton irradiations on shallow-Arsenic and deep-Phosphorus photodiodes based CMOS Image Sensors have been performed. Results suggest that Phosphorus-based implant does not play a major role in radiation-induced dark current increase and RTS.

POSTER PAPERS

PE-1 **Combined effect of radiation and temperature: towards optical fibers suited to distributed sensing in extreme radiation environments**

G. Melin[1], A. Barnini[1], A. Morana[2], S. Girard[2], P. Guitton[1], R. Montron[1]
1. iXblue, France
2. Laboratoire Hubert Curien - Université Jean Monnet, France

Combined effect of gamma-rays irradiation (1 to 10 MGy) and temperature (up to 250°C) is evaluated on RIA and strength of polyimide coated pure silica core single-mode fibers fabricated from MCVD and SPCVD deposition techniques

PE-2 **Steady State X-ray radiation responses of Optical Fibers at Room and Liquid Nitrogen Temperatures**

A. Morana[1], V. De michele[1], C. Campanella[1], J. Vidalot[1], A. Alessi[1], A. Boukenter[1], M. Cannas[2], Y. Ouerdane[1], P. Paillet[3], N. Richard[3], T. Robin[4], S. Girard[5]
1. Laboratory Hubert Curien, France
2. University of Palermo, Department of Physics and Chemistry - Emilio Segré, Italy
3. CEA, France
4. iXblue, France
5. Université de Saint Etienne, France

We characterize the response, under continuous X-ray irradiation, of fibers representative of the most common types of optical fibers, diversified by the composition. The on-line RIA spectra were recorded at room and liquid nitrogen temperatures.

PE-3 **X-ray irradiation response of antireflection coatings**

C. Muller[1], T. Allanche[2], A. Morana[2], P. Paillet[3], T. Lépine[2], A. Boukenter[2], Y. Ouerdane[2], S. Girard[4]
1. CEA, DIF / Laboratory Hubert Curien, France
2. Laboratory Hubert Curien, France
3. CEA, France
4. Université de Saint Etienne, France

In the domain of imaging in harsh environments, antireflection coatings increase the flux on the sensor. We studied the radiation response of such coatings under X-rays at the MGy level and showed no significant effect.

PE-4 **Abnormal photoresponse properties of hybrid perovskite photodetector induced by proton beam irradiation**

G. Xiong[1], Z. Qin[2], H. Zhu[1], S. Zhao[3], L. Wang[1], B. Li[1], X. Zhang[1], Z. Zheng[1], J. Gao[1], J. Yang[4], X. Li[4], B. Li[1], Y. Huang[1], J. Luo[1], Z. Han[1], X. Liu[1]
1. Institute of Microelectronics of Chinese Academy of Science, China
2. Key Laboratory of Luminescence and Optical Information, Ministry of Education, Institute of Optoelectronic Technology, Beijing Jiaotong University, China
3. Institute of Optoelectronic Technology, Beijing Jiaotong University, China
4. School of Materials Science and Engineering, Harbin Institute of Technology, China

Radiation effects on the electrical and optical properties of hybrid perovskite photodetectors were evaluated.An abnormal transient inverse current came out due to proton beam induced electron centers.Energy band model was established to reveal the mechanism.

PE-5 **Similarities between Heavy Ions and LASER tests in Back-Side Illuminated CMOS image sensor**

C. Virmontois[1], J. Belloir[1], A. Leroch[2]
1. CNES, France
2. *ISAE-SUPAERO /CNES, France*

This paper focuses on the similarities between heavy ions and LASER tests to evaluate single event effect in back-side illuminated CMOS image sensor using last generation imaging process.

PE-6 **Several-Mrad(Si) total ionization dose effect on backside-illuminated CMOS image sensors**

X. Zhang[1], Y. Li[1], Q. Guo[1], L. Wen[1], J. Feng[1], L. Ma[1], T. Wang[1], Y. Cai[1], Z. Wang[1], B. Liu[1]
1. Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, China

Due to some novel oxide structures in BSI CISs, they may behave different degradation effects. Several-Mrad(Si) ionizing experiment has been carried out on BSI CIS along with parameter tests before and after the irradiation experiment.

PE-7 **Proton Irradiation Effects on the Static and Dynamic Characteristics of GaN-based Blue Light Emitting Diodes for Space Light Communication**

L. Wang[1], B. Li[1], J. Wang[2], X. Guan[3], X. Zhang[1], N. Liu[2], Z. Gong[2], Z. Wei[3], H. Zhu[1], N. Liu[4], B. Li[1], J. Gao[1], Y. Huang[1], M. Liu[1], J. Yang[5], X. Li[5], J. Luo[1], Z. Han[1], X. Liu[1]
1. Key Laboratory of Silicon Device Technology and Institute of Microelectronics, Chinese Academy of Sciences, China
2. Guangdong Institute of Semiconductor Industrial Technology, Guangdong Academy of Sciences, Guangzhou, China
3. Laboratory of Nanophotonic Functional Materials and Devices, Laboratory of Quantum Information Technology, South China Normal University, Guangzhou, China
4. Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China
5. School of Materials Science and Engineering, Harbin Institute of Technology, Harbin, China

Although light-output power of GaN-LEDs decreased after proton irradiation, the 3dB bandwidth was improved beyond 16 times. Based on frequency response data, the competition between Shockley-Read-Hall and radiative recombination process was enhanced by proton irradiation.

17:10 End of Tuesday Sessions

18:30-21h30 **INDUSTRIAL EXHIBIT RECEPTION**
Antigone Hall, Level 2

Pasteur Auditorium, Level 1

08:30 **INVITED TALK**

Mars missions and the search for traces of life missions

Sylvestre Maurice, IRAP

The Martian program has evolved considerably in recent years. First designed to look for traces of water in all its forms, it is now interested in the past habitability of the red planet.

To date, we have 6 active orbiters (NASA/Odyssey-MRO-MAVEN, ESA/MEx-TGO, ISRO/Mangalyaan), 1 geophysical rover (NASA/Curiosity) and very recently a lander (NASA/Insight) equipped with a seismometer. On this momentum, 3 new rovers (NASA, ESA, CNSA) are under construction for launch in July 2020 and even an orbiter (Emirates). These new rovers will study potential traces of life. One of them by NASA will even prepare samples that may one day be brought back to Earth, as the community has wanted for years. We are living in a wonderful time! We will explain the recent challenges of Mars exploration and this incredible international organization, made up of competition and collaboration.

Dr. Sylvestre MAURICE is a planetary scientist at IRAP (Institut de recherche en astrophysique et planétologie), Toulouse, France. He is an expert in magnetospheric observations and surface composition, from purely scientific data modeling and interpretation, to building instruments.

His research on neutron spectroscopy in collaboration with an international team led to important discoveries of water deposits at the lunar poles (1998), at the equator of Mars (2004), and at the poles of Mercury (2012).

He is co-PI of the first laser induced breakdown spectroscopy instrument ChemCam on the Curiosity rover which discovered Mars past habitability (2014), Co-PI of the first CW-Raman in space onboard the ESA ExoMars rover, co-PI of the first pulse-Raman, ground-NIR experiments, as part of the SuperCam package on the future Mars NASA rover. Author of more than 150 publications.

09:30 **SESSION B**

RADIATION EFFECTS ON DEVICES & ICS

Chairs: Alain Michez (Université de Montpellier) & Hipolito Guzman (Universidad de Sevilla)

B-1 **Total Dose Effects on Negative and Positive Low-Dropout Linear Regulators**

09:35 A. Privat[1], P. Davis[1], H. Barnaby[1], P. Adell[2]

1. ASU, USA

2. NASA JPL, USA

Total ionizing dose functional failure analysis on positive and negative voltage regulators is performed. Different failure mechanisms are observed that can be explained through electrical simulations. Experimental data and electrical simulations are provided.

B-2 09:50 **Radiation-induced point- and cluster-related defects in epitaxial silicon pad diodes irradiated with different particle types and fluences**

Y. Gurimskaya[1], I. Mateu[1], M. Moll[1], L. Makarenko[2], E. Fretwurst[3], I. Pintilie[4]
1. CERN, Switzerland
2. Department of Applied Mathematics, Belarusian State University, Belarus
3. University of Hamburg Institute for Experimental Physics, Germany
4. National Institute of Material Physics, Romania

A consistent quantitative description of radiation-induced degradation on p-type Silicon detectors is conducted within CERN RD50 collaboration. Present contribution summarizes obtained results for epitaxial thin pad diodes irradiated with protons, neutrons and gamma rays.

B-3 10:05 **Temperature Response on NPN and PNP Bipolar Junction Transistors after Total Ionizing Dose Irradiation Exposure**

A. Privat[1], H. Barnaby[1], B. Tolleson[1], M. Kiraneswar[1], P. Adell[2]
1. ASU, USA
2. NASA JPL, USA

A temperature-dependent analytical model for TID-induced excess base current in BJTs is proposed for implementation in SPICE circuit simulators. Model captures base current evolution with temperature after irradiation. Simulations show good correlation with experimental results.

B-4 10 :20 **Proton Irradiation Test on a Piezoelectric Actuator**

P. Serrano gálvez[1], S. Solis paiva[1], E. Guillermain[1], M. Butcher[1], M. Di castro[1], A. Masi[1]
1. CERN, Switzerland

A Proton Irradiation Test up to 2MGy and 1.14e16 p/cm^2 fluence on a piezoelectric actuator used for Crystal Collimation is presented. The results show an impedance increase of <25% and a free-stroke reduction of <25%.

10:35 **BREAK**

B-5 11:05 **Effects of Total Ionizing Dose on Transient Radiation Upset sensitivity of 40-180nm SRAMs**

J. Li[1], R. Li[1], W. Chen[1], C. He[2], G. Wang[1], C. Qi[1], Y. Liu[1], X. Jin[1], C. Wang[1], X. Bai[1]
1. Northwest Institute of Nuclear Technology, China
2. Xian Jiaotong University, China

The synergistic effects of total ionizing dose on transient radiation upset sensitivity of SRAMs with three distinct technology nodes from sub-micrometer to nano-meter was investigated by using Co-60 gamma rays and pulsed X-ray.

B-6 11:20 **DCR degradation probability in CMOS SPADs exposed to a non-monochromatic neutron source**

L. Ratti[1], P. Brogi[2], G. Collazuol[3], G. Dalla betta[4], A. Ficorella[4], P. Marrocchesi[2], F. Morsani[5], L. Pancheri[4], G. Torilla[1], C. Vacchi[1]
1. Università di Pavia, Italy
2. Unievrsità di Siena, Italy
3. Università di Padova, Italy
4. Unviersità di Trento, Italy
5. INFN, Italy

A model for the probability of neutron-induced DCR increase in CMOS SPADs fabricated in 180 nm and 150 nm technology is evaluated through comparison with experimental data obtained with a non-monochromatic source.

B-7 11:35 **Highlight of Total Ionizing Dose Effects on a RF Front-end by means of Microwave Nonlinear Characterization**

S. Jarrix[1], L. Chusseau[1], J. Raoult[1], J. Boch[1], T. Maraine[1]
1. IES, University of Montpellier, France

The measurement of the reflected IM3 tone at the input of an RF front-end is shown to be an interesting tool for predicting dysfunctionalities in high frequency circuits with respect to TID.

B-8 11:50 **Effects of Total Ionizing Dose on I-V and Low Frequency Noise characteristics in advanced Si/SiGe:C Heterojunction Bipolar Transistors**

J. El Beyrouthy[1], A. Vauthelin[1], M. Seif[1], B. Sagnes[1], F. Pascal[1], A. Hoffmann[1], M. Valenza[1], J. Boch[1], T. Maraine[1], S. Haendler[3], A. Gauthier[2], P. Chevalier[2], D. Gloria[2]

1. IES, University of Montpellier, France
2. STMicroelectronics, France

This study presents an investigation of the dose response of Si/SiGe HBTs developed with the last generation of BiCMOS technologies. DC electrical characterization and low-frequency noise measurements are carried out to evaluate the post-radiation degradations

B-9 12:05 **Investigation of transient radiation effects in GaAs field effect transistors under pulse ionization**

I. Metelkin[1], V. Elesin[1], A. Kuznetsov[1], N. Usachev[1]

1. National Research Nuclear University MEPhI, Russian Federation

Measurements and numerical simulation results of GaAs MESFET and PHEMT response to transient irradiation for different bias conditions are presented. Specific bias conditions and ionization levels were found for detail investigation of radiation effects origin.

POSTER PAPERS

PB-1 **Radiation Hardness of GaN HEMTs to TID Effects: COTS for harsh environments**

A. Vilas Bôas[1], M. De Melo[1], R. Santos[1], R. Giacomini[1], N. Medina[2], L. Seixas[3], S. Finco[3], F. Palomo[4], A. Romero-Maestre[4], M. Guazzelli[5]

1. FEI - Fundação Educacional Inaciana Padre Sabóia de Medeiros, Brazil
2. IFUSP, Brazil
3. CTI, Brazil
4. Universidad de Sevilla, Spain
5. Centro Universitário FEI, Brazil

GaN-COTS transistors were exposed to TID effects by X-rays. Characteristic curves were performed in the On- and Off-state. Switching and temperature tests indicate the GaN is tolerant to TID effects and candidate to harsh invironments.

PB-2 **Effect of Proton Irradiation Energy on AlGaN/GaN HEMTs fabricated by Ion-implanted Isolation**

D. Kim[1], J. Lee[2], J. Kim[2], J. Lee[1], J. Lee[2]

1. Korea Atomic Energy Research Institute, Korea, Republic of
2. Kyungpook National University, Korea, Republic of

The effect of proton irradiation energy on AlGaN/GaN HEMTs fabricated by Ar ion-implanted isolation was evaluated.

PB-3 **High-fluence proton induced radiation effects on the AlGaN/GaN high-electron-mobility transistors**

S. Yue[1], Z. Lei[1], J. Wang[2], Y. En[1], X. Zhong[2], C. Peng[1], Z. Zhang[1], Y. Wang[1]

1. China Electronic Product Reliability and Environmental Testing Research Institute, China
2. School of Materials Science and Engineering, Xiangtan University, China

The electrical characteristics and low-frequency noise (LFN) behavior of AlGaN/GaN high-electron-mobility transistors after 3MeV proton irradiation up to a total dose of 5.0×10 14 p/cm 2 have been investigated in this paper.

PB-4 **Total-ionizing-dose Effects in InGaAs MOSFETs with High-k Gate Dielectrics and InP Substrates**

S. Bonaldo[1], E. Zhang[2], S. Zhao[2], V. Putcha[3], B. Parvais[3], D. Linten[3], S. Gerardin[1], A. Paccagnella[1], R. Reed[2], R. Schrimpf[2], D. Fleetwood[2]

1. University of Padova, Italy
2. Vanderbilt University, USA
3. Imec, Belgium

Total-ionizing-dose response is evaluated for InGaAs MOSFETs at several channel lengths and under different biases. Radiation-induced degradation mechanisms are investigated through DC static measurements and low-frequency noise measurements.

PB-5 **TID test results of radiation hardened SiC MOS structures**

V. Cantarella[1], F. Pintacuda[1], S. Massetti[2], M. Muschitiello[2]
1. St Microelectronics, Italy
2. European Space Agency - ESTEC, Netherlands

This paper describe the results about TID test related to SiC PowerMosfet structures. This study shall be considered as preparatory work supporting the planned development of discrete European radiation-hardened SiC powerMOSFETs for space applications.

PB-6 **Combined Effects of Tantalum Ion and Gamma Ray Irradiations on MOS Devices with Atomic Layer Deposited Al2O3 Gate Dielectrics**

Z. Zheng[1], H. Zhu[1], X. Chen[1], L. Wang[1], B. Li[1], J. Gao[1], D. Li[1], J. Luo[1], Z. Han[1], J. Liu[2]
1. Institute of Microelectronics of Chinese Academy of Sciences, China
2. Institute of Modern Physics, Chinese Academy of Sciences, China

MOS devices with Al2O3 dielectrics are irradiated sequentially using gamma rays and 1907 MeV tantalum ions, and the combined irradiation effects on the Al2O3 based MOS devices are investigated and the mechanism is analyzed.

PB-7 **Radiation-induced Degradation Mechanism in Double-SOI pMOSFETs**

Y. Huang[1], F. Liu[1], B. Li[1], B. Li[2], J. Gao[1], L. Wang[2], X. Su[1], H. Liu[1], Z. Han[1], J. Luo[1]
1. IMECAS, China
2. Institute of Microelectronics, Chinese Academy of Sciences, China

A significant degradation of drain current in Double-SOI pMOSFET is observed after irradiation. The degradation mechanism is analyzed by extracting the related parameters from Y-function. Impact of negative SOI bias on parameter degradation is investigated.

PB-8 **Analysis of Total Dose Effects on a PDSOI n-channel High Voltage Transistor for Analog Applications**

F. Perez[1], F. Saigne[2], A. Michez[2], S. Furic[3], E. Leduc[3], F. Malou[4], J. Boch[2], A. Touboul[2], F. Wrobel[2]
1. CNES/MICROCHIP/University of Montpellier, France
2. IES, University of Montpellier, France
3. MICROCHIP, France
4. CNES, France

In this paper, TID irradiations have been performed on a PDSOI n-channel High Voltage transistor for analog applications. ECORCE TCAD modeling software is used to qualitatively analyze and model the physical processes at play.

PB-9 **TID-Induced Breakdown Voltage Degradation in Uniform Doping and Linear Variable Doping SOI p-LDMOSFETs**

L. Shu[1], Y. Zhao[2], L. Wang[3], K. Zhao[4], X. Zhou[4], K. Galloway[5], C. Liu[6], W. Cao[3], C. Sui[3], W. Chen[6], L. Xiao[6], X. Luo[7], Y. Li[8], T. Wang[6]
1. Harbin Institute of Technology, China
2. HIT & BMTI, China
3. BMTI, China
4. UESTC, China
5. Vanderbilt, USA
6. HIT, China
7. UT, China
8. BJUT, China

The BVDS for UD and LVD SOI p-LDMOSFETs is examined after exposure to TID. Results show BVDS degradation with accumulated dose. TCAD simulation is used to gain insight into the mechanism causing BVDS degradation.

PB-10 **Threshold Voltage Shift Saturation in P-Channel Power MOSFET's under X-ray Irradiation**

F. Principato[1], M. Muschitiello[2], C. Poivey[2], A. Costantino[2], V. Cantarella[3], L. Abbene[1], F. Pintacuda[3]
1. Dipartimento Fisica e Chimica-Palermo University, Italy
2. ESA, Netherlands
3. St Microelectronics, Italy

This paper reports on saturation of the threshold voltage shift of P-channel Power MOSFET's irradiated with X-ray radiation. This effect is not present under 60Co radiation.

PB-11 **Pulsed X-ray irradiation response in the linear voltage regulator LM7805 : before and after TID accumulation**

R. Li[1], C. He[2], C. Wang[1], W. Chen[1], J. Li[1], X. Jin[1], C. Qi[1], X. Bai[1], Y. Liu[1], G. Wang[1]
1. Northwest Institute of Nuclear Science and Technology, China
2. Xian Jiaotong University, China

Linear voltage regulators LM7805 are irradiated in a Co-60 unit and subsequently irradiated in a pulsed X-ray radiation. The differences in the pulsed-irradiation response before and after the total ionizing dose (TID) accumulation are analyzed.

PB-12L **Radiation Testing of the IDE3380 SiPM Readout ASIC**

T. Stein[1], A. Fredriksen[2], J. Holter[2], P. Oya[2], K. Roed[3], D. Meier[2]
1. IDEAS / University of Oslo, Norway
2. IDEAS, Norway
3. University of Oslo, Norway

The IDEAS IDE3380 mixed-signal SiPM readout ASIC and ADC technology for space in AMS 0.35um CMOS shows no relevant change below 340 krad(Si) TID, no latch-up below 137 MeV.cm2/mg, and no SEU/SETs below 18 MeV.cm2/mg.

12:20 **LUNCH** - *Level 3*

13:30 **WOMEN IN ENGINEERING** - *Barthez room, Level 2*
Networking Coffee & Invited Talk
Nathalie Pelletier, Local Network for Women Business Leadership

14:10 **SESSION I**
FACILITIES AND DOSIMETRY
Chairs: Jean-Marie Lauenstein (NASA GSFC) & Nancy Postiau (Université Catholique de Louvain)

I-1 **Characterizing High-energy Ion Beams with PIPS Detectors**
14:15

M. Bagatin[1], V. Ferlet-Cavrois[2], S. Gerardin[3], M. Muschitiello[2], A. Paccagnella[1], A. Costantino[2], G. Santin[2], C. Boatella-Polo[2], R. Garcia Alia[4], P. Fernandez Martinez[4], M. Kastriotou[4]
1. University of Padova, Italy
2. ESA, Netherlands
3. DEI - Padova University, Italy
4. CERN, Switzerland

We measured high-energy ion beams using a Passivated Implanted Planar Silicon (PIPS) detector. The importance of accounting for secondaries production in the packaging materials and the presence of items in the beam is highlighted.

I-2 **On-Chip Total Ionizing Dose Digital Monitor in Fully-Depleted SOI Technologies**
14:30

F. Abouzeid[1], V. Bertin[1], G. Gasiot[1], G. Lallement[1], C. Lecat-Mathieu de Boissac[1], V. Malherbe[1], D. Soussan[1], J-L. Autran[2], P. Roche[1]
1. STMicroelectronics, France
2. IM2NP, France

This paper presents a digital dosimeter for on-chip total ionizing dose computation. It was designed and fabricated in 28nm and 22nm Fully-Depleted SOI technologies, and experimentally validated with X rays, gamma rays and alpha particles.

I-3 14:45 **Fast Neutron Production at Particle Accelerators for Radiation Hardness Assurance Tests**

P. Casolaro[1], L. Campajola[2]
1. Istituto Nazionale di Fisica Nucleare (INFN) - Section of Napoli, Italy
2. Università di Napoli Federico II and INFN-Napoli, Italy

The fast neutron production was carried out with MeV-protons on a lithium target. The modulation of the target thickness and proton current and energy allow production of neutron spectra for DDD and SEE tests.

POSTER PAPERS

PI-1 **Remote Measurements of X-rays Dose Rate using a Cerium-doped Air-clad Optical Fiber**

J. Bahout[1], Y. Ouerdane[2], H. El hamzaoui[1], G. Bouwmans[1], M. Bouazaoui[1], A. Cassez[1], K. Baudelle[1], R. Habert[1], A. Boukenter[2], S. Girard[2], B. Capoen[1]
1. Laboratoire PhLAM-Université de Lille, France
2. Université de Saint Etienne, France

We designed and fabricated a cerium-doped air-clad optical fiber for ionizing radiations dosimetry. We demonstrate that X-rays dose rates can be measured using this active microstructured fiber in an all-fibered remote configuration.

PI-2 **Dosimetric characterization of an irradiation set-up for electronic components testing at the TOP-IMPLART proton linear accelerator**

G. Bazzano[1], A. Ampollini[1], F. Cardelli[1], E. Cisbani[2], P. Nenzi[1], L. Picardi[1], M. Piccinini[1], C. Ronsivalle[1], C. De angelis[2], S. Delle monache[2], A. Mastrandrea[3], L. Blasi[4], F. Menichelli[4], F. Vigli[4], M. Olivieri[4], G. Palmerini[4], M. Sabatini[4]
1. ENEA Frascati, Italy
2. Istituto Superiore di Sanità, Italy
3. Università di Bologna, Italy
4. Sapienza Università di Roma, Italy

This contribution describes the irradiation set-up for electronic and space components testing with pulsed 30 MeV proton beam of high instantaneous dose rate provided by the TOP-IMPLART linear accelerator at ENEA Frascati Research Centre

PI-3 **Design of 3-D scintillator detector for Compton imaging based on laser engraving**

J. Zhang[1], X. Pang[1], L. Shuai[1], H. Tang[1], B. Feng[1], D. Li[1], Z. Zhang[1], L. Wei[1]
1. Beijing Engineering Research Center of Radiographic Techniques and Equipment, Institute of High Energy Physics, Chinese Academy of Sciences, China

A 3-D scintillator detector pixelated by sub-surface laser engraving in the depth direction is proposed for Compton imaging, which shows good capabitity on detection efficiency, energy resolution and angle resolution.

PI-4 **Investigation of TSL properties of potential fibered-OSL dosimeter materials**

M. Benabdesselam[1], F. Mady[1], A. Guttilla[1], W. Blanc[1], H. El hamzaoui[2], M. Bouazaoui[2], N. Al helou[2], J. Bahout[2], G. Bouwmans[2], B. Capoen[2]
1. INPHYNI Université Côte d'Azur, France
2. PhLAM, Université de Lille, France

We report on TSL properties of two doped sol-gel silica glasses. By comparing their performances like sensitivity and karma response, it is shown that they constitute potential candidates for both TSL and OSL dosimetry applications.

PI-5 **Influence of temperature and electrical modes on radiation sensitivity and errors of RADFETs**

B. Podlepetsky[1], V. Pershenkov[2], A. Bakerenkov[2], V. Felitsyn[2], A. Rodin[2]
1. MEPhI, Russian Federation
2. NRNU MEPhI, Russian Federation

Influence of temperature and electrical modes on errors and radiation sensitivity of dose senor based on n-MOSFET have been investigated. Proposed models interpreting the experimental data can be used to predict performances of MOSFET-based dosimeters.

PI-6 **Irradiation facilities within the PAC-G: from atmospheric to space applications**

M. Letiche[1], R. Varela della giustina[1], U. Köster[1], E. Capria[2], M. Baylac[3], M. Cheymol[3], J. Guillermin[4], N. Chatry[4], F. Bezerra[5], J. Beaucour[1]

1. ILL, France
2. ESRF, France
3. LPSC, France
4. TRAD, France
5. CNES, France

The Platform for Advanced Characterization of Grenoble (PAC-G) is offering world unique and complementary techniques for HiRel components characterization. Among them low and high-energy neutron SEU testing, preliminary and/or selective heavy ion tests.

PI-7 **Upgrade of Low Flux Proton Irradiation Facility for Radiation Effect Test at KOMAC**

Y. Kim[1], S. Yun[1], Y. Song[1], H. Kim[1], H. Kwon[1], K. Kim[1], Y. Cho[1]

1. KOMAC, Republic of Korea

A new low flux proton irradiation facility is being upgrade with new beam diagnostics and new control system interface in order to efficient beam tuning process and the details will be given in this study.

PI-8L **Longitudinal direct ionization impact of Heavy Ions on SEE testing for Ultra-High Energies**

V. Wyrwoll[1], R. Garcia alia[1], K. Roed[2], C. Cazzaniga[3], M. Kastriotou[4], P. Fernandez martinez[1], F. Cerutti[1]

1. CERN, Switzerland
2. University of Oslo, Norway
3. STFC, United Kingdom
4. CERN, France

Ultra High Energy (UHE) Heavy Ions (HI) have various advantages for modern SEE testing. This work is dedicated to the longitudinal energy deposition mechanisms in silicon by mentioned HI beams while traversing through material

15:00 **POSTER SESSION**

Chair: Florent Miller (Nucletudes)

17:30 End of Wednesday Sessions

Pasteur Auditorium, Level 1

08:30 **INVITED TALK**

30 years of parabolic flights at CNES

Sébastien Rouquette, CNES

Aircraft parabolic flights are a useful tool for performing short duration scientific and technological experiments in reduced gravity. Together with drop towers, sounding rockets, the International Space Station (ISS) and other manned and unmanned spacecraft, aircraft parabolic flights with the Airbus A310 ZERO-G completes the set of flight research opportunities for European scientists.

The principal value of parabolic flights is twofold: firstly, in conducting verification tests prior to space experiments in order to improve their quality and success rate, and after a space mission to confirm or invalidate (sometimes conflicting) results obtained from space experiments; and secondly, in providing a flying laboratory in which the gravity level can be modified, producing, at a relatively low cost, scientific results for experiments operated by the scientists themselves and for which the microgravity duration and levels are adequate. Aircraft parabolic flights are the only flight opportunity beside ISS and Chinese spacecraft where medical research on human test subjects can be performed in weightlessness.

Sébastien Rouquette is engineer at CNES (Centre National d'Etudes Spatiales), the French Space agency. He joined the CNES in 2000, after a PhD in astrophysics and planetology. Between 2000 and 2010, he took part in the design and preparation of several space missions in astrophysics and Earth observation.

Since 2011, he holds the position of parabolic flight project manager at CNES. He coordinates the selection of scientific experiments and oversees the organization of flight campaigns. He has accumulated more than 3000 parabolas which represent more than 15 hours of weightlessness. He is also involved on the program of discovery flights with AirZeroG since 2013 and acts as flight instructor since the beginning of these flights.

Sébastien is also part of the team in charge of the development and implementation of experiments in the International Space Station (ISS). He provided experiments for the PROXIMA mission of astronaut Thomas Pesquet. As such, he was able to witness the departure of the French astronaut in space in the plains of Kazakhstan and contributed to the influence of the mission by regularly participating in media events. He is now involved in the preparation of the second mission of the French astronaut.

Also private pilot, glider instructor and scientific mediator for twenty years, in various non-governmental organizations, he shares his passion for science, the sky and space exploration, by giving courses or conferences.

09:30 **SESSION D**

SINGLE EVENT EFFECTS: DEVICES & ICS

Chairs: Anne Samaras (AIRBUS Defence & Space) & Farokh Irom (NASA-Jet Propulsion Laboratory)

D-1 **Reliability analysis of a 65nm Rad-Hard SRAM-Based FPGA for CERN applications**

09:35 G. Tsiligiannis[1], C. Debarge[2], J. Le Mauff[2], S. Danzeca[1], A. Masi[1]

1. CERN, Switzerland

2. NanoXplore, France

In this work, the effects of proton induced radiation on a 65nm Rad Hard SRAM-Based Field Programmable Gate Array (FPGA) are studied. Based on the presented results, the Reliability analysis of this device, is performed.

D-2 09:50

Analysis of SET propagation in a system in package point of load converter

T. Rajkowski[1], F. Saigné[2], V. Pouget[2], F. Wrobel[2], A. Touboul[2], J. Boch[2], P. Kohler[1], P. Dubus[1], P. Wang[1]
1. 3D-Plus, France
2. IES, University of Montpellier, France

Propagation of SETs in a point of load converter is shown to be dependent on the competition between the negative and positive part of the SET waveform. Results are analyzed and explained using Spice simulation.

D-3 10:05

Irradiation Test of 65-nm Bulk SRAMs with DC Muon Beam at RCNP-MuSIC Facility

T. Mahara[1], S. Manabe[1], Y. Watanabe[1], W. Liao[2], M. Hashimoto[2], T. Saito[3], M. Niikura[3], K. Ninomiya[4], D. Tomono[5], A. Sato[4]
1. Department of Advanced Energy Engineering Science, Kyushu University, Japan
2. Osaka University, Japan
3. Department of Physics, the University of Tokyo, Japan
4. the Graduate School of Science, Osaka University, Japan
5. Research Center for Nuclear Physics (RCNP), Osaka University, Japan

Reliable muon-induced SEU cross section for 65-nm bulk SRAM was measured taking advantage of a DC muon beam. Also, a muonic X-ray measurement was performed to investigate muon stopping positions in the device board.

D-4 10:20

Tradeoffs Between RF Performance and SET Robustness in Low-Noise Amplifiers in a Complementary SiGe BiCMOS Platform

A. Ildefonso[1], N. Lourenco[2], G. Tzintzarov[3], Z. Fleetwood[4], A. Khachatrian[5], S. Buchner[5], D. Mcmorrow[5], J. Warner[5], M. Kaynak[6], J. Cressler[1]
1. Georgia Institute of Technology, USA
2. Georgia Tech Research Institute, USA
3. Georgia Tech, USA
4. SpaceX, USA
5. Naval Research Laboratory, USA
7. IHP Microelectronics, Germany

The tradeoffs between RF performance and single-event transient robustness are explored in low-noise amplifiers designed in a complementary SiGe BiCMOS Platform.

D-5 10:35

Understanding the Impact of Binary Quantization on the Reliability of Convolutional Neural Networks on FPGAs

F. Libano[1], B. Wilson[2], M. Wirthlin[2], J. Brunhaver[1]
1. Arizona State University, USA
2. Brigham Young University, USA

Through extensive fault-injection experiments, we determine the reliability impact of applying binary quantization to convolutional layers of neural networks on FPGAs, by analyzing the relationships between resource utilization, error criticality and overall accuracy.

POSTER PAPERS

PD-1

Experimental investigation of SEUs Induced by Heavy Ions in 28-nm FDSOI SRAMs

J. Xu[1], Y. Guo[1], R. Song[1], Y. Chi[1], B. Liang[1], C. Hu[1], W. Qu[1]
1. College of Computer, National University of Defense Technology, Changsha, Hunan, China

We have performed an irradiation test of heavy ions. Linear energy transfer (LET), temperature, supply volt-age and body bias dependence of single event upset (SEU) cross section in 28-nm FDSOI SRAMs is investigated.

PD-2 **Assessment of Current Sensor on Chip for Detecting Neutron-Induced Transients via Body Terminals**

R. Possamai bastos[1], J. Dutertre[2], M. Trindade[1], R. Andreoni Camponogara Viera[2], O. Potin[2], S. Rey[3], B. Cheymol[3], M. Baylac[3]

1. Laboratoire TIMA, France
2. Ecole Nationale Supérieure des Mines de Saint-Etienne, France
3. LPSC, France

This work assesses for the first time a body built- in current sensor in a CMOS 65-nm test chip under neutron radiation and laser irradiation. The sensor is effective to detect transient faults induced from both.

PD-3 **Heavy Ions Testing of an All-Convolutional Neural Network for Image Classification Evolved by Genetic Algorithms and Implemented on SRAM-Based FPGA**

F. Benevenuti[1], I. Lopes[1,4], F. Lima Kastensmidt[1], N. Added[2], V. P. Aguiar[2], N. H. Medina[2], M. Guazzelli[3], V. Pouget[4], K. Roed[5]

1. Universidade Federal do Rio Grande do Sul (UFRGS), Brazil
2. Universidade de São Paulo (USP), Brazil
3. Centro Universitário da FEI (UNIFEI), Brazil
4. IES, University of Montpellier
5. University of Oslo, Norway

This work investigates the vulnerability of an image classification engine under heavy-ions accelerated irradiation. The engine is based on all-convolutional neural-network trained with the GTSRB traffic sign recognition benchmark and embedded into 28nm SRAM-based FPGA.

PD-4 **Simultaneous Single Event Transient (SET) observation on Majority Voter design based on LM139A Quad Voltage Comparators**

S. Morand[1], C. Binois[1], H. Claret[1], K. Kruckmeyer[2], R. Mangeret[1], M. Marin[1], G. Salvaterra[1], D. Staerk[3]

1. Airbus Defence And Space, France
2. Texas Insruments, USA
3. Tesat-Spacecom, Germany

The LM139A majority voter design is identified as sensitive to Simultaneous SETs. Either internal charge sharing or input coupling lead to the function failure. Root cause analysis and mitigation technics are extensively discussed.

PD-5 **Impact of Tensor Cores and Mixed-Precision on the Reliability of Matrix Multiplication in GPUs**

P. Basso[1], F. Santos[1], P. Rech[1]

1. UFRGS, Brazil

We investigate the impact of tensor cores and mixed precision in GPUs reliability. We show that low precision operations are more reliable and tensor core increases the amount of data correctly produced by the GPU.

PD-6 **Inherent Uncertainty in the Determination of Multiple Event Cross Sections in Radiation Tests**

F. Franco[1], J. Clemente[1], G. Korkian[1], J. Fabero[1], H. Mecha[1], R. Velazco[2]

1. Universidad Complutense de Madrid, Spain
2. Universite Grenoble-Alpes, CNRS, France

In radiation experiments with too many bitflips, accidentally nearby flipped cells can be misled with a multiple event. In this summary, a general method to determine the expected number of false events is developed.

PD-7 **Single Event Upsets under 14-MeV Neutrons in a 28-nm SRAM-based FPGA in Static Mode**

J. Fabero[1], H. Mecha[1], F. Franco[1], J. Clemente[1], S. Rey[2], B. Cheymol[2], M. Baylac[2], G. Hubert[3], R. Velazco[2]

1. Universidad Complutense de Madrid, Spain
2. Université Grenoble-Alpes, CNRS, France
3. ONERA French Aerospace Laboratory, France

A sensitivity characterization of a Xilinx Artix-7 FPGA against 14.2 MeV neutrons is presented. Errors in flip-flops, BRAMs and configuration memory, and the applicability of statistical methods for extracting MCUs on this device are discussed.

PD-8 **Reliability analysis of an Ethernet-based solution for data transmission in the CERN radiation environment**

G. Gnemmi[1], G. Tsiligiannis[1], A. Masi[1], S. Danzeca[1]
1. CERN, Switzerland

At CERN the necessity for a communication link reliable under radiation and compatible with a wide range of devices has prompted to the qualification of an Ethernet based solution.

PD-9 **Vertical Line Fault Mechanism Induced by Heavy Ions in an SLC NAND Flash**

V. Gupta[1], A. Bosser[2], L. Matana luza[3], D. Söderström[4], A. Javanainen[4], H. Kettunen[4], J. Praks[2], K. Voss[5], A. Virtanen[4], L. Dilillo[3]
1. ESA/ESEC, Belgium
2. Aalto University, Finland
3. LIRMM, France
4. University of Jyväskylä Physics Department, Finland
5. GSI Helmholtzzentrum für Schwerionen-forschung, Germany

The vertical line fault mechanism occurring in NAND flash devices under heavy-ion irradiation is described in detail. The location where the fault is generated as well as the recovery sequence are identified.

PD-10 **Evaluating Soft-Core RISC-V Processor in SRAM-based FPGA under Radiation Effects**

A Oliveira[1], F. Benevenuti[1], L. Contreras[1], F. Limakastensmidt[1], N. Added[2], V. Aguiar[2], N. Medina[2], M. Silveira[3]
1. UFRGS, Brazil
2. USP, Brazil
3. Centro Universitario da FEI, Brazil

This work evaluates the susceptibility of RISC-V processor embedded into SRAM-based FPGA through heavy ions and accumulated fault injection experiments. Results demonstrated the RISC-V outcomes are improved three times by combining mitigation techniques.

PD-11 **Impact of Incident Angle on Negative Muon-induced SEU Cross Section of 65-nm Bulk SRAM**

W. Liao[1], M. Hashimoto[2], S. Manabe[3], Y. Watanabe[3], S. Abe[4], M. Tampo[5], S. Takeshita[5], Y. Miyake[5]
1. Kochi University of Technology, Japan
2. Osaka University, Japan
3. Kyushu University, Japan
4. Japan Atomic Energy Agency, Japan
5. High Energy Accelerator Research Organization (KEK), Japan

65-nm bulk SRAMs were irradiated with negative muons at vertical and tilt direction to investigate the angular dependence on SEU cross section. Results show tilt irradiation leads to higher peak energy and different voltage dependence.

PD-12 **Heavy-Ion Induced Single-Event Upset Response for Flip-Chip Packaged SRAM Device in 14-nm Bulk FinFET Technology**

M. Lihua[1], Z. Zhang[2], B. Ye[1], J. Liu[1], T. Tong[3]
1. the institute of modern physics, Chinese Academy of Sciences, China
2. the Science and Technology on Reliability Physics and Application Technology of Electronic Component Laboratory, China
3. the Institute of High Energy Physics, Chinese Academy of Sciences, China

Experiment and simulation for flip-chip packaged SRAM device in 14-nm Bulk FinFET Technology suggest MCU is the dominant factor affecting the upset cross-section and the concept of effective LET may inapplicable in 3-D structure device.

PD-13 **CLASS: on-Chip Lightweight Accurate SEU/SET event claSSifier**

S. Thomet[1], S. De-Paoli[1], F. Ghaffari[2], F. Abouzeid[1], O. Romain[2], P. Roche[1]
1. STMicroelectronics, France
2. ETIS UMR 8051 ENSEA, France

This paper presents an on-chip error classifier for Soft-Error Rate characterization of cells under radiations. Implemented on top of flip-flop chains, it counts Single-Event Upset and Single-Event Transient at mission profile.

PD-14 **Towards a Characterization of Vulnerability of XCR4C ASIC on Heavy-Ion Induced Transient Events**

B. Li[1], B. Lu[2], H. Jia[2], Y. Chen[2], W. Wei[2], F. Zhang[1], Z. Su[1], J. Gao[1], C. Wang[1], W. Zhao[1], H. Liu[1]
1. Institute of Microelectronics, Chinese Academy of Sciences, China
2. Institute of High Energy Physics, Chinese Academy of Sciences, China

Transients with durations of dozens of seconds in a rad-hard four-channel CDS ASIC (XCR4C) for X-ray CCD were observed during 181Ta31+ ions irradiation and were attributed to the complementary feedback mechanism in the bias circuit.

PD-15L **SEU Experimental Evaluation of 15-MeV Protons on a COTS SRAM at Low Bias Voltage**

M. Rezaei[1], F. Franco[1], J. Fabero[2], H. Mecha[2], Y. Morilla[3], P. Martinholgado[3], H. Puchner[4], G. Hubert[5], J. Clemente[3]
1. Universidad Complutense de Madrid, Spain
2. Complutense University of Madrid, Spain
3. CNA, Spain
4. Cypress Semiconductor, Technology R&D, USA
5. ONERA, France

An experimental study on the sensitivity of 65-nm COTS SRAM to 15-MeV proton radiation at low-bias voltages in static and dynamic modes is presented. SBUs and mostly vertical shape MCUs were observed at various voltages.

10:50 **BREAK**

11:15 **SESSION F**
HARDENING TECHNIQUES
David Truyen (MICROCHIP) & Cristina Plettner (ESA)

F-1 **Evaluation of Soft-Error Tolerance by Neutrons and Heavy Ions on Flip Flops with Guard Gates in a**
11:20 **65 nm Thin BOX FDSOI Process**

M. Ebara[1], K. Yamada[1], K. Kojima[1], Y. Tsukita[1], J. Furuta[1], K. Kobayashi[1]
1. Kyoto Institute of Technology, Japan

We evaluated soft-error tolerance by neutrons and heavy ions on four types of flip flops. We revealed that the guard-gate structure has high soft-error tolerance by low-LET heavy ions.

F-2 **New Single Event Transient phenomenon in 28FDSOI and its impact on hardening**
11:35

G. Gasiot[1], F. Abouzeid[1], V. Malherbe[1], J. Damiens[1], F. Monsieur[1], C. Lecat-Mathieu de Boissac[1], D. Soussan[1], V. Lorquet[1], T. Thery[1], P. Roche[1]
1. STMicroelectronics, France

A novel Single Event Transient mechanism is measured for the first time in FDSOI28 technology. Associated detection mechanism and impact on radiation hardening are discussed.

F-3 **SE Response of Guard-Gate FF in 16-nm and 7-nm Bulk FinFET Technologies**
11:50

J. Cao[1], L. Xu[1], B. Bhuva[1], S. Wen[2], C. Cazzaniga[3], C. Frost[4]
1. Vanderbilt University, USA
2. cisco, USA
3. STFC, United Kingdom
4. ISIS Neutron and Muon Facility, United Kingdom

SER of Guard-Gate Flip-Flop and D-FF is evaluated at 16nm and 7nm nodes. Heavy-ion and alpha test results show GG-FF have significant improvement of SER. The number of short SET pulses is also estimated.

F-4 12:05 **Error Detection and Mitigation of Data-Intensive Microprocessor Applications using SIMD and Trace Monitoring**

M. Peña-Fernandez[1], A. Lindoso[2], L. Entrena[2], M. Garcia-valderas[2]
1. Arquimea Ingenieria SLU, Spain
2. Universidad Carlos III, Spain

This work proposes a novel software error mitigation approach using SIMD coprocessor to accelerate computation over redundant data, combined with Trace Monitoring for control-flow error detection. The proposed approach was tested with neutron radiation.

12:20 **LUNCH** – *Level 3*

F-5 14:00 **An Approximate Error-Detection Technique for Multi-Core Real-Time Systems**

G. Rodrigues[1], A. Oliveira[1], I. Lopes[2], V. Pouget[2], A. Bosio[3], F. Lima Kastensmidt[1]
1. UFRGS, Brazil
2. IES, University of Montpellier, France
3. Ecole Centrale de Lyon - Lyon Institute of Nanotechnology, France

This paper presents a parallel error detection method evaluated using laser fault injection on a dual-core ARM processor. It exploits approximation to improve performance. Results are satisfactory, especially with algorithms that are not memory intensive.

F-6 14:15 **A Multi-objective Optimization Framework to Design Soft-Error-Immune Circuit**

Y. Li[1], J. Han[1], Y. Han[1], X. Zeng[1]
1. Fudan University, China

With the help of neural network algorithm and NSGA-II algorithm, this study investigates a multi-objective optimization model as a guidance on Soft-Error-Immune circuit design to explore a trade-off between power, area and Soft Error Rate.

F-7 14:30 **A Low-Overhead Radiation Hardening Approach using Approximate Computing and Selective Fault Tolerance Techniques at the Software Level**

A. Aponte-Moreno[1], F. Restrepo-calle[1], C. Pedraza[1]
1. Universidad Nacional de Colombia, Colombia

This paper presents a method to reduce execution time overheads in the design of radiation-induced fault-tolerant systems by means of Approximate Computing and selective FT software techniques. A case study for MSP430 microcontroller is presented.

POSTER PAPERS

PF-1 **Configuration Memory Scrubbing of the Xilinx Zynq-7000 FPGA using a Mixed 2-D Coding Technique**

V. Vlagkoulis[1], A. Sari[1], J. Proko[1], D. Zografakis[1], M. Psarakis[1], A. Tavoularis[2], G. Furano[2], C. Boatella-polo[2], C. Poivey[2], V. Ferlet-Cavrois[2], M. Kastriotou[3], P. Fernandez Martinez[3], R. Garcia Alia[3]
1. University of Piraeus, Greece
2. European Space Agency, ESTEC, Netherlands
3. European Organization for Nuclear Research (CERN), Switzerland

The paper presents a configuration memory scrubbing approach for the Xilinx Zynq-7000 devices. It combines the embedded ECC code of the FPGA and an interframe, interleaved parity scheme to form a mixed two-dimensional coding scheme.

PF-2 **Experiment and Simulation on Single-Event Transient Effects of the MOS Capacitor in LDO**

C. Sui[1], Y. Zhao[1], W. Cao[1], L. Wang[1], X. Han[1], J. Liu[1], L. Shu[2], T. Li[1]
1. Beijing Microelectronics Technology Institute, China
2. Electronic Science and Technology Department, Harbin Institute of Technology, China

Performance of a RHBD LDO is verified by experiments. According to the experimental results of LDOs, a novel SET sensitive mechanism of compensation MOS capacitor is found and the mitigation method is proposed.

PF-3 **Self-robust Non-Volatile C-element for Single Event Upset enhanced tolerance**

O. Coi[1], G. Di Pendina[2], G. Prenat[2], L. Torres[3]
1. INAC-SPINTEC CEA/CNRS/UGA/INP- CNES-LIRMM/CNRS/University of Montpellier, France
2. INAC-SPINTEC CEA/CNRS/UGA/INP, France
3. LIRMM CNRS-University of Montpellier, France

The first radiation hardened Non Volatile C-element is presented. This state holding circuit reduces the counting of sensitive nodes while addressing the undesirable MTJ switching issue. Immunity against SEU of around 300 fC has achieved

PF-4 **An open source embedded-GPGPU model for the accurate analysis and mitigation of SEU effects**

B. Du[1], E. Rodriguez[1], M. Sonza Reorda[1], L. Sterpone[1]
1. Politecnico di Torino, Italy

In this paper, we propose a new hardware and synthesizable model of an embedded General Purpose Graphic Processing Unit (GPGPUs) designed for analyzing and mitigating radiation effects. Comparative SEU injection experiments confirms the model effectiveness.

PF-5 **Exploiting Transistor Folding Layout as RHBD technique against Single-Event Transients**

Y. Quadros de Aguiar[1], F. Wrobel[1], J. Autran[2], F. Kastensmidt[3], P. Leroux[4], F. Saigné[1], V. Pouget[1], A. Touboul[1]
1. Université de Montpellier, IES - UMR UM/CNRS 5214, France
2. Aix-Marseille University, France
3. UFRGS, Brazil
4. KU Leuven University, Belgium

This work analyzes the efficiency of transistor folding combined with diffusion splitting in improving the Single-Event Transient robustness of digital circuits. Results show that these techniques can reduce cross-section and increase threshold Linear Energy Transfer.

PF-6 **Circuit-Level Hardening Techniques to Mitigate Soft Errors in FinFET Logic Gates**

A. Lackmann zimpeck[1], L. Artola[2], G. Hubert[2], C. Meinhardt[3], F. Lima Kastensmidt[1], R. Reis[1]
1. UFRGS, Brazil
2. ONERA, France
3. UFSC, Brazil

Transistor reordering and insertion of decoupling cells are explored to reduce the SE susceptibility of circuits designed in FinFET technology. This work shows that robustness improves up to 37% and 10% with the respective methodologies.

PF-7 **LVDS Transmitter for Cold-Spare Systems in High Flux Environments**

T. Yoshikawa[1], A. Aoyama[1], T. Iwata[1], K. Kobayashi[2]
1. Toyama Prefectural University, Japan
2. Kyoto Institute of Technology, Japan

LVDS Transmitter (TX) has been proposed for cold-spare systems. A test-chip of the TX shows remarkable suppression of BER degradation compared to commercial device in 10 times higher flux environment of 84Kr17+.

PF-8 **Radiation hardened analog-to-digital convertor with automatic offset voltage compensation**

V. Felitsyn[1], A. Bakerenkov[1], A. Zhukov[1], V. Butuzov[1], Y. Bocharov[1], V. Pershenkov[1], A. Rodin[1], V. Telets[1], V. Belyakov[1]
1. National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Russian Federation

Radiation hardened ADC with automatic offset voltage compensation was developed. TID radiation effect in the ADC was investigated. Developed device can be considered as a good technical decision for self-diagnostic systems of satellites and spacecrafts.

PF-9 **Displacement Damage Effects Mitigation Approach for HBT RF Frequency Synthesizers**

D. Sotskov[1], V. Elesin[1], A. Kuznetsov[1], N. Zhidkov[1], I. Metelkin[1], K. Amburkin[1], D. Amburkin[1], N. Usachev[1], D. Boychenko[1]

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

This paper was focused on the design issues of RF bipolar ICs for extreme environment applications. Design approach for RF bipolar ICs based on specialized HBT macro-models and hardening techniques was presented and carried out.

PF-10L **Improving Selective Fault Tolerance in GPU Register Files by Relaxing Register Criticality**

M. Goncalves[1], I. Lamb[1], R. Brum[1], J. Azambuja[1]

1UFRGS, Brazil

This paper uses an approximate computing perspective to relax register criticality in order to improve selective fault tolerance techniques. Results show that our approach reduces replicated registers by an average 42.4%, maintaining 100% fault coverage.

14:45 **RADIATION EFFECTS DATA WORKSHOP**

Chairs: Philippe Adell (NASA JPL) & Geraldine Chaumont (STMicroelectronics)

DW-1 **Photonic 5 Gbps and 10 Gbps Transceiver Radiation Test Summary**

R. Logan[1], D. Basuita[2]

1. Glenair, USA

2. Glenair Ltd., United Kingdom

Radiation test results for 5Gbps and quad-channel 10Gbps VCSEL-based optical transceivers are presented including SEL, heavy-ion and proton SEE, and TID data for the 5Gbps; and SEL and heavy-ion SEE for the 10Gbps device.

DW-2 **Mixed-Field Radiation Qualification of a COTS Space On-Board Computer along with its CMOS Camera Payload**

A. Coronetti[1], F. Manni[2], J. Mekki[2], D. Dangla[2], C. Virmontois[2], N. Kerboub[2]

1. CERN, France

2. CNES, France

The system-level radiation characterization of a full space COTS-based system in mixed-field environment is presented. The critical functional aspects affecting system reliability are analyzed and predictions and actions for meeting the RHA objectives are highlighted.

DW-3 **Application of effective LET approach for modern CMOS devices**

D. Bobrovsky[1], A. Akhmetov[1], A. Smolin[1], A. Chumakov[1]

1. NRNU MEPHI/SPELS, Russian Federation

Applicability of effective LET concept to SEU testing of modern CMOS devices was investigated. Heavy ion irradiations of two 28nm FPGAs were performed for a wide range of LET values and angles of incidence

DW-4 **Total Ionizing Dose and Single-Events characterization of Xilinx 20nm Kintex UltraScale™**

P. Maillard[1], J. Barton[1], M. Hart[1]

1. XILINX Inc., USA

This paper examines the total ionizing dose (TID), single event upset (SEU) and latchup (SEL) response of Xilinx 20nm Kintex UltraScale™ for space applications. The Single Event Mitigation IP tool SEU response is also evaluated.

DW-5 **Single Event Effect Characterization of the GR740 Rad-Hard Quad-Core LEON4FT System-on-Chip**

L. Tambara[1], F. Hernandez[1], F. Sturesson[1], M. Hjorth[1], J. Andersson[1], R. Weigand[2]
1. Cobham Gaisler, Sweden
2. ESA, Netherlands

This work presents the SEE characterization of the Cobham Gaisler's GR740 SoC. The low rate of functional errors recorded in application-level testing under irradiation demonstrates the effectiveness of the radiation-hardening scheme selected for this device.

DW-6 **SEE & TID characterization for a GHz class PowerPC rad tolerant microprocessor – PC8548E (Jan. 2019)**

M. Ball[1], Y. Rialland[1], O. Bonnet[1], T. Guillemain[1]
1. Teledyne e2v, France

The PC8548E GHz class PowerPC rad tolerant microprocessor using the CMOS 90nm SOI technology from NXP, has successfully passed the TID test up to 100KRad and the Heavy Ions test (SEL immunity up to 86MeV).

DW-7 **Reliability of a DLS 3D scanner system in the radiotherapy environment**

S. Cotta[1], R. Höfling[1]
1. ViALUX Messtechnik+Bildverarbeitung GmbH, Germany

The radiation-hardness of a 3D scanner system for radiotherapy is evaluated during a radiation test at a nuclear reactor. The reliability of the Direct-Link-Sensor (DLS) has been investigated after high levels of irradiation.

DW-8 **Radiation Effects (Single Event Effects and Total Ionization Dose) on Commercial-Off-The-Shelf DDR3 SDRAM for ESA JUICE Mission**

B. Tanios[1], F. Tilhac[1], F. Lochon[1], O. Perrotin[1], P. Fontana[1], B. Forgerit[1], F. Guerre[1], C. Poivey[2]
1. Hirex Engineering, France
2. ESA, Netherlands

This work presents a comparative study of Total Ionization Dose (TID) and Single Event Effects (SEE) radiation sensitivity of three commercial DDR3 SDRAM memories for the ESA JUpiter ICy moons Explorer (JUICE) Mission.

DW-9 **Radiation Tolerance of RHBD techniques on a SiGe BiCMOS 350 nm ASIC technology**

S. Chen[1], D. Prêle[1], F. Voisin[1], P. Laurent[1], A. Goldwurm[1]
1. AstroParticle and Cosmology Laboratory, France

This paper presents radiation tolerance evaluation of an ASIC with RHBD techniques based on a SiGe BiCMOS 350nm techonology. The TID and SEL have been tested, and hardened ability of our design are discussed.

DW-10 **2019 Compendium of Recent Test Results of Single Event Effects Conducted by the Jet Propulsion Laboratory's Radiation Effects Group**

G. Allen[1], S. Vartanian[1], F. Irom[1], S. Guertin[1], A. Bozovich[1], S. Zajac[1], W. Parker[1], P. Adell[1], A. Daniel[1], M. O'Connor[1]
1. NASA JPL, USA

This paper reports heavy ion, proton, and pulsed-laser induced SEE results for a variety of microelectronics targeted for possible use in JPL spacecraft. The compendium covers devices tested within from August 2017 through March 2018.

DW-11 **SEE Responses of Mos-SiC, Mos-Si and SiC Mosfet**

F. Pintacuda[1], S. Massetti[2], M. Muschitiello[2], A. Javanainen[3], V. Cantarella[1]
1. STMicroelectronics, Italy
2. ESA-ESTEC, Netherlands
3. University of Jyvaskyla, Finland

This paper report the SEE results measured on Mos-SiC, Mos-Si and SiC Mosfet. The goal of this study is to characterize SiC oxides gate as one of the key factors for rad-hard SiC MOSFET development.

DW-12 **Total Ionizing Dose Characterization of 28 nm PolarFire SONOS-based FPGA**

N. Rezzak[1], J. Wang[1], A. Cai[1], F. Hawley[1], E. Hamdy[1]
1. Microchip, USA

This paper presents Total Ionizing Dose (TID) results on 28nm PolarFire™ SONOS-based FPGA. Gamma and X-ray induced TID effects at the device and product level are presented and discussed.

DW-13 **TID Radiation Effects of 1Gb COTS NOR Flash Memories for the ESA JUICE Mission**

S. Vargas-Sierra[1], B. Tanios[2], J. González-luján[1], F. Tilhac[2], M. Domínguez[1], C. Poivey[3]
1. Alter Technology, Spain
2. Hirex, France
3. ESTEC (TEC-QEC), European Space Agency, Netherlands

This work presents the comparative study of the TID radiation sensitivity of three COTS NOR Flash memories for the ESA JUpiter ICy moons Explorer (JUICE) Mission.

DW-14 **Stuck and Weakened SDRAM Cells due to Heavy-Ion Irradiation**

D. Soderstrom[1], L. Matana luza[2], A. Bosser[3], T. Gil[2], K. Voss[4], H. Kettunen[5], A. Javanainen[5], L. Dilillo[2]
1. University of Jyväskylä, Finland
2. Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM), France
3. Aalto University School of Electrical Engineering, Finland
4. GSI Helmholtzzentrum für Schwerionenforschung, Germany
5. RADEF, Finland

Stuck and weakened bits in the ISSI 512 Mb SDRAM has been investigated in irradiation experiments with a heavy ion microbeam in the GSI facility.

DW-15 **Radiation characterization of COTS MicroSD Memories for CERN applications**

G. Piscopo[1], C. Mcallister[1], G. Tsiligiannis[1], S. Danzeca[1], A. Masi[1]
1. CERN, Switzerland

The sensitivity of several MicroSD Cards under the harsh radiation environment of the Large Hadron Collider (LHC) at CERN is analysed in this paper. The radiation effects of each MicroSD Card will be presented.

DW-16 **Compendium of Radiation-Induced Effects on µProcessors for CERN applications**

G. Tsiligiannis[1], A. Masi[1], S. Danzeca[1]
1. CERN, Switzerland

In this paper, we analyze the sensitivity of four ARM-based microprocessors under Proton induced radiation. The purpose of the study is to explore the reliability limitations of these devices under the CERN radiation environment.

DW-17 **Single event sensitivity and de-rating of SiC power devices to heavy ions and protons**

M. Steffens[1], S. Hoeffgen[1], T. Kündgen[1], E. Paschkowski[1], M. Poizat[2], D. Wölk[1]
1. Fraunhofer INT, Germany
2. ESA, Netherlands

We present SEE tests on SiC devices. The data were taken across four campaigns at UCL, GANIL, H8 beamline at CERN and protons at the research centre Jülich. Significant derating is required across all LETs.

DW-18 **Single Event Effects by atmospheric neutrons in commercial (COTS) normally-off GaN HEMTs**

D. Wölk[1], S. Hoeffgen[1], E. Paschkowski[1], M. Steffens[1]
1. Fraunhofer INT, Germany

We present the results of SEE testing of COTS high power normally-off GaN-devices with an atmospheric-like neutron spectrum. Three different designes of GaN-HEMTs an one SiC-MOSFET were tested at different voltages and crossections were determined.

DW-19 **Voltage Supervisors Post Heavy Ion Irradiation Behavior After Holding in SEL**

S. Vorobiev[1], O. Bakhirko[1], L. Bakirov[1], P. Chubunov[1], V. Anashin[1], A. Koziukov[1], S. Iakovlev[1]
1. Branch of JSC URSC-ISDE, Russian Federation

In this study we performed the radiation tests on the TPS3305-18DGN and MAX6755UKLD3+T voltage supervisors to characterize its resistance to heavy ion irradiation.

DW-20 **SEE Test Results for different analog, digital-analog and digital devices various integration levels**

A. Kalashnikova[1], P. Chubunov[1], S. Iakovlev[1], A. Koziukov[1], T. Maksimenko[1], V. Lykov[1], K. Bu-khasan[1], T. Napolova[1], S. Kolpachkov[1], I. Maslennikova[1], N. Bondarenko[1], M. Vyrostkov[1], L. Arutyunyan[1], Y. Gladysheva[1], V. Kovtun[1], M. Shekhovtsov[1], A. Klyayn[1], L. Bakirov[1], N. Zakharenkova[1], P. Kurkova[1], S. Vorobiev[1], O. Bakhirko[1]
1. Branch of Joint - Stock Company "United Rocket and Space Corporation"- "Institute of Space Device Engineering" (Branch of JSC URSC - ISDE), Russian Federation

The paper presents heavy-ion test results of different devices for a wide temperature range. LET thresholds for SET, SEL, Supply voltage Safe Operating Area and Destructive Failure have been obtained.

DW-21 **Total Dose and Single-Event Effects Test Results of the Intersil ISL7x814SEH High Current Driver**

W. Newman[1], N. Van vonno[2], L. Pearce[2], E. Thomson[2], A. Robinson[2], D. Turner[2]
1. Renesas Electronics America, USA
2. Renesas, USA

We report the results of total ionizing dose (TID) and destructive and nondestructive single-event effects (SEE) testing of the Intersil ISL72814SEH and ISL73814SEH radiation hardened, high-voltage, high-current, driver circuits.

DW-22 **Characterizing Neutron-Induced SDC Rate of Matrix Multiplication in Tesla P4 GPU**

K. Ito[1], W. Liao[1], M. Hashimoto[1], J. Kuroda[2], S. Manabe[2], Y. Watanabe[2], S. Abe[3], M. Harada[3], K. Oikawa[3], Y. Miyake[4]
1. Osaka University, Japan
2. Kyushu University, Japan
3. Japan Atomic Energy Agency, Japan
4. High Energy Accelerator Research Organization, Japan

This work experimentally investigates neutron-induced SDC rate in matrix multiplication on Nvidia Tesla P4. Results indicate the hardware resource that is not disclosed to GPU users contributes to more than half of overall SDC rate.

DW-23 **TID Test Results of LVDS Driver and Receiver ICs with Extended Common Mode Capability**

Y. Tcherniavskaya[1], V. Burkhay[1], A. Rocke[1], V. Shunkov[1], F. Gerfers[2]
1. Space IC GmbH, Germany
2. Technical University of Berlin, Germany

This report provides results of TID robustness tests of LVDS driver and receiver. 56 krad (Si) hardness with full performance has been achieved. With certain limitations circuits are working up to 100 krad (Si).

DW-24 **Measuring SER and NBTI by Neutron Irradiation Between Volatile SRAM-based and Nonvolatile Flash-based FPGAs**

Y. Kawano[1], Y. Tsukita[1], J. Furuta[1], K. Kobayashi[1]
1. Kyoto Institute of Technology, Japan

We compared the SRAM-based and flash-based FPGAs to investigate their radiation hardness. Those results show that in the SRAM-based FPGA must be rebooted or configuration memory must be refreshed more frequently than the flash-based one.

TECHNICAL PROGRAM - THURSDAY

DW-25 **SAMV71RT 32-bits ARM® Cortex®-M7 Microcontroller Total Ionizing Dose and Single Effects performances**

B. Treuillard[1]

1. Microchip Technology Nantes, France

The subject is based on SAMV71RT Cortex® M7 radiation tolerant product addressing New Space requirements. This document proposes the description of the device capability against radiation environment. The poster describes TID and Heavy ions results

DW-26L **Total Ionizing Dose Characterization of Microchip Programmable Current Limiting Power Switch LX7712**

M. Sureau[1], M. Leuenberger[2], N. Rezzak[2], D. Johnson[2]

1. Microsemi, USA

2. Microchip, USA

The total ionizing dose characterization results of the Microchip radiation hardened programmable current limiting power switch IC, the LX7712, are presented.

DW-27L **SRAM-Based FPGA: High Dose Test Methods Using Evaluation Boards**

S. Vartanian[1], G. Allen[1], D. Thorbourn[1]

1. Jet Propulsion Laboratory, USA

We present low-cost and effective methods and results for high levels of Total Ionizing Dose testing performed on the Xilinx Kintex UltraScale (20nm) Field-Programmable Gate Array evaluation board using 60Co and 2 MeV electron sources.

DW-28L **Characterisation of the DARE180U MOSFET Channel Geometry TID Radiation Sensitivity**

R. Jansen[1], B. Glass[1], C. Boatella_polo[2], G. Thys[3], S. Verhaegen[3], G. Franciscatto[3], J. Wouters[3], D. Lambrichts[3], S. Vargas-sierra[4], J. Gonzalez lujan[4]

1. European Space Agency, Netherlands

2. ESA, Netherlands

3. IMEC, Belgium

4. Alter Technology, Spain

The TID radiation behaviour of the electrical response for the devices of the DARE180U technology has been measured as a function of geometry. New transistor geometry TID response features have been observed.

16:15 **RADECS GENERAL ASSEMBLY**

17:30 End of Thursday Sessions

18:30 **BUS DEPARTURE FOR GALA DINNER** – *Level 0*

Pasteur Auditorium, Level 1

09:00 **SESSION G**
RADIATION HARDNESS ASSURANCE
Chairs: Pavel Chubunov (Branch of JSC URSC-ISDE) & Pierre_xiao Wang (3D PLUS)

G-1 **Radiation Specification and Testing of Heterogenous Microprocessor SOCs**
09:05 S. Guertin[1], R. Some[1], P. Nsengiyumva[2], E. H. Cannon[2], M. Cabanas-Holmen[2], J. Ballast[2]
1. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
2. Boeing Research & Technology, Seattle, WA, 98195
Developing new RHBD microprocessors risks sacrificing processing performance for system-wide radiation requirements. Modern SOCs are heterogenous in design and performance goals for subsystems. New RHBD devices benefit from heterogenous radiation requirements and testing for subsystems.

G-2 **Six-Faces Induced Margins on Dose Calculation and Proposal for a New Satellite Geometry Exchange method**
09:20 A. Varotsou[1], P. Pourrouquet[1], R. Benacquista[1], R. Mangeret[2], L. Pater[3], G. Santin[4], H. Evans[4], D. Standarovski[5], R. Ecoffet[5]
1. TRAD, France
2. Airbus Defense and Space France, France
3. Airbus Defense and Space UK, United Kingdom
4. ESA, Netherlands
5. CNES, France
The 6-faces method is commonly used for geometry information exchange between primes and subcontractors. Margins induced by this method were identified and analyzed for a geostationary mission. A new method is proposed with promising results.

G-3 **Thermal Neutron Induced SEUs in the LHC Accelerator Environment**
09:35 M. Cecchetto[1], R. Garcia Alia[1], F. Wrobel[2], M. Tali[3], O. Stein[1], G. Lerner[1], K. Bilko[1], Y. Kadi[1], S. Danzeca[1], M. Brucoli[1]
1. CERN, Switzerland
2. University of Montpellier, France
3. CERN/ESA/University if Jyvaskyla, Switzerland
In addition to high-energy hadrons, thermal neutrons are a major concern in terms of SER for electronics in the LHC accelerator. The related RHA considerations are derived analysing the radiation environment and state-of-the-art component sensitivity

G-4 **COTS Optocoupler radiation qualification process for LHC applications based on mixed-energy neutron irradiations**
09:50 R. Ferraro[1], G. Foucard[1], A. Infantino[1], L. Dilillo[2], M. Brugger[1], A. Masi[1], R. Alia[1], S. Danzeca[1]
1. CERN, Switzerland
2. LIRMM, France
In this work, a new method of qualifying COTS-based optocouplers adapted to the neutron dominated LHC radiation environment is studied. The responses of components made of different materials irradiated with protons and neutrons are analyzed.

POSTER PAPERS

PG-1 **Contactless Approaches for the Electronic Device Heating during Radiation Hardness Assurance Tests for Single-Event Effects**

E. Nekrasova[1], E. Mitin[1], P. Gromov[1], V. Anashin[2]
1. LLC NPC Granat, Russian Federation
2. Branch of JSC URSC - ISDE, Russian Federation

Different approaches to perform the electronic device heating during radiation hardness assurance tests are discussed. A new heating approach based on the use of ceramic infrared heaters is presented along with experimental results.

PG-2 **Evaluation of ELDRS on Bipolar Devices Using Temperature-Switching Irradiation**

X. Li[1], W. Lu[1], X. Wang[1], X. Yu[1], J. Sun[1], M. Liu[1], S. Yao[1], Y. Chang[1], Q. Guo[1], C. He[1]
1. Xinjiang Technical Institute of Physics and Chemistry, China

Based on the first-principles understanding of interface-trap buildup and annealing, a temperature-switching irradiation (TSI) sequence is shown to be a conservative test for ELDRS at ultra-low dose rates in linear bipolar devices.

PG-3 **Method for System-level testing of COTS electronic board under High Energy Heavy Ions**

A. De Bibikoff[1], P. Lamberbourg[1]
1. ZODIAC DATA SYSTEMS, France

We describe a method to characterize the SEE sensitivity of an electronic system. The tests are in air without opening the devices, with LETs up to more than 40 Mev·cm2·mg-1. TRIM is used for calculations.

PG-4 **Extreme Value Based Estimation of Critical Single Event Failure Probability**

G. Zebrev[1], A. Galimov[2], I. Fateev[2], U. Rustem[3]
1. National Research Nuclear University MEPHI, Russian Federation
2. JSC NIIMA Progress, Russian Federation
3. Research Institute of Scientific Instruments, Russian Federation

A new survival probability function of ICs under space ion impact is proposed. Unlike the conventional approach, the function is based on the extreme value statistics which is rele-vant to the critical single event effects.

PG-5 **Non-Stable Latchups in CMOS ICs under Pulsed Uniform Laser Irradiation**

I. Shvetsov-Shilovskiy[1], A. Chumakov[1], A. Pechenkin[1], D. Bobrovsky[1]
1. NRNU MEPhI, Russian Federation

The paper concerns experimental results on latchup in CMOS ICs with holding voltage close to their normal supply voltage. The radiation test results are presented as well as the discussion of non-stable latchup origin mechanisms.

10:05 **BREAK**

10:35 **SESSION H**
RADIATION ENVIRONMENTS
Chairs: Athina Varotsou (TRAD) & Grigory Protopopov (Branch of JSC URSC - ISDE)

H-1 **A new model for the 1-10 MeV proton fluxes (part of ONERA GREEN-V3 model)**
10:40 A. Sicard[1], S. Bourdarie[1], D. Lazaro[1], D. Standarovski[2], R. Ecoffet[2], L. Lanzerotti[3], A. Gerrard[3]
1. ONERA, France
2. CNES, France
3. NJIT, USA
A new version of the ONERA GREEN model is in development, with a focus on 1-10 MeV proton fluxes. Measurements the dual Van Allen Probes spacecraft and from NOAA-POES spacecraft have been used.

H-2 **How much solar cycle variations impact long term effect predictions at LEO?**
10:55 S. Bourdarie[1], P. Calvel[2], C. Barillot[2], L. Rey[2], T. Parrinello[3], B. Hoyos[3], R. Ecoffet[4]
1. ONERA, France
2. TAS, France
3. ESA, Italy
4. CNES, France
An 8 year long flight database from an EDAC implemented onboard an altimeter flying on CryoSat-2 spacecraft at 715 km altitude is analyzed to investigate on solar cycle variations impact on long term effect predictions.

H-3 **Space Weather Measurements From New Generation GOES Spacecraft (GOES-16 and GOES-17)**
11:10 B. Dichter[1], G. Galica[1]
1. Assurance Technology Corporation, USA
New space weather measurement capabilities are available on new generation GOES spacecraft. Spacecraft instruments will be described. Several examples of space weather data of interest for scientific and engineering studies will be presented.

H-4 **A proton detector for energies from 2MeV to 20MeV**
11:25 M. Ruffenach[1], S. Bourdarie[1], J. Mekki[2], D. Falguère[1], J. Vaillé[3], J. Carron[2]
1. ONERA, France
2. CNES, France
3. IES, University of Montpellier, France
The objective of this study is to extend capabilities of the CNES-ONERA radiation monitor ICARE-NG by adding a low energy proton sensor. Response functions and count rates are calculated using Monte-Carlo simulations and AP-8/AE-8 models.

H-5 **Inter-Comparison of Ionizing Doses from Space Shielding Analyses using MCNP, Geant4, FASTRAD, and NOVICE**
11:40 B. Jun[1], L. Martinez Sierra[1], B. Zhu[1], I. Jun[1]
1. NASA-Jet Propulsion Laboratory, USA
Total ionizing doses (TID) are computed using FASTRAD, NOVICE, MCNP, and Geant4 for space radiation shielding analysis, and the results are compared to better understand their predictive capabilities for TID in very high-energy electron environments.

POSTER PAPERS

PH-1 **Comparison of Ray-Tracing and Reverse Monte-Carlo Methods: Application to GEO orbit**

R. Benacquista[1], P. Pourrouquet[1], A. Varotsou[1], R. Mangeret[2], C. Barillot[3], G. Santin[4], H. Evans[4]
1. TRAD, France
2. Airbus Defense and Space France, France
3. TAS, France
4. ESA, Netherlands

We present a comparison between Ray-Tracing and Reverse Monte-Carlo methods for dose calculation on GEO orbit. Realistic models of platforms, units and components were considered.

PH-2 **Design Environment for Internal Electrostatic Discharge**

W. Kim[1], J. Chinn[1], I. Jun[1], H. Garrett[1]
1. NASA JPL, USA

The one of most important task of the iESD assessment is to define the relevant environment. We show how the iESD design environments of Juno mission and Europa Clipper mission have been determined.

PH-3 **Linking Single Event In-Orbit Data to Space Weather**

P. Hornung[1], A. Menicucci[1], G. Mandorlo[2], G. Furano[2], M. Prochazka[2]
1. TU Delft, Netherlands
2. ESA ESTEC, Netherlands

We study Sentinel 2A+B single event counters. Influence of space weather and device degradation on event rate, as well as the movement of the South Atlantic Anomaly, are extracted. Peculiar differences exist between the satellites.

PH-4 **Method for Estimating the LET Spectrum Using Data from SEE Monitors Based on SRAM**

E. Mrozovskaya[1], V. Anashin[1], G. Protopopov[1]
1. Branch of JSC URSC - ISDE, Russian Federation

The method for estimating LET spectra using the data of SEE monitors using the existing heavy ions models is proposed. The accuracy of the method is estimated taking into account variations in space environment characteristics.

PH-5 **Analysis of the Drift of the South Atlantic Anomaly from ICARE's flight data**

M. Aubry[1], V. Costes-ori[2], D. Standarovski[2], R. Ecoffet[2]
1. CNES / iXblue / Laboratoire Hubert Curien / Politecnico di Bari, France
2. CNES, France

We investigate the drift of the South Atlantic Anomaly from flight data. To study the drift of the anomaly, we mainly focused on the area, the maximum proton flux values and the centroid.

PH-6 **Dose measurements and simulations of the RADFETs response onboard the ALPHASAT CTTB experiments**

J. Sampaio[1], P. Gonçalves[1], C. Pinto[2], T. Sousa[2], P. Ribeiro[3], C. Poivey[4]
1. LIP - Lab. Instrumentação e Física Experimental de Partículas, Portugal
2. Efacec Electric Mobility S.A., Portugal
3. Evoleo Technologies, Portugal
4. European Space Agency (ESA), Netherlands

Dose calculations of four years RADFET response onboard ALPHASAT will be presented using a conversion function from voltage shift to dose that includes temperature-dependence. Geant 4 simulations to validate the results will be presented.

PH-7 **Radiation Environment in the LHC Arc Sections during Run 2 and Future HL-LHC Operations**

K. Bilko[1], C. Bahamonde Castro[1], M. Brugger[1], R. Garcia Alia[1], Y. Kadi[1], A. Lechner[1], G. Lerner[1], O. Stein[1]
1. CERN, Switzerland

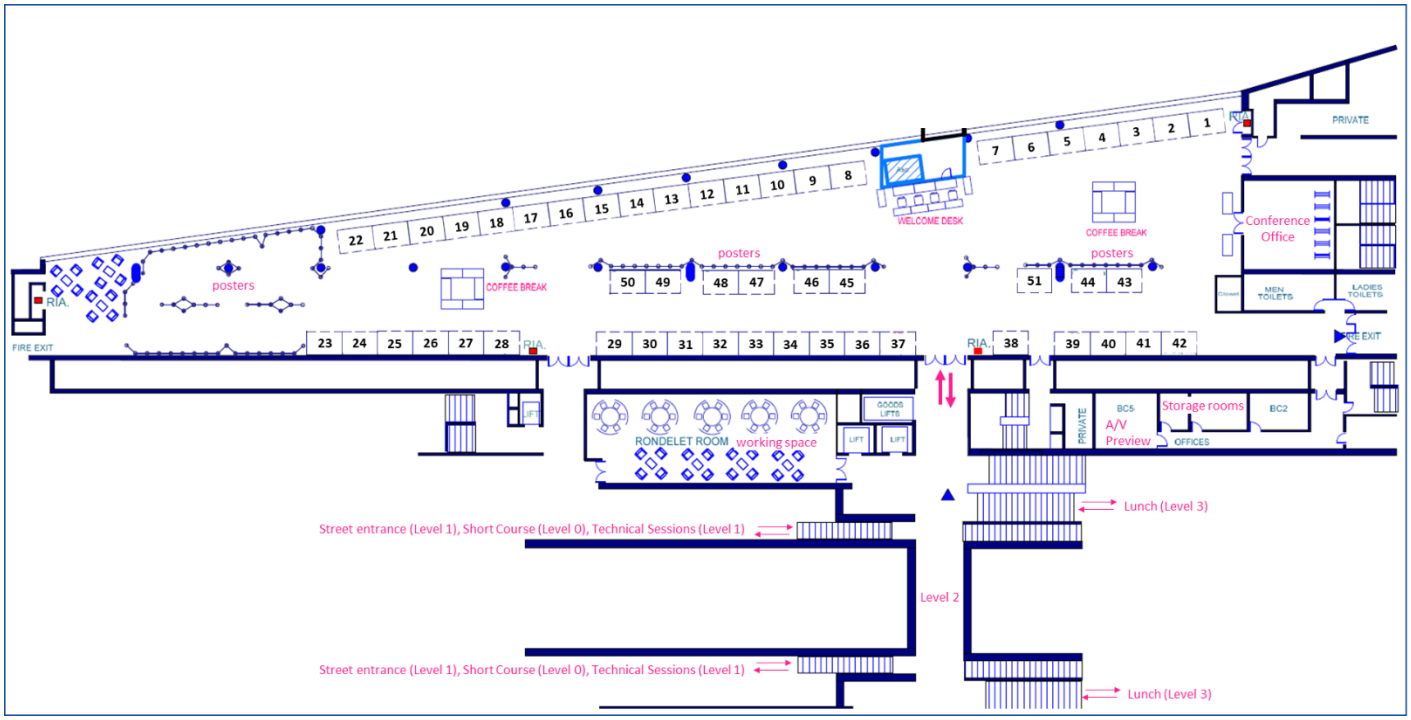
During the LHC operation small fractions of the beams are being continuously lost, creating mixed field radiation. Radiation environment in the arc sectors over Run 2 was analysed with the possible implications on electronic systems.

TECHNICAL PROGRAM - FRIDAY

11:55	**CLOSING REMARKS**
12:05	**BEST STUDENT PRESENTATION AWARD ANNOUNCEMENT**
12:10	End of Conference
14:00	**BUS DEPARTURE FOR TECHNICAL VISITS**

INDUSTRIAL EXHIBIT

Antigone Hall, Level 2



Company	Booth #	Company	Booth #
3D-Plus	29	IXBlue	46
ATRON	9	Magics Instruments	2
Advantest Europe GmbH	38	Microchip	34-35
Aerial	41	Micropac Industries	44
Airbus	26	NanoXplore	6
Alpha-Data	21	NASA NEPP	51
Alter Technology	10	Nuclétudes	15
Analog Devices	3	PAC-G	11
Branch of URSC-ISDE	5	Pulscan	28
ChipIr - ISIS Facility - STFC	22	RADSAGA	32
Cobham	49-50	Robust Chip	18
Crane AE	8	STMicroelectronics	19
Data Device Corporation	48	Seibersdorf Laboratories	45
Delphea	43	Skylabs	39
EMPC	30	Space-Suite	20
Fraunhofer INT	7	Synopsys	42
GANIL	40	TRAD	4
GlenAir	12	Teledyne e2v	31
HiLevel	1	Texas Instruments	16-17
IHP Microelectronics	13	University of Jyväskylä - RADEF	33
Intersil/Renesas	36	Université Catholique de Louvain	14
IPN Orsay	23	VORAGO Technologies	25
IR HiRel/Infineon	27	VPT	37
Isocom	47	Xilinx	24

INDUSTRIAL EXHIBIT

DATE	SCHEDULE	
Monday, September 16	15:30 – 17:00	Booths set-up
Tuesday, September 17	10:00 – 17:00	Exhibition opening
	18:30 – 21:30	Industrial Exhibit Reception
Wednesday, September 18	9:00 – 17:00	Exhibition opening
Thursday, September 19	9:00 – 16:00	Exhibition opening
	13:30	Raffles draw
	16:00 - 17:30	Booths dismantling

For any question regarding the exhibit, please contact exhibit@radecs2019.org

CONFERENCE INFORMATION

REGISTRATION

Pre-registration before September 13th through the conference website is strongly encouraged: www.radecs2019.org/registration

On-site registration is possible at the Registration desk (Level 2) of the conference.

ON-SITE REGISTRATION FEES			
Registration type	***Option***	***Category***	***Fees, EUROS***
Conference Attendee	**Short Course**	Regular	410
		Student*	330
	Technical Sessions	Regular	950
		Student*	700
		ESREF Attendee**	850
Accompanying guest		-	150
Exhibit-only One-day pass		-	250
Two-days pass for ESREF attendee** (Tuesday, Sept 17 & Wednesday, Sept 18)		ESREF Attendee**	570
* The *Student* fees require a valid proof document (e.g. student ID card) at the time of registration. ** The *ESREF Attendee* fees and *Two-days pass* are restricted to holders of a full-registration to the ESREF 2019 Conference.			

The **Registration desk** will be open:

- **Monday to Thursday**: from **8:00** to **17:00**
- **Friday**: from **8:30** to **12:00**

Note that there is no registration on the Sunday prior to the conference.

For any question regarding registration, please contact: registration@radecs2019.org

AUTHORS INSTRUCTIONS

Authors must register to the Technical Sessions to present their work.

Final Paper Submission

Authors shall post their final paper **before September 9**, 2019, midnight (Paris time) on the RADOCS web site. Papers will be published in the conference proceedings that will be made available electronically to all conference attendees after the conference. They will also be available on IEEE Xplore.

IEEE Transactions on Nuclear Science Submission

All papers, except data workshop papers, are eligible for submission to IEEE Transactions on Nuclear Sciences. They will be subjected to the normal IEEE TNS peer review process. To submit your RADECS paper for possible publication in TNS, you must upload your paper at the TNS Manuscript Central web site at http://mc.manuscriptcentral.com/tns-ieee/ **before October 9**, 2019. If your submission is accepted, it will be published in a RADECS 2019 special issue of TNS and it will be removed from RADECS Proceedings to avoid duplication (RADECS2019 Proceedings will be published after IEEE TNS RADECS 2019 special issue).

CONFERENCE INFORMATION

Oral presentations

Authors accepted for oral shall prepare a 12min presentation using Microsoft PowerPoint in wide screen format. Authors should upload their presentation on the RADOCS website **before September 13**, 2019, midnight (Paris time).
Presentations will be available for preview and update during the conference in the A/V preview room. All presentations must be provided no later than the day before they are scheduled.
Speakers should meet their Session Chairs near the podium not later than during the break that precedes their session to review procedures and equipment for the talk.

Posters

Authors accepted for poster in technical sessions or data workshop shall prepare a poster. The useable area is A0 format in portrait orientation (height: 1189mm, width: 841mm).
Posters shall be displayed **by 12:00 noon on Tuesday**. All posters shall be left in place until the end of the conference. Posters must be removed **by 10:00 am on Friday**.

Awards

The conference will deliver three awards:
- Best Conference Paper Award
- The Jean-Marie Palau Award for Best Student Presentation
- Best Data Workshop Award

To be eligible for awards, the final papers must be submitted in time (see above). The Jean-Marie Palau Award for Best Student Presentation will be announced during the conference closing remarks on Friday. The other awards will be announced during RADECS 2020.

A/V PREVIEW

The A/V PREVIEW room is located in the Antigone Hall on Level 2 (take a right when entering the hall).

The **A/V Preview room** will be open:

- **Monday to Thursday**: from **8:00** to **11:00** and from **13:30** to **16:30**
- **Friday**: from **8:30** to **10:30**

LUNCHES

The Short Course Lunch on Monday is for registered Short Course attendees only.
Lunches, Tuesday to Thursday, are for registered Technical Sessions attendees and pass holders only.
Lunches will be served on Level 3. A ticket is required to enter the lunch area each day.
From Tuesday to Thursday, after-lunch coffee will be served in the Industrial Exhibit area, Antigone Hall on Level 2.
On Wednesday, after-lunch coffee will also be served in the Women in Engineering event area, Barthez room on Level 2.

BREAKS

Breaks will be served in the Industrial Exhibit area, Antigone Hall on Level 2.
Breaks on Monday are for registered Short Course attendees only.
Breaks, Tuesday to Friday, are for registered Technical Sessions attendees and pass holders only.

TRAMWAY PASS

Free tramway passes, valid for 4 days, will be available on request at the conference Registration desk. The TAM Tramway is a convenient way to move around the city. The Corum tramway station is served by lines 1, 2 and 4.
Map available here: https://tam.cartographie.pro/

TECHNICAL VISITS

FRIDAY, SEPT. 20

Bus departure: 14:00 from Le Corum. Meeting point at street entrance, Level 1

The bus will take you to the Saint Priest Campus, part of the University of Montpellier. There, you will successively visit three different units of the University of Montpellier.

The Institute of Electronic and Systems (IES) is a joint research laboratory of the University of Montpellier and the CNRS. Its experience and know-how is about photonics, sensors and reliability. The tour of the IES laboratory will provide an overview on the radiation testing facilities, the clean room facilitity for micro and nanotechnology applications, and the Antimonides center dedicated to the fabrication of Antimonide-based compound semiconductors and heterostructures.

The LIRMM (Laboratory of Computer Science, Robotics and Microelectronics of Montpellier) is a major multi-disciplinary French research center. It is affiliated with the University of Montpellier and the French National Center for Scientific Research (CNRS). It conducts research in Computer Science, Microelectronics and Robotics and is organized along 3 departments. The tour of the LIRMM laboratory will provide an overview of the robotics department and more specifically of the robotic hall.

The tour of the University Space Center will provide an overview of the nanosatellite activities at the University of Montpellier. The tour will comprise a vi sit of the clean-room with a view on the nano-satellites being integrated (depending on availability), the test benches, the Concurrent Design Facility, the ground station and the Mission Control Center where the radiation effects payload data are displayed.

Bus will return to Le Corum at 16:30.

Preregistration is required through the conference registration website for this event. No on-site registration is possible. Due to the limited capacity of this event, tickets for this event will be delivered based on the date of registration to the conference.

SOCIAL PROGRAM

MONDAY, SEPT. 16 - WELCOME RECEPTION AT FABRE MUSEUM

18:30 – 20:30

The Conference Committee invites the RADECS 2019 attendees to a Welcome Reception at the Fabre Museum, just across the street from the conference facility. The City of Montpellier will welcome you and you will have the opportunity to visit the permanent and temporary exhibitions of the Museum. Drinks and appetizers will be served.
The Welcome Reception is for registered Technical Sessions attendees and Accompanying Guests only. Due to the limited capacity of the Museum, the number of tickets for this reception is limited and those tickets will be delivered based on the date of registration to the conference.

TUESDAY, SEPT. 17 - INDUSTRIAL EXHIBIT RECEPTION

18:30 – 21:30

Exhibitors invite RADECS 2019 attendees to a reception in the Industrial Exhibit hall to learn about their products, see their demonstrations, enter their raffles and enjoy refreshments and food.

This reception is for registered Technical Sessions attendees, Tuesday pass holders and Accompanying Guests only.

WEDNESDAY, SEPT. 18 – RADECS FOOTBALL TOURNAMENT

Bus departure: 18:30 from Le Corum. Meeting point at street entrance, Level 1

Participants will be taken by bus to a nearby football field to defend the honor of their team! Bring your football shoes. After the sport, a convivial dinner will be offered to conclude the evening. Bus will return to Le Corum at 23:30.

Preregistration is required through the conference registration website to participate. Due to the limited capacity of this event, tickets for this event will be delivered based on the date of registration to the conference.

THURSDAY, SEPT. 19 - 30TH ANNIVERSARY GALA DINNER

Bus departure: 18:30 from Le Corum, Level 0

Buses will leave from Level 0 of Le Corum and will take you for a 30 min ride outside of the city of Montpellier to an authentic and elegant place for an evening to remember, during which we will celebrate the 30 years anniversary of the RADECS community. There will be food, drinks and music!

Return buses back to Le Corum will be spread over time from 23:00 to 1:30.

The Gala dinner is for registered Technical Sessions attendees and Accompanying Guests only.

TOURS

The following tours are proposed to RADECS 2019 conference attendees and accompanying guests as opportunities to socialize and to discover the Montpellier area.

- Tickets for each tour can be purchased from the registration website.
- We recommend to purchase tickets in advance as the capacity of each tour is limited. Early ticket prices are valid before **September 8, 2019**.
- Tours may be cancelled with refund by the organizers due to particular weather conditions or insufficient number of participants.

SUNDAY, SEPT. 15: AROUND THE PIC SAINT-LOUP

For those arriving in advance in the Montpellier area, we propose to gather on Sunday before the conference for this hiking and wine-tasting tour around the Pic Saint-Loup, a small (658m) but emblematic mountain of the North of Montpellier backcountry that is well-known for hosting on its sides some of the finest vineyards of the Languedoc region.
Morning: Choose your group between Hikers (group A) and Wine-tasters (group B). Group A will hike up to the Pic Saint-Loup summit and down in approximately 2 hours. This is a gentle family hike, but sport shoes are required, and a bottle of water is recommended. Group B will visit a recent wine domain and taste several blends typical of the Pic Saint-Loup area.
Lunch: lunch-box picnic
Afternoon: Visit of a traditional wine domain with wine tasting

- Full day excursion
- Bus departure: 9:30 from Le Corum*, back at 16:30
- Ticket price: Early 30 Euros (no on-site registration)

* since the conference registration desk will not be open before the departure of this tour, a physical ticket is not required, you can just bring the Registration ID associated to your ticket(s).

TUESDAY, SEPT. 17: A DAY IN MONTPELLIER

Afternoon: **Guided Tour of Montpellier by foot**
A thousand-year journey into the city's past.
This English guided tour takes you to the oldest parts of Montpellier, along its almost millenary streets, where you will see many vaulted ceilings, typical of the Middle Ages. Your guide will tell you about the ancient city, the way people lived in the Middle Ages and, using the streets names' as a starting point, tell you about the trades and jobs of Montpellier's citizens during this era. You will also be able to visit the Arc de Triomphe's rooftop. A unique moment with a spectacular view guaranteed!
Highlights of the visit: The Arc de Triomphe and the Peyrou Royal Square ; the faculty of medicine ; St. Peter's Cathedral...

- Duration of visit: 2 hours (wear comfortable shoes)
- Departure: 14:00 from Le Corum, Conference Registration desk. Meeting 15min before for on-time departure.
- One small bottle of water per person will be provided upon departure.
- Ticket price: Early 11 Euros, On-site 15 Euros

TOURS

WEDNESDAY, SEPT. 18: A DAY BY THE SEA

Morning: **Visit of Aigues-Mortes**

Enjoy a guided tour of the lively medieval town of Aigues-Mortes (30 minutes by bus from Corum). A bit of history ... In 1240, the King of France Saint-Louis was looking for an open port with access to the Mediterranean Sea to launch his crusades. He decided to focus on Aigues-Mortes, a country of marshes, sand and water. Then he began building the ramparts, a wall of 1640 m perimeter.

Lunch: **Restaurant La Camargue**

A place steeped in history...

Afternoon: **Guided tour of La Grande-Motte**

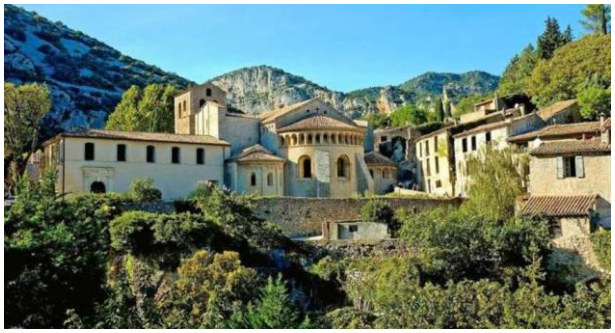
Discover the architectural work of Jean Balladur, the story of the birth of La Grande Motte, heritage of the twentieth century, a garden city filled with sculptures and hidden symbols.

Free time for a drink by the beach.

- Full day excursion
- Bus departure: 9:30 from Le Corum, Level 0. Meeting 15min before for on-time departure.
- Ticket price: Early 65 Euros, On-site 80 Euros

THURSDAY, SEPT. 19: A DAY IN THE BACK COUNTRY

Morning: **Visit of Saint Guilhem le Désert**



This Classified site is one of the most beautiful villages in France and today its abbey is registered as a World Heritage Site by UNESCO in conjunction with the French section of St James' Way to Santiago de Compostela in western Spain. Its houses are snuggled tightly together in ancient alleyways, with roof tiles baked by the Languedoc sun for twelve centuries. See traces of the past in their arcatures, their lintels, their gemelled windows…Built around the Abbey of Gellone, the village has kept its impressive medieval imprint and constitutes a rare, harmonious site in Languedoc.

Lunch: **Restaurant l'Oustal Fonzes**

We offer a stop in this traditional restaurant, on its terrace overlooking the gorges of Herault for a rich flavored lunch.

Afternoon: **Guided tour of the Cave of Clamouse**

The cave of Clamouse located in the heart of the Gorges de l'Herault, is a site classified by the Ministry of Ecology and a must-see in Occitania. You will be able to enjoy a diversity of unique underground landscapes. Your guide will introduce you to the story of these world famous caves and take you on a magical journey through time.

- Full day excursion (back in time for Gala dinner departure)
- Bus departure: 9:00 from Le Corum, Level 0. Meeting 15min before for on-time departure.
- Ticket price: Early 65 Euros, On-site 80 Euros

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RADIATION EFFECTS ON COMPONENTS & SYSTEMS

14th - 18th September 2020
Palais des Arts et des Congrès (PAC)
Vannes – Morbihan - Brittany – France
www.radecs2020.org

Call for Papers

The 2020 **RAD**iation **E**ffects on **C**omponents & **S**ystems (RADECS) Conference will be held September 14-18th in Palais des Arts & des Congrès (PAC), Vannes – Morbihan, Brittany, France. The RADECS 2020 conference features consist of a full-day RADCOTS 2020 workshop, a technical program including oral and poster presentations, a radiation effects data workshop and an industrial exhibit.

The RADECS Conference is the annual European scientific and industrial forum on the effects of radiation effects on electronic and photonic materials, devices, circuits, sensors and systems where

- Radiation environments
- Radiation effects modeling, from materials to device, circuit and system level
- Test facilities & dosimetry
- Radiation hardness assurance
- Hardening and mitigation solutions
- Applications & case studies

- **Sept. 14th, 2020: RADCOTS 2020**
  - Workshop
- **Sept. 15th-18th, 2020: RADECS 2020**
  - Technical program: oral and poster presentations
  - Radiation effects data workshop
  - Industrial exhibit

RADECS 2020 theme is " Be prepared for the extensive use of commercial parts (COTS) in space satellite systems", with the ambition to register what has been done so far, and to explore the new technical challenges that will drive the radiation effects community over the coming years.

The first day of the conference (September 14th, 2020) will be dedicated to a **RADCOTS 2020**. This workshop will provide the state of the art on the use of COTS in space satellites, based on previous experience in this field. At the end of the day, a round table will be organized in order to (a) register the current Radiation Hardness Assurance (RHA) for COTS, and (b) to identify new axis to investigate in the near future, to increase the use of COTS but keeping the same high reliability objective.

RADECS 2020 is soliciting papers describing significant new findings or developments in the field of Radiation Effects. Visit the conference website for the full list of topics.

CALL FOR PAPER DEADLINE : APRIL 12th 2020

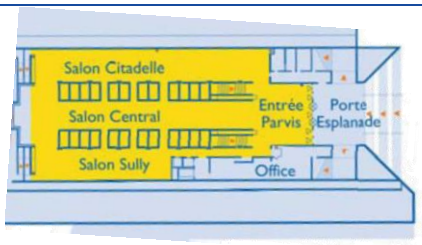
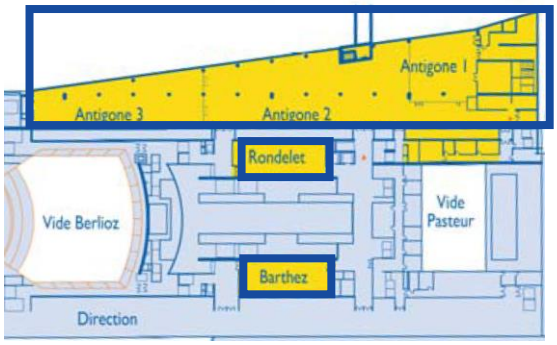
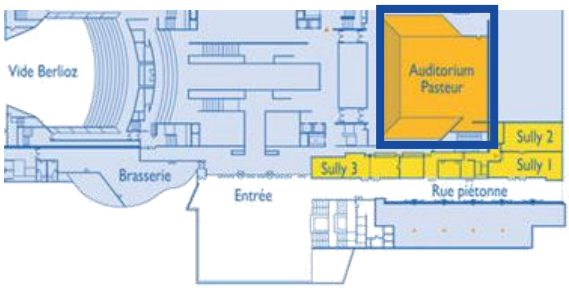
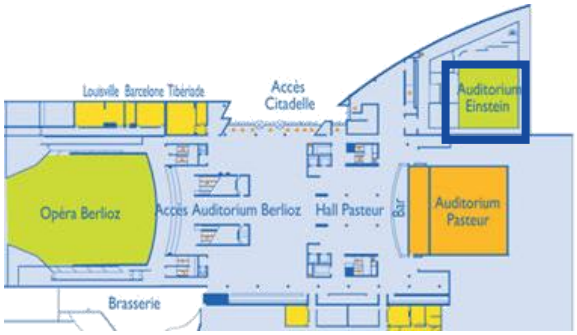
RADECS 2020 is organized by:

CONFERENCE MAP

The CORUM Conference Centre

Place Charles de Gaulle

34000 Montpellier

LEVEL 3	• **Salon Central** Lunches	
LEVEL 2	• **Antigone Hall** Registration desk Industrial Exhibition Breaks Poster Session Data Workshop Session AV Preview • **Rondelet room** Working space • **Barthez room** Woman in Engineering event	
LEVEL 1	• **Street entrance** • **Pasteur Auditorium** Technical Sessions	
LEVEL 0	• **Einstein Auditorium** Short Course • **Citadelle Access** Bus departure for Gala Dinner	

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