



July 22-26, 2024

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Chairman's Invitation



"It is my distinct honor to invite you to attend NSREC 2024 in Canada's capital city, Ottawa, Ontario! My Conference Committee and I are excited to host all of you in this wonderful small city. We hope that you enjoy this outstanding conference and make time to enjoy all the social opportunities. Ottawa is the educational and cultural heart of Canada with many universities and cultural institutions, including the National Arts Centre and the National Gallery of Canada. As the year continues, the NSREC website and brochure will provide information on different local offerings Ottawa has, so that you and your family can make your plans. On behalf of the many who make NSREC possible, I welcome you to NSREC 2024. Canada Ho!"

Heather Quinn
NSREC 2024 General Chair

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On behalf of the Institute of Electrical and Electronics Engineers (IEEE), its Nuclear and Plasma Sciences Society (NPSS), the Radiation Effects Steering Group (RESG) and the 2024 Nuclear and Space Radiation Effects Conference (NSREC) committee and volunteers, it is my sincere pleasure to invite you to attend the 61st NSREC to be held July 22-26, 2024. The conference will be held in Canada's capital, Ottawa, Ontario, at the Shaw Centre.

The conference begins Monday, July 22nd, with a one-day Short Course titled *"Radiation Effects on Electronic and Photonic Technologies: from Basic Concepts to Advanced Mechanisms"*. It is organized by **Vincent Goiffon** of ISAE SUPAERO. The day covers the main three radiation effects in electronics with a special fourth section on photonics. This short course provides the basic knowledge necessary to understand how radiation affects electronics, which will provide a wonderful introduction to the topic for new attendees and a brush-up on knowledge for more experienced attendees. The Short Course notebook will provide an in-depth write up of the discussion.

The Technical Program will be held from Tuesday, July 23rd to Friday, July 26th. **William Robinson**, Georgia Tech Research Institute, is the Technical Program Chair. William and his technical committee will oversee the development an outstanding contributed papers organized into nine sessions of oral presentations and a poster session. William will be working with **Daisuke Kobayashi**, JAXA, who will oversee the poster session. In addition, the technical committee will oversee the development of the Radiation Effects Data Workshop with the Data Workshop Chair, **Li Chen**, University of Saskatchewan. Workshop posters will present radiation effects data on electronics or test facilities. Finally, the technical program includes three invited speakers that present on topics of general interest to the NSREC community.

The Industrial Exhibit, organized by **Nadia Rezzak**, Microchip, opens Tuesday morning. Our exhibitors will display their latest developments, including electronics, engineering services, facilities, modeling, and equipment. Attendees will be able to visit the booths during scheduled breaks, and lunch on Tuesday and Wednesday. A special Industrial Exhibits Reception will be held on Tuesday night that attendees and their guests can attend. The exhibits will conclude at noon Wednesday with the ever-popular exhibitor raffle.

Ottawa is a lovely small city filled with wonderful official and unofficial museums, including The Unofficial Museum of Fueling up and The Unofficial Museum of Saying Football Instead of Soccer! Local Arrangements Chair, **Anthony Sanders**, NASA GSFC, is organizing an outstanding social program for attendees and guests. The conference social, which is held on Wednesday evening, will be held at the outstanding Canadian History Museum with cocktails, sit-down dinner, and a tour of the museum. This venue is a must see for attendees with its beautiful architecture reminiscent of canoe paddles and its river-front view of Parliament. There will also be two companion tours, including a trip to the Canadian Parliament and the Canadian War Museum.

On behalf of my Conference Committee, which also includes Finance Chair **Ethan Cannon** (The Boeing Corporation); Publicity Chairs **Teresa Farris** (Archon-LLC) and **Michael Campola** (NASA GSFC); Awards Chair **Sylvain Girard** (Université de Saint-Etienne); Webmaster **Greg Allen** (NASA/JPL); A/V **Carl Szabo** (NASA) and **Martha O'Bryan** (NASA); and Meeting Planner **John Teehan** (IEEE MCE), I invite you to join us in Ottawa for an outstanding conference!

We look forward to seeing you in person this July!

Short Course Program

RADIATION EFFECTS ON ELECTRONIC AND PHOTONIC TECHNOLOGIES: FROM BASIC CONCEPTS TO ADVANCED MECHANISMS

OTTAWA, ONTARIO,
CANADA

OTTAWA SALON
JULY 22, 2024

- 7:00 AM **BREAKFAST**
(Trillium Ballroom)
- 8:00 AM **SHORT COURSE INTRODUCTION**
Prof. Vincent Goiffon, *ISAE-SUPAERO, Université de Toulouse*
- 8:10 AM **PART I – BASIC MECHANISMS AND DISPLACEMENT
DAMAGE EFFECTS IN ELECTRONICS**
Dr. Elizabeth Auden, *Los Alamos National Laboratory*
- 9:40 AM **BREAK (Rideau Canal Atrium)**
- 10:10 AM **PART II – TOTAL IONIZING DOSE EFFECTS IN SI MOSFETS
UP TO ULTRAHIGH DOSES**
Dr. Federico Faccio, *CERN*
- 11:40 AM **SHORT COURSE LUNCHEON**
(Trillium Ballroom)
- 1:00 PM **PART III – SINGLE-EVENT EFFECTS IN DEVICES AND ICS:
PHENOMENA AND TESTING METHODS**
Dr. Ani Khachatrian, *US Naval Research Laboratory*
- 2:30 PM **BREAK (Rideau Canal Atrium)**
- 3:00 PM **PART IV – RADIATION EFFECTS ON PHOTONICS: IMAGE
SENSORS AND OPTICAL FIBERS**
Prof. Sylvain Girard and Dr. Cedric Virmondois, *University of Saint-
Etienne and CNES, respectively*
- 4:50 PM **WRAP-UP**
- 5:00 PM **EXAM (only for students requesting CEU credit)**
- 5:20 PM **END OF SHORT COURSE**

*The NSREC 2024 Short Course Notebook will be available for download at www.NSREC.com for
all registered Short Course Attendees one week before NSREC conference.*

Short Course

COURSE DESCRIPTION

A short course, “*Radiation Effects on Electronic and Photonic Technologies: from Basic Concepts to Advanced Mechanisms*”, will be presented at the 2024 IEEE Nuclear and Space Radiation Effects Conference. The ongoing need to expose sensors and systems to more and more demanding radiation environments combined with the fast evolution of technologies lead to complex radiation effects in modern electronics and photonics. To enable their use in harsh radiation environments such as space, nuclear power plants, medical imaging/scientific instruments, or particle physics facilities, it appears critical for users, designers, manufacturers, and researchers to get an up-to-date overview of the underlying physics and failure mechanisms.

The short course is organized into four sections, all featuring introductory material and advanced topics. The first section addresses the basic mechanisms of radiation effects in electronics, with emphasis on displacement damage on various devices and technologies. The second part focuses on total ionizing dose induced degradation in MOS transistors, discussing the evolution of these effects with the advancement of CMOS manufacturing technologies. The third section describes single event effects in electronics, and includes discussions about the testing approaches used to reproduce in the laboratory the failure mechanisms observed in the application. The final course deals with effects on photonic material, devices and integrated circuits focusing on optical materials, optical fibers, image sensors and detector pixel arrays. More detailed descriptions of each lecture are provided below. The topics covered should benefit people new to the field as well as experienced engineers and scientists, by providing up-to-date material and insights.

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

CONTINUING EDUCATION UNITS (CEUs)

Continuing Education Units (CEUs) will be available. For the interested attendees, an exam will be given at the end of the short course. The course is valued at 0.6 CEUs, and is endorsed by the IEEE and by the International Association for Continuing Education and Training (IACET).

SHORT COURSE CHAIRMAN



Vincent Goiffon, Ph.D.
ISAE-SUPAERO
Short Course Chair

Vincent Goiffon received his Ph.D. in EE from ISAE-SUPAERO, University of Toulouse, France, in 2008. The same year he joined the ISAE-SUPAERO Image Sensor Research group as Associate Professor and has been a Full Professor of EE at the Institute since 2018. In September 2021, he took over the responsibility of the Research Group.

He has contributed to advancing the understanding of radiation effects on solid-state image sensors, notably by identifying original degradation mechanisms in pinned photodiode pixels and clarifying the role of interface and bulk defects in the mysterious dark current random telegraph signal phenomenon.

Besides his contributions to various space R&D projects, Vincent has been leading the development of radiation-hardened CMOS image sensors (CIS) and cameras for nuclear fusion experiments (e.g., ITER and CEA Laser MegaJoule) and nuclear power plant safety.

Vincent Goiffon has authored one book chapter and more than 110 publications, including awards received at IEEE NSREC, RADECS, and IISW conferences. He has been an associate editor of the IEEE Transactions on Nuclear Science since 2017 and has served the community as a reviewer and session chair.

Short Course Monday



Dr. Elizabeth Auden is an electrical engineer in the Radiation Effects and Reliability capability at Los Alamos National Laboratory (LANL). She received an M. S. in electrical engineering from Tulane University in 2000 and a Ph.D. in electrical engineering from Vanderbilt University in 2013. Elizabeth's professional background includes radiation effects and reliability in electronics, DC electrical metrology, and software engineering. Her radiation effects research focuses on single-event effects and displacement damage in semiconductor and superconductor components.

PART I – BASIC MECHANISMS AND DISPLACEMENT DAMAGE EFFECTS IN ELECTRONICS

Dr. Elizabeth Auden

Los Alamos National Laboratory

Electronics operating in space-based applications are subject to radiation effects from galactic cosmic rays, solar energetic particles, and trapped particles in planetary orbits. Radiative particles can cause single-event effects (SEEs) as well as accumulated damage from total ionizing dose (TID) and displacement damage (DD), leading to data corruption, off-normal electrical conditions, performance degradation, and failure. During the first half of this short course, **Dr. Elizabeth Auden** from *Los Alamos National Laboratory* will provide an overview of space radiation environments; concepts such as particle / matter interactions, stopping power, and dose; radiation effects including TID, DD, and SEEs; and common units necessary for the study of radiation effects such as dose, displacement damage dose (DDD), linear energy transfer (LET), and non-ionizing energy loss (NIEL). The second half of the short course will focus on displacement damage. Topics will include basic physical mechanisms, electrical degradation observed in different device types, and recent displacement damage research in devices with emerging materials and feature sizes.

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

- Introduction to radiation effects in materials
 - o Space radiation environments
 - o Particle / matter interactions and ionization
 - o Depletion regions and pn-junctions
- Units for investigating radiation effects
 - o Stopping power and linear energy transfer (LET)
 - o Absorbed dose
 - o Non-ionizing energy loss (NIEL)
 - o Displacement damage dose (DDD)
- Basic mechanisms for displacement damage
 - o Displacement damage generation: Frenkel pairs and defect clusters
 - o Stable defect creation and annealing
 - o Carrier mobility
 - o Shockley-Reed-Hall recombination and generation
 - o Messenger-Spratt equation
 - o Measurements and modeling tools for material damage
- Electrical effects of displacement damage in different electronic components
 - o Displacement damage-induced degradation in electrical metrics: leakage current, resistance, gain, charge collection efficient
 - o Displacement damage-induced degradation in components: diodes, transistors, solar cells, pixels and other photonic devices, and more complex circuits
 - o Measurements and modeling tools for electrical effects of damage
 - o Displacement damage in non-silicon devices
- Recent displacement damage results in emerging devices and materials

Short Course Monday



Dr. Federico Faccio received the M.S. degree in physics from the University of Turin (IT) in 1991 and the PhD degree from INPG (FR) in 1997. He joined CERN, the European laboratory for particle physics, in 1991 where he is now the leader of the Microelectronics section in the electronics group. In the past 30 years, his technical work focused on the study of radiation effects in CMOS technologies used for the design of ASICs exposed to the ultra-high TID levels and hadron fluxes at the CERN LHC and HL-LHC colliders. In this context, he also contributed to the design of radiation-hard ASICs like ADCs, optical receivers and data recovery circuits, linear regulators and DCDC converters. He has authored and co-authored more than 100 technical papers, receiving awards at the NSREC, RADECS and ECCE conferences. He has served the radiation effects community as session and short course chairman at RADECS, and more recently he became associate editor of IEEE TNS.



Dr. Giulio Borghello
CERN



Dr. Stefano Bonaldo
DEI, University of
Padova

PART II – TOTAL IONIZING DOSE EFFECTS IN SI MOSFETS UP TO ULTRA-HIGH DOSES

Dr. Federico Faccio
CERN

Silicon MOSFETs have been sensitive to Total Ionizing Dose (TID) since the early days of radiation studies on electronic devices, and that is still the case after more than 40 years and 20 generations (nodes) of CMOS technologies. Silicon dioxide (SiO₂), the insulator that has been a blessing for the semiconductor industry because of its compatibility with Si, has instead been a curse for the application of CMOS circuits in radiation environments. Defects in SiO₂ and at its interface with the Si channel of MOS transistors have determined the TID response of CMOS circuits built in micrometer bulk planar technologies of the 80s as well as in today's nanometer-scale FinFETs.

In this course, prepared in collaboration with **Dr. Giulio Borghello** (CERN), and **Dr. Stefano Bonaldo** (DEI, University of Padova), **Dr. Federico Faccio** (CERN) will illustrate the basic mechanisms of TID in SiO₂: charge yield, charge and hydrogen transport, charge trapping and de-trapping, interface state activation and annealing. The course will show how very similar mechanisms have differently affected the performance of MOSFETs in time. While in older technologies the gate oxide was the weak point and determined failure at krad TID levels, with the down-scaling of CMOS in the 100 nm range and below, the radiation response became dominated by auxiliary oxides like Shallow Trench Isolation (STI) or spacers.

The last part of the course will thus focus on the consequences of ionization in these insulators: the leakage currents that often represent the prevalent limitation to radiation tolerance in recent technologies, the dose-rate effects observable at high TID levels, and the transistor size dependencies including RINCE, RISCE (Radiation-Induced Narrow or Short Channel Effects) and halo implant effects. The manufacturing of these auxiliary oxides is less controlled and less uniform across nodes and fabrication plants than for the thermally grown gate oxide, leading to a wide variability in radiation response. This will be illustrated by a comparison between manufacturers, plants of the same manufacturer and manufacturing lots. In conclusion the course will show how, with or even without costly dedicated design techniques, TID tolerance to ultra-high levels (>100Mrad) is not a dream anymore.

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

- Introduction
 - o Environments with ultra-high TID levels
 - o MOS transistors and CMOS technologies
 - o TID-induced failures in CMOS ICs: all originate in the oxides
- Basic mechanisms behind TID effects in the oxides
 - o Ionization and charge yield for different radiation sources
 - o Charge transport in the oxide
 - o Charge trapping: traps in the oxide, border traps, interface traps
 - o Time evolution of the defects: switching and annealing
 - o Influence of bias, temperature and dose rate
- The oxides in CMOS technologies and associated TID effects
 - o Gate oxide
 - Threshold voltage, transconductance, carrier mobility
 - Proportionality between oxide thickness and TID effects
 - Low-frequency noise in MOS transistors
 - o STI oxide
 - Leakage currents: drain-source and inter-device
 - Radiation-Induced Narrow Channel Effects (RINCE)
 - Influence of the Halo implants on the STI effects
 - Hardness-By-Design techniques (HBD) to eliminate the STI effects
 - o Spacers
 - Radiation-Induced Short Channel Effects (RISCE)
 - o Buried oxide in SOI technologies
 - o True Enhanced Low-Dose Rate Sensitivity (ELDRs) in CMOS
- Trends in the TID sensitivity of CMOS technologies over time (technology nodes)
 - o From old planar technologies to FinFETs
 - o Variability in the radiation response: Fab-to-Fab, lot-to-lot
- Summary and conclusion

Short Course Monday



Dr. Ani Khachatrian is a Research Scientist at the Optoelectronics & Radiation Effects Branch of the US Naval Research Laboratory. She received her Ph.D. in Chemical Physics from the University of Illinois at Chicago. Dr. Khachatrian completed her Postdoctoral Research Fellowship at the Johns Hopkins University Department of Chemistry and American Society of Engineering Education Fellowship at the Electronic Science and Technology Division of the US Naval Research Laboratory. Dr. Khachatrian's current research interests include development and implementation of linear and nonlinear optical methods to simulate single-event effects in micro- and nano-electronic devices and integrated circuits; application of pulsed-lasers to study single-event effects in wide bandgap material systems.

PART III – SINGLE-EVENT EFFECTS IN DEVICES AND ICS: PHENOMENA AND TESTING METHODS

Dr. Ani Khachatrian

US Naval Research Laboratory

Dr. Ani Khachatrian from the *US Naval Research Laboratory* will present an overview of single-event effects phenomena in devices and integrated circuits. In harsh radiation environment, in addition to total ionizing dose, displacement damage dose, microelectronic devices are susceptible to single-event effects. SEE is a phenomenon that occurs when single energetic particle such as alpha particle, heavy ion, proton, neutron or other highly energetic particle, strikes sensitive area of a microelectronic device. There are three steps that can lead to a single-event effect: charge generation via both direct and indirect interactions of an energetic particle with matter; charge collection and the associated modification of the electrical potential at a sensitive node; and the response of the circuit to the collected charge. Single-event effects can be either non-destructive or destructive and can disrupt the normal operation of a device leading to potential failure events. Non-destructive single-event effects can manifest as single-event upset, single-event transient, multi-bit error, and single hard error. Single-event latchup, single-event burnout and single event gate rupture are the examples of destructive events. With continued technology scaling, microelectronic devices growing more complex and emergence of novel semiconductor materials, the understanding of the mechanisms leading to single-event effects becomes increasingly important.

The presentation will discuss mechanisms responsible for single-event effects formation in devices and integrated circuits; types of single-event effects in analog, digital, logic circuits, memory cells and modern microelectronic devices and different test methods of single-event effects in modern technologies, their benefits and limitations.

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

- Introduction
 - Radiation Effects in Devices and ICs
 - Definition of single event effects (SEE) phenomena
 - Environments that can cause SEE
- Three Steps in SEE Formation
 - Charge generation
 - Charge collection mechanisms
 - Circuit response to SEE
- SEE effects in devices and integrated circuits
 - SETs in linear analog circuits
 - SEUs in digital circuits
 - SETs in power devices
 - SEE in memory cells
 - SEE in logic circuits
- Testing methods
 - HI testing – advantages and limitations
 - HI testing vs pulsed laser SEE method
- Conclusion

Short Course Monday



Prof. Sylvain Girard obtained his PhD in Photonics in 2003 from Université Jean Monnet (UJM), France. He joined the CEA in 2004 to investigate the

vulnerability and radiation hardening of optical components for the Laser Mégajoule and became a CEA Senior Expert in 2011. In 2012, Sylvain joined the UJM as Full Professor. He is today leading the MOPERE research group of Lab. Hubert Curien and is one of the founders of the LabH6 joint research lab between UJM, CNRS and the industrial Exail. His main research axis deals with the radiation effects on photonic technologies, in particular fiber-based technologies. He serves the radiation effects community in several positions, in particular as Member-at-Large on the IEEE NPSS Radiation Effects Steering Group and as one of the Associate Editors of IEEE Transactions on Nuclear Science. He has authored or co-authored more than 280 peer-reviewed papers. Sylvain received the 2013 IEEE NPSS Early Achievement Award, the 2014 IEEE/SEE Léon-Nicolas Brillouin Award from and the 2021 Research Prize from the iXcore, iXblue, iXlife Foundation. In 2023, he has been nominated as a Senior Member of the Academic Institute of France, IUF.



Dr. Cedric Virmontois received the Ph.D. degree in Microelectronic from the Institut Supérieur de l'Aéronautique et de l'Espace

(ISAE-SUPAERO), Toulouse, France, in 2012. Cedric presently works for the Centre National d'Études Spatiales (CNES) in Toulouse, France, in the Technology & Digital Directorate. He started as Detection Chain specialist from 2012 to 2018, his work involves the development of imagers for future space imaging missions, electro-optical characterizations, analysis and testing of detectors. He extends his researches to several solid state image sensors dedicated to visible and infrared imaging using ground and in-flight data in order to find generic ways to predict and mitigate space radiation effects. Cedric has also contributed to the understanding and modeling of dark-current Random Telegraph Signals (RTS) in image sensor. Since 2021 he is the head of the Opto-Electronic detection department.

PART IV – RADIATION EFFECTS ON PHOTONICS: IMAGE SENSORS AND OPTICAL FIBERS

Prof. Sylvain Girard
University of Saint-Etienne
Dr. Cedric Virmontois
CNES

Photonics is an important topic due to its wide-ranging applications and transformative impact on various fields, from communications, data transfer, imaging and sensing. Today, high performance photonic solutions developed for terrestrial applications are more and more implemented in radiation-rich environments. It is then crucial to study the radiation effects on these technologies in order to be able to assess their vulnerabilities and if needed to apply hardening techniques before integrating them under irradiation.

In this lecture **Prof. Sylvain Girard** from *University of Saint-Etienne* and **Dr. Cedric Virmontois** from *CNES* will describe radiation effects on two of the main photonic technologies: image sensors and optical fibers.

The first part will address radiation effects on silica-based optical fibers and bulk glasses. The advantages and limitations for the implementation of these technologies in various harsh environments will be discussed as well as the different targeted applications from communications to sensors. The parameters governing their macroscopic radiation responses through the generation of radiation induced point defects will be reviewed as well as the existing strategies to design radiation hardened optical fibers and fiber sensors.

The second part will address image sensors and detectors. A particular emphasis will be made on visible and infrared technologies used in space. After a description of the device principles, the lecture will focus on the performances degraded by radiation. Dark signal, noises, charge transfer inefficiency, quantum efficiency and blinking pixels will be introduced as well as how these parameters evolve under irradiation.

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

Part A – Radiation Effects on Silica-Based Optical Fibers and Bulk Glasses

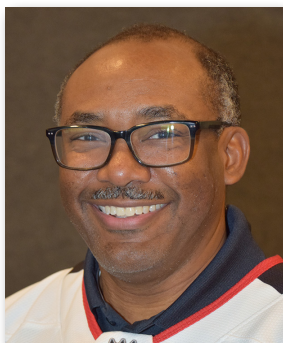
- Introduction to fiber-based technologies and their applications under irradiation
 - Optical fiber operation principles & manufacturing processes
 - Optical fibers for telecommunications and sensing
- Optical Fibers in Radiation-Rich Environments
 - A short historical perspective
 - Main applications domains and environments of interest
- Radiation Effects on Optical Fibers & Bulk Glasses
 - Radiation-glass interactions
 - At microscopic scale: physics of point defects
 - At macroscopic scale: RIA, RIE, RIRIC
 - Intrinsic and Extrinsic Parameters influencing the RIA levels and kinetics
- Radiation Hardening Strategies
 - For optical fibers
 - For optical fiber sensors
- Fiber Radiation Sensors and Dosimeters
- Current and Future Challenges

Part B – Radiation Effects on Detectors and image sensors

- Presentation of Detectors and Image Sensors Technologies
- Basic Mechanisms of Radiation Effects on Detectors
 - Ionizing effects
 - Displacement Damage Effects
- Radiation effects on detector technologies
 - Bolometer and calorimeter
 - Silicon-based image sensor
 - IR sensors

Technical Program

TECHNICAL INFORMATION



"On behalf of the Technical Program Committee, I invite you to attend the 2024 NSREC Technical Program in Canada's capital city of Ottawa. This international gathering of representatives from industry, academia, and government will enhance our understanding of the latest developments in nuclear and space radiation effects on materials, microelectronics, and systems. We welcome the attendance from students to seasoned professionals to engage in robust technical debates across a broad set of topics in the research field. I am grateful for the service of our poster chair, data workshop chair, and our session chairs who will assemble an outstanding program. I look forward to working with all the authors, reviewers, invited speakers, and chairpersons who will contribute to the 2024 NSREC Technical Program."

William H. Robinson,
Georgia Tech Research Institute
Technical Program Chair

The NSREC Technical Program consists of contributed oral and poster papers, a data workshop, and invited talks. The oral presentations will be 12 minutes in duration with an additional three minutes for questions. The technical sessions and their chairpersons are:

- **Basic Mechanisms of Radiation Effects**
Chair: David Hughart, Sandia National Laboratories
- **Dosimetry and Facilities**
Chair: Federico Ravotti, CERN
- **Hardening by Design**
Chair: Dakai Chen, Zero-G Radiation Assurance
- **Hardness Assurance Technologies, Modeling, and Testing**
Chair: Camille Bélanger-Champagne, TRIUMF
- **Photonic Devices and Integrated Circuits**
Chair: Serena Rizzolo, Airbus Defence and Space
- **Radiation Effects in Devices and Integrated Circuits**
Chair: Adrian Ildefonso, Naval Research Laboratory
- **Single-Event Effects: Devices and Integrated Circuits**
Chair: Daniel Limbrick, North Carolina A&T State University
- **Single-Event Effects: Mechanisms and Modeling**
Chair: Florent Miller, Nuclétudes
- **Space and Terrestrial Environments**
Chair: Justin Likar, Johns Hopkins University Applied Physics Laboratory
- **Poster Session**
Chair: Daisuke Kobayashi, JAXA
- **Radiation Effects Data Workshop**
Chair: Li Chen, University of Saskatchewan

POSTER SESSION

Those papers that can be presented more effectively in a visual format with group discussion will be displayed in the Poster Session. Posters can be viewed during the week, and authors will be available during the Poster Session (date TBA). The Poster Session is chaired by **Daisuke Kobayashi** from JAXA.

RADIATION EFFECTS DATA WORKSHOP

Workshop papers provide piece part radiation response data and radiation test facilities technical information. Workshop papers can be viewed during the week, and authors will be available during the Workshop Session (date TBA). The Data Workshop is chaired by **Li Chen** from the *University of Saskatchewan*.

Technical Program

LATE-NEWS PAPERS

A limited number of late-news papers will be accepted and included in the Poster Session and the Radiation Effects Data Workshop. The submission window for these newsworthy papers will be open from April 12, 2024 through May 10, 2024. Detailed instructions for submitting late-news summary will be available on the NSREC website at www.nsrec.com.

Session Chairs



David Hughart
Sandia National Laboratories
Basic Mechanisms of Radiation
Effects



Federico Ravotti
CERN
Dosimetry and Facilities



Dakai Chen
Zero-G Radiation Assurance
Hardening by Design



Camille Bélanger-Champagne
TRIUMF
Hardness Assurance
Technologies, Modeling,
and Testing



Serena Rizzolo
Airbus Defence and Space
Photonic Devices and
Integrated Circuits



Adrian Ildefonso
Naval Research Laboratory
Radiation Effects in Devices
and Integrated Circuits



Daniel Limbrick
*North Carolina A&T State
University*
Single-Event Effects:
Devices and Integrated
Circuits



Florent Miller
Nuclétudes
Single-Event Effects:
Mechanisms and Modeling



Justin Likar
Johns Hopkins University
Applied Physics Laboratory
Space and Terrestrial
Environments



The purposes of the Radiation Effects Committee (REC) of the IEEE Nuclear and Plasma Sciences Society are to advance the theory and application of radiation effects and its allied sciences, to disseminate information pertaining to those fields, and to maintain high scientific and technical standards among its members.



*Robert Reed
Chair*

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

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



*Kay Chesnut,
Raytheon Technologies
Executive Vice-Chair*

NSREC 2024 will be held in Ottawa, Canada, July 22-26 at the Shaw Center. Heather Quinn, Air Force Research Laboratory is the Conference Chair. Supporters of the 2024 NSREC include Aerospace Corporation, EPC Space, Frontgrade, Honeywell, IR HiRel (an Infineon Technologies Company), Jet Propulsion Laboratory, L3Harris, Northrop Grumman, Radiation Test Solutions, Renesas, SkyWater Technologies and Southwest Research Institute. We thank our supporters for their significant and continuing commitments to the conference and welcome other organizations to consider becoming supporters of the IEEE NSREC.

Dolores Black, Sandia National Laboratories, is the Conference Chair for NSREC 2025 in Nashville, Tennessee. Philippe Paillet was selected as the 2026 NSREC Conference Chair. Jonathon Pellish, NASA GSFC was selected as the 2027 NSREC Chair.

Papers presented at the 2024 NSREC are eligible for publication in the January 2025 issue of the IEEE Transactions on Nuclear Science. Authors must upload their papers prior to the conference for consideration for publication in the January 2025 TNS Special Issue. Detailed instructions can be found at www.nsrec.com.

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

EDITORS

Dan Fleetwood
Vice-Chair of Publications



All papers accepted for oral or poster presentation in the technical program will be eligible for publication in a special issue of the *IEEE Transactions on Nuclear Science* (to be published in early 2025), based on a separate submission of a complete paper. Each paper will be subject to the standard full peer review given all papers submitted to the *IEEE Transactions on Nuclear Science*. All papers must be submitted on IEEE ScholarOne. Instructions for submitting papers can be found at the Conference web site

www.nsrec.com. The deadline for submission of papers is July 19, 2024. Data Workshop papers are published in a Workshop Record and are not candidates for publication in the *IEEE Transactions on Nuclear Science*. The process for the Workshop Record is managed by the Workshop Chair.

The review process for papers submitted to the *Transactions* is managed by a team of editors. To provide consistent review of papers, this editorial team manages the review process for all radiation effects papers submitted to the *Transactions* throughout the year. The editorial team consists of a senior editor and associate editors who are technically knowledgeable in one or more specializations and are experienced in the publication process. If you would like to serve as a reviewer for the NSREC special issue of the *Transactions* or for radiation effects papers submitted throughout the year, please contact one of the editors. The editors for the 2024 NSREC are:

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

Heather Quinn, Associate Editor, Air Force Research Laboratory
Email: heather.quinn.2@spaceforce.mil

Steven Moss, Associate Editor, The Aerospace Corporation, retired
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RESG NEWS / Awards

ARE YOU A MEMBER OF IEEE?

Now is the time to join the Institute of Electrical and Electronics Engineers (IEEE) and the Nuclear Plasma Sciences Society (NPSS). Why? First of all, you'll become a member of the largest professional engineering society in the world. About 60% of NSREC attendees are IEEE members. The cost of membership in the IEEE depends on your country and your career phase. IEEE members receive access to a broad range of benefits, including a terrific insurance program, on-line access to IEEE publications, and reduced rates at all IEEE sponsored conferences, including, of course, the IEEE NSREC and Short Course!

NPSS membership is \$35. NPSS members receive a free subscription to NPSS News, and free on-line electronic access via IEEE Xplore to the IEEE Transactions on Nuclear Science (TNS) and the NSREC Data Workshop Record. Now members can search and view digital copies of all IEEE TNS papers on-line all the way back to the first IEEE NSREC in 1964. NPSS members get to vote in our NSREC elections, held at the annual open meeting held during the conference. What are you waiting for? Apply for membership at <http://ieee-npss.org/why-join-npss-and-ieee/> or visit the IEEE registration desk at the conference.

NSREC PUBLICATIONS

NSREC has two publications each year:

- **IEEE Transactions on Nuclear Science.** This IEEE journal is the official archive of research papers presented at NSREC. Papers presented at the conference undergo an additional review before they are accepted for the January 2025 issue.
- **Radiation Effects Data Workshop Record.** Published each year in October, this IEEE proceedings has become the source for radiation test data on semiconductor components.

A complimentary copy of the 2024 *IEEE Radiation Effects Data Workshop Record* and the January 2024 special NSREC issue of the *IEEE Transactions on Nuclear Science* will be mailed to each NSREC technical session attendee if the attendee registered to be listed on the attendee list.

RADIATION EFFECTS COMMITTEE ANNUAL OPEN MEETING

**THURSDAY, JULY 25
4:45 PM – 6:30 PM**

You are invited to attend the IEEE Radiation Effects Committee's Annual Open Meeting on Thursday, July 25, 4:45 – 6:30. All conference attendees are encouraged to attend.

During the meeting we will discuss the 2024 conference and future IEEE Nuclear and Space Radiation Effects Conferences. A report on the nomination processes for the 2024 Junior Member-at-Large on the Radiation Effect Steering Group will be presented. Voting instructions for IEEE NPSS members will be provided.

2023 OUTSTANDING PAPER AWARD

Effect of Energy, Flux and Bias Conditions on Proton-Irradiated CMOS Single Photon Avalanche Diodes

A. Jouni, V. Malherbe, B. Mamdy, T. Thery, V. Correias, S. De- Paoli, V. Luluca, C. Virmondois, G. Gasiot, and V. Goiffon

2023 MERITORIOUS PAPER AWARDS

In-Situ Observation of Circuit Behavior Using Pump-Probe Laser Voltage Probe Technique

M. King, J. Beutler, N. Smith, I. Kohl, T. Meisenheimer, O. Atli, P. Mohan, and K. Mai

Awards

Ion-Induced Stuck Bits in 5-nm bulk FinFET SRAMs at High Fluences

Y. Xiong, N. Pieper, N. Dodds, G. Vizkelethy, N. Nowlin, and B. Bhuvra

2023 OUTSTANDING STUDENT PAPER AWARD

Effect of Energy, Flux and Bias Conditions on Proton-Irradiated CMOS Single Photon Avalanche Diodes

A. Jouni, V. Malherbe, B. Mamdy, T. Thery, V. Correias, S. De- Paoli, V. Lalluca, C. Virmondois, G. Gasiot, and V. Goiffon

2023 OUTSTANDING DATA WORKSHOP PRESENTATION AWARDS

NASA Goddard Space Flight Center's Current Radiation Effects Test Results

M. O'Bryan, E. Wilcox, M. Joplin, T. Carstens, J. Barth, M. Casey, J. Lauenstein, M. Campola, J. Osheroff, E. Wyrwas, A. Antonsanti, A. Le Roch, L. Ryder, K. Ryder, R. Austin, M. Berg, P. Majewicz, and J. Pellish

Comparison of Figure of Merit Calculations to On-Orbit Data

R. Sean, C. David, B. Vermeire, and D. Hansen

2024 RADIATION EFFECTS AWARDS

The winners of the 2024 Radiation Effects and Radiation Effects Early Achievement Awards will be announced Tuesday, July 23 at the opening. The purpose of the Radiation Effects Award is to recognize individuals who have had a sustained history of outstanding and innovative technical and/or leadership contributions to the radiation effects community. The purpose of the Radiation Effects Early Achievement Award is to recognize an individual early in his or her career whose technical contributions and leadership have had a significant impact on the field of radiation effects.

2025 RADIATION EFFECTS AWARD

Nominations are currently being accepted for the 2025 IEEE Nuclear and Plasma Sciences Society (NPSS) Radiation Effects Award. The basis of the award is for individuals who have: (1) a substantial, long-term history of technical contributions that have had major impact on the radiation effects community. Examples include benchmark work that initiated major research and development activities or a major body of work that provided a solution to a widely recognized problem in radiation effects; and/or (2) a demonstrated long-term history of outstanding and innovative leadership contributions in support of the radiation effects community. Examples include initiation or development of innovative approaches for promoting cooperation and exchange of technical information or outstanding leadership in support of the professional development of the members of the radiation effects community.

Nominations are currently being accepted for the 2025 Radiation Effects Early Achievement Award. The basis of the award is for individuals whose technical contributions and leadership during the first ten years of the recipient's career that have had a major impact on the Radiation Effects Community. Examples include work that provides a solution to important technical problems in radiation effects or work that identifies significant new issues in the field. Other factors are cumulative research contributions over the first part of the career, internationally recognized leadership, and mentorship. It is the intent of the RESG to give special consideration for this award to members of the community who are IEEE/NPSS members.

Cash awards and plaques will be presented at the NSREC in Nashville, Tennessee in July 2025. Nomination forms are available electronically in PDF Format or in Microsoft Word format at <http://ieee-npss.org/technical-committees/radiationeffects/>. Forms should be sent to Megan Casey, Member-at-Large, NAS GSFCC at megan.c.casey@nasa.gov

Conference Information

CONFERENCE LOCATION

The Westin Ottawa with the adjoining Shaw Centre is the location for NSREC 2024.

Ottawa is Canada's capital, a dynamic showcase city of more than one million people. Located in Ontario at the Quebec border, it's a place where you'll hear English and French spoken in the streets; where you can discover Canada's proud heritage at impressive national sites and famous landmarks, including

the Rideau Canal, a UNESCO World Heritage Site. It's a city steeped in culture, with world-class museums and galleries displaying stunning national collections and special exhibitions from Canada and around the world.



Photo courtesy of The Westin Ottawa

This city is a uniquely beautiful place: an urban centre on the edge of nature where you can enjoy the great outdoors either just outside your hotel room or nearby in the surrounding countryside. There's an easy cosmopolitan vibe here, and Ottawa is known for being both welcoming and walkable. Explore the distinctive local neighbourhoods, including the historic ByWard Market: by day this area boasts a bustling farmers' market and chic shops, by night it hums with activity at the restaurants, pubs, and nightclubs.

This is also a city that enjoys the finer things in life, with a culinary community that's earning wide acclaim, unique boutiques and shopping districts, a lively local music and art scene, and always exciting nightlife. The Westin Ottawa is ideally located right downtown, mere steps away from the historic sites and landmarks, and only a short drive from Ottawa's international airport.

This is Ottawa, Canada's capital. Please join us for NSREC 2024 and experience it for yourself.

The location for NSREC 2024 will be the Westin Ottawa and the adjoining Shaw Centre Convention Space in Ottawa, Canada.

Westin Ottawa, 11 Colonel By Dr, Ottawa, ON K1N 9H4, Canada. Website: <https://www.marriott.com/en-us/hotels/yowwi-the-westin-ottawa/overview/>

Shaw Centre, 55 Colonel By Drive, Ottawa, ON K1N, Ottawa, ON K1N 9J2, Canada
Website: <https://shaw-centre.com/>



Photo courtesy of The Shaw Centre

Conference Information

BREAKFASTS, LUNCHES AND BREAKS

The 2024 IEEE NSREC will provide breakfast and refreshments at breaks during the NSREC Short Course and Technical Sessions. Additionally, lunch will be included on Monday for the Short Course attendees. These meals and refreshments are for *registered conference attendees only*. Please see the schedule for times and locations.

The exhibitors will host a lunch on Wednesday, July 26, in the Exhibit Hall. This lunch is for *registered conference attendees and Exhibit Booth Staffers only*.

BUSINESS CENTER

The Westin Ottawa has a Business Center. Designed to accommodate those traveling on business, this self-service facility allows guests to fax, copy, and print documents and surf the web. Take advantage of black and white printers as well as reliable parcel service.

ROOMS FOR SIDE MEETINGS

A few “side meeting rooms” are available for use by any registered conference attendee at the Shaw Centre on a first-come, first-served basis. *NSREC encourages side meetings to be scheduled at times other than during technical sessions*. Send an e-mail to **j.teehan@ieee.org** to make side meeting reservations before the conference. To make a side meeting room reservation during the conference, see the NSREC Registration staff Meeting Room 210 room in the Shaw Centre.

Notes: You must register for the conference before a side meeting room can be reserved! All audio/visual equipment and refreshments must be coordinated directly with the hotel and are the responsibility of the attendee hosting the meeting.

HEALTH AND WELLNESS PROTOCOLS/COVID-19 PREPAREDNESS:

IEEE NSREC will implement health and wellness protocols appropriate to the public health recommendations existing at the time of the conference. Compliance with the protocols adopted by IEEE NSREC may be mandatory for in-person attendance and participation at the conference. We will communicate any additional information regarding the specific health and safety measures, and any necessary consents by you, to attendees and exhibitors before the conference.

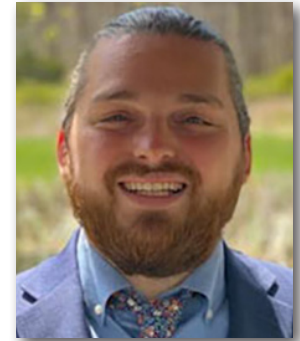
Registration and Travel

CONFERENCE REGISTRATION

NSREC encourages Pre-Registration and offers a lower registration rate, “Early Registration,” if the payment is received no later than Friday, June 28. After that date, the “Late Registration” rates apply.

Registrations can be submitted using the NSREC website link: **www.nsrec.com**. All Registrations must be completed online using the Registration Portal. Telephone registrations will not be accepted.

There are three acceptable forms of payment for registration and activity fees: 1) check made payable to “IEEE NSREC” in U.S. dollars and drawn on a U.S. bank, 2) Wire Transfer, or 3) MasterCard, VISA, Discover, and American Express credit card.



*John Teehan
IEEE Registration Services*

ON-SITE REGISTRATION LOCATION & TIMES IN OTTAWA

Shaw Centre Meeting Room 210.

Registration hours are:

Sunday, July 21	5:00 PM – 8:00 PM
Monday, July 22	7:30 AM – 5:00 PM
Tuesday, July 23	7:30 AM – 5:00 PM
Wednesday, July 24	7:30 AM – 3:00 PM
Thursday, July 25	7:30 AM – 3:00 PM
Friday, July 26	7:30 AM – 10:00 AM

CONFERENCE CANCELLATION POLICY

A \$50 processing fee will be withheld from all refunds. Due to advance financial commitments, refunds of registration fees requested after June 28, 2024, cannot be guaranteed. Consideration of requests for refunds will be processed after the conference. To request a refund, you must notify NSREC at **NSRECCreg@ieee.org**

Registration and Travel

HOTEL ACCOMMODATIONS:

Westin Ottawa
11 Colonel By Dr.
Ottawa, ON K1N 9H4, Canada

Accommodations for the 2024 IEEE NSREC are available at the **Westin Ottawa**

Rest assured with our Commitment to Clean experience at The Westin Ottawa hotel. Our modern downtown Ottawa hotel is located in the Ottawa business district across from the Rideau Canal, an UNESCO World Heritage Site. Our renowned Shore Club restaurant is a popular dining choice for hotel guests and Ottawa locals alike. Stay active during your visit to Canada with our hotel's fitness offerings, including our indoor saltwater pool, our modern fitness center and our private squash courts. Host your next conference or event in our dynamic venues, connected to the Shaw Convention Centre, and take advantage of our state-of-the-art AV equipment and expert planning services. Enjoy a restful night sleep in refined hotel rooms and suites with enriching amenities and stunning views of the Ottawa cityscape at our hotel on Colonel By Drive, Ottawa



Photos courtesy of The Westin Ottawa

Westin Ottawa room rates for a standard king or two queen are:

NEGOTIATED GROUP RATE:
\$259.00 CAD single/double per night

Room taxes currently at 18.45% will be added to all rates listed above.

**If you prefer, you can also call *Marriott Reservations* to confirm your room:
Tel. +1 613-560-7000. Ask for the group named IEEE NSREC.**

Registration and Travel

HOTEL RESERVATIONS

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

Westin Ottawa – Group rate

<https://www.marriott.com/event-reservations/reservation-link.mi?id=1700583106932&key=GRP&app=resvlink>

In any case, enter your arrival and departure dates and follow the prompts.

Room reservations require a credit card as a guarantee. The cut-off for IEEE NSREC reservations is at 5:00 PM Eastern Daylight Time (EDT) on June 21, 2024. Once the room block has been filled OR after the cut-off date (whichever comes first!), it is at the hotel's discretion as to whether they can book more rooms and at what room rate will be offered. Early reservations are strongly suggested!

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

AIRPORT AND TRANSPORTATION INFORMATION

Ottawa Macdonald-Cartier International Airport (code: **YOW**) is located approximately 15 KM from the Westin Ottawa. Traveling outside of normal commuting hours, the drive typically takes between 20-30 minutes. During heavy commuting times, the drive can take up to 60 minutes.

TAXI SERVICE & RIDESHARE

Airport to Hotel Transportation:

There is no scheduled shuttle service between the Hotel and the airport, but there are other options.

- 1) Taxi Service is available at the Ottawa International Airport. Courtesy phones for taxi service are located both inside and outside the terminal at each bag claim area and at other strategic locations outside the terminal exits. Make sure that you give the dispatcher your exact location.

Fares may be pro-rated (shared) when the originating passenger requests it and all other passengers agree.

Rates will be around \$30 - \$50 CAD. Rates may vary due to traffic delays and waiting time.

- 2) OC Transpo is the public transit provider in Ottawa. Bus Route 97 serves the airport using low-floor, fully accessible buses that can accommodate mobility devices. **www.octranspo.com**

- 3) Uber Website: **<https://www.uber.com/>**

- 4) Lyft Website: **<https://www.lyft.com/>**

Registration and Travel

PARKING AND DRIVING DIRECTIONS

On-Site Parking: \$30 CAD

Valet: \$55 CAD

Ottawa Macdonald-Cartier International Airport to the Westin Ottawa:

- Head northeast on Airport Parkway Private/Airport Pkwy
- Keep left to continue on Bronson Ave/Route 79 N
- Turn right onto Findlay Ave
- Turn right onto Broadway Ave
- Turn right onto Torrington PL
- Turn left onto Queen Elizabeth Driveway
- Turn right onto Hawthorne Ave/Pretoria Bridge/Ottawa Regional Rd 91
- Turn left onto Colonel By Dr
- Turn right onto Daly Ave
- Destination will be on your left

GETTING AROUND TOWN

The NSREC optional tours are the easiest way to explore the area. Still, there is much to see and do within walking distance of the hotels. The city is quite safe, so feel free to experience it at your leisure.

TIPS WHEN VISITING OTTAWA

Weather: July is a hot summer month in Ottawa, Canada, with an average temperature fluctuating between 60°F (15°C) and 80°F (26°C).

Driving: Be patient in traffic and mindful of pedestrians. Obey all traffic rules and be alert, whether driving or walking.

Restaurants & Tipping: Be aware that upscale restaurants might require reservations, especially during the busy dining hours of 6:00pm – 8:00pm. Most restaurants accept “casual” dress, although some are less “casual” than others. Standard tipping is 20 percent of the bill. Some restaurants add a “service charge” (gratuity) for groups of 6 or more, so check your bill to see if this has already been added.

Industrial Exhibits



Nadia Rezzak
Industrial Exhibits Chair
Microchip Technology Inc.

The 2024 NSREC Industrial Exhibits will feature the leading worldwide suppliers of radiation hardened products, related materials, services, and research and development. This will be an excellent opportunity for key suppliers, technical engineers and managers to meet and discuss the needs and solutions for electronics used in space vehicles, military electronics, and applications requiring radiation tolerance in harsh environments.

The 2024 NSREC Industrial Exhibits will be held in Canada Hall 2 and 3 on Tuesday and Wednesday. Breakfast and conference breaks will be in the Exhibit Area on Tuesday and Wednesday for registered attendees, with an Exhibitor Lunch to be held on Tuesday and Wednesday. NSREC badges must be worn at all times.

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

We plan to open Exhibit and Supporter Registration in mid-October.

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

For more information contact:

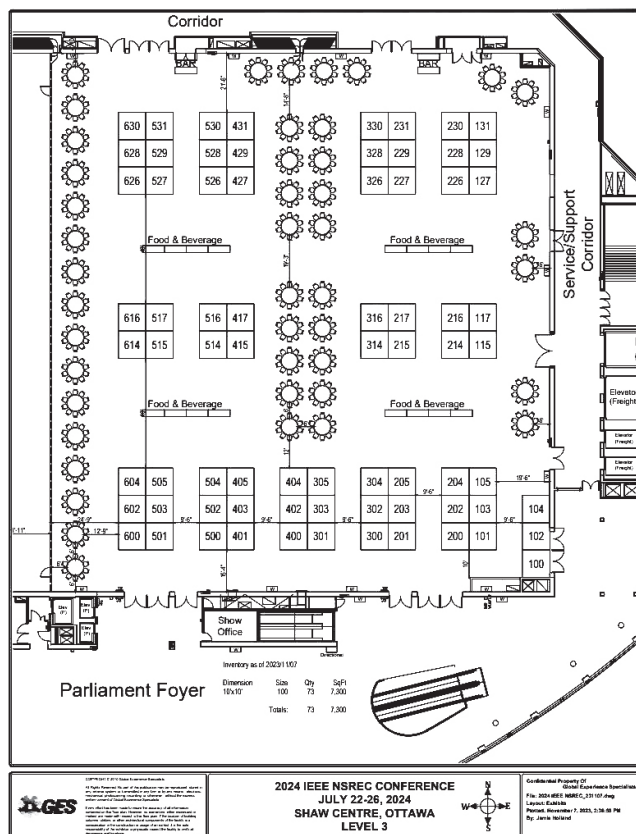
Nadia Rezzak

Phone: 1-615-968-4010

Email: nadia.rezzak@microchip.com

Or visit the 2023 NSREC Industrial Exhibits web site:

Please visit <https://nsrec2024.expofp.com/> for a full sized interactive map



Industrial Exhibits

Please check our web site (www.nsrec.com) for a current listing of companies exhibiting at 2023 NSREC.

NSREC INDUSTRIAL EXHIBITS

CROWN CENTER

EXHIBIT HALL A

EXHIBIT HALL HOURS

TUESDAY, JULY 25

7:00 AM – 4:30 PM

10:15 AM - 10:45 AM
MORNING BREAK

11:50 AM - 1:15 PM
LUNCH

2:50 PM - 3:20 PM
AFTERNOON BREAK

5:30 PM – 7:30 PM
RECEPTION

WEDNESDAY, JULY 26

7:00 AM – 1:30 PM

10:20 AM - 11:00 AM
MORNING BREAK

11:50 AM - 1:30 PM
LUNCH

1:00 PM RAFFLES

(All of the exhibit events are for Registered Attendees; the Exhibit Reception is for Registered Attendees and Guests)

EXHIBITORS

Organization	Internet Site	Booth
3D PLUS USA, INC.	3d-plus.com	404
88-Inch Cyclotron	88-Inch Cyclotron (lbl.gov)	214
Air Force Research Laboratory	afrl.af.mil/RV/	115
AMD	https://www.xilinx.com/	403
Apex Microtechnology	https://www.apexanalog.com/	227
Apogee Semiconductor	apogeesemi.com/	314
Cyclo Technologies Inc.	https://www.cyclotechnologies.com/	401
Crane Aerospace & Electronics	cranae.com	305
Defense Microelectronics Activity	https://www.acq.osd.mil/asds/dmea/	301
Electro Magnetic Applications, Inc.	ema3d.com	515
EMPC	empc.com	216
EPC Space	epc.space/	415-417
EXAIL PHOTONICS	https://www.exail.com/	105
FRIB	frib.msu.edu/fsee	626
FASTRAD®	fastrad.net	526
Foss Therapy Services, Inc.	fosstherapyservices.net/	303
Frontgrade	frontgrade.com	602-604
Honeywell	honeywellmicroelectronics.com	300
IR HiRel, an Infineon Technologies company	infineon.com/hirel	328-330
J.L. Shepherd & Associates	http://jlshepherd.com/	528
Magics Technologies NV	https://www.magics.tech/	304
Micropac	micropac.com	205
Micross Components	micross.com	226
Northrop Grumman	https://www.northropgrumman.com/	204
Phoenix LLC	https://www.phoenixneutronimaging.com/	402
ProNova Solutions	ProNovaRadEffects.com	502
PULSCAN	pulscan.com/	117
QuickLogic Corporation	quicklogic.com/	200
Radiation Test Solutions	radiationtestsolutions.com	503-505
RADNEXT & PAC-G	radnext.web.cern.ch/	504
Renesas Electronics America Inc.	renesas.com/us/en/products/	427-429
Robust Chip	robustchip.com	316
SkyWater Technology	skywatertechnology.com	326
STMicroelectronics	st.com	614-616
Teledyne Brown Engineering	www.tbe.com	500
Texas A&M University Cyclotron Institute	cyclotron.tamu.edu	400
Texas Instruments	ti.com/Space	201-203
Triad Semiconductor	triadsemi.com	517
Trusted Semiconductor Solutions	trustedsemi.com	501
TTM Technologies	www.ttm.com	405
UNITES Systems a.s.	https://unites-systems.com/	127
University of Saskatchewan	https://www.usask.ca/	527
VPT, Inc.	www.vptpower.com/	215-217
Zero-G Radiation Assurance	https://www.zerogradiation.com/	529

Social Program



"Welcome to the Westin Ottawa hotel located in the heart of the Ottawa business district across from the Rideau Canal. Stay active during your visit to Canada with the hotel's fitness offerings, including an indoor saltwater pool, modern fitness center, and private squash courts. We present our social program that will take you to Parliament Hill in Ottawa, Ontario, the capital of Canada to the French Canadian area of Gatineau in Quebec. Come see why Ottawa is so much more than a hockey town."

*Anthony Sanders
NASA Goddard Space Flight Center
Local Arrangements Chair*

The Westin Ottawa with the adjoining Shaw Centre is the location for NSREC 2024. Ottawa is Canada's capital, a dynamic showcase city of more than one million people. Located in Ontario at the Quebec border, it's a place where you'll hear English and French spoken in the streets; where you can discover Canada's proud heritage at impressive national sites and famous landmarks, including the Rideau Canal, a UNESCO World Heritage Site. It's a city steeped in culture, with world-class museums and galleries displaying stunning national collections and special exhibitions from Canada and around the world.

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This is also a city that enjoys the finer things in life, with a culinary community that's earning wide acclaim, unique boutiques and shopping districts, a lively local music and art scene, and always exciting nightlife. The Westin Ottawa is ideally located right downtown, mere steps away from the historic sites and landmarks, and only a short drive from Ottawa's international airport.

The conference committee has designed a social program that will provide you with the highlights of popular and historic sites in Ottawa. **Rideau Hall** and **Parliament Hill** will be the focus of the Tuesday's companion events. Experience the rich history of the Canadian government walking the halls of the **House of Commons**. On Thursday, we will cruise down the **Rideau Canal** and visit the **Canadian War Museum** that serves as both an educational facility on Canadian military history and a place of remembrance.

Wednesday's conference social will be at the **Canadian Museum of History**, Canada's most-visited museum presents the events, people and objects that have shaped the nation. This architectural gem is in Gatineau, Quebec, directly across the Ottawa River from Parliament Hill.

This is Ottawa, Canada's capital. Please join us for NSREC 2024 and experience it for yourself.

Children must be accompanied by an adult during all tours and social events.



Courtesy Ottawa Tourism

Social Program

**SUNDAY, JULY 21, 2024
6:00 PM TO 9:00 PM**

REGISTRATION WELCOME RECEPTION

TRILLIUM

Join us for **complimentary refreshments** in the Trillium Ballroom, located on level 4 of the Shaw Conference Center. The reception is **open to Short Course attendees and registered guests** and is a great time to meet new friends and renew old acquaintances. NSREC attendees and guests must wear **NSREC badges for entrance to the Welcome Reception**. The conference registration desk is open from 5:00 to 8:00 PM to secure badges.

The NSREC 2024 short course and technical sessions will be held in the adjoining Shaw Centre. Experience a renowned convention center in Canada's capital. Known for attention to detail, extensive event resources, and cordial customer service staff. The Shaw Centre boasts three stories of exquisite space with beautiful views of the river and Parliament.



Photo Courtesy: Shaw Centre

**TUESDAY, JULY 23, 2024
8:30 AM TO 4:30 PM**

RIDEAU HALL AND PARLIAMENT HILL

Rideau Hall is a national historic site set in an idyllic, 79-acre urban oasis located only a few minutes from downtown Ottawa and Gatineau. It has been the official residence of every governor general of Canada since 1867 and their workplace since 1940. This site has nearly two centuries of history and has become an important gathering place and site of official activities.



Photo Courtesy: Michael Gatti

The villa, which forms the main part of Rideau Hall, was built in 1838 by Thomas MacKay as a home for his family. A stonemason and contractor, he was also involved in building the entrance locks of the Rideau Canal and the mills at Rideau Falls. Rideau Hall is named after these landmarks. Period photographs show Rideau Hall as a stone villa with a three-storey, semi-circular south façade overlooking the gardens.

At the time when Ottawa—previously known as Bytown—was about to become the new capital of the province of Canada, the Canadian government leased and expanded the residence for Lord Monck, 21st governor general of British North America, who later became Canada's first governor general. A long wing was added to resemble his Québec residence, Spencer Wood (which was renamed Bois-de-Coulange in 1950). It was also during Lord Monck's mandate that the handsome path leading to the front of the house was laid out.

In 1868, the year after Confederation, the Government of Canada purchased the house and grounds for \$82,000 and declared it the official residence for Canada's governors general.

Come visit the residence and workplace of the governor general and the grounds!

Social Program

THE CANADIAN HERITAGE GARDEN



Photo Courtesy: National Capital Commission

Parliament Hill is home to Canada's federal government, where representatives from across Canada gather to make laws that affect the lives of every Canadian. It is also much more. A place to meet, a place to celebrate, and a place to visit, Parliament Hill is the symbolic heart of Canada. It's an area of Crown land on the southern bank of the Ottawa River in downtown Ottawa, Ontario, Canada. It accommodates a suite of Gothic revival buildings whose architectural elements were chosen to evoke the history of parliamentary democracy. Parliament Hill attracts approximately three million visitors each year. The Parliamentary Protective Service is responsible for law enforcement on Parliament Hill and in the parliamentary precinct, while the National Capital Commission is responsible for maintaining the nine-hectare (22-acre) area of the grounds.



Photo Courtesy: Getty Images

Development of the area, which in the 18th and early 19th centuries was the site of a military base, into a governmental precinct began in 1859 after Queen Victoria chose Ottawa as the capital of the Province of Canada. Following several extensions to the Parliament and departmental buildings, and a fire in 1916 that destroyed the Centre Block, Parliament Hill took on its present form with the completion of the Peace Tower in 1927. In 1976, the Parliament Buildings and the grounds of Parliament Hill were designated as National Historic Sites of Canada. Since 2002, an extensive \$3 billion renovation-and-rehabilitation project has been underway throughout the precinct's buildings that is expected to be completed after 2028.

We will tour the **House of Commons**, which came into existence in 1867, when the British Parliament passed the British North America Act 1867, uniting the Province of Canada (which was divided into Quebec and Ontario), Nova Scotia and New Brunswick into a single federation called Canada. The new Parliament of Canada consisted of the monarch (represented by the governor general, who also represented the Colonial Office), the Senate and the House of Commons. The Parliament of Canada was based on the Westminster model (that is, the model of the Parliament of the United Kingdom). Unlike the UK Parliament, the powers of the Parliament of

Social Program

Canada were limited in that other powers were assigned exclusively to the provincial legislatures. The Parliament of Canada also remained subordinate to the British Parliament, the supreme legislative authority for the entire British Empire. Greater autonomy was granted by the Statute of Westminster 1931, after which new acts of the British Parliament did not apply to Canada, with some exceptions. These exceptions were removed by the Canada Act 1982.

The House of Commons has 338 members, each of whom represents a single electoral district (also called a riding). The constitution specifies a basic minimum of 295 electoral districts, but additional seats are allocated according to various clauses. Seats are distributed among the provinces in proportion to population, as determined by each decennial census, subject to the following exceptions made by the constitution. Unlike the members of Parliament in the House of Commons, the 105 senators are appointed by the governor general on the advice of the prime minister.



Photo Courtesy: Library of Parliament

Timeline

- 8:30am: Depart from the Westin hotel to Rideau Hall
- 9:00am: Guided tour Rideau Hall and Grounds
- 11:00am: Depart Rideau Hall
- 11:45am: Arrive to Social Restaurant
- 1:45pm: Depart Social restaurant
- 2:00pm: Arrive to Parliament Hill
- 2:30pm: Security check
- 3:00pm: Guided Parliament House of Commons tour
- 4:00pm: Depart Parliament Hill
- 4:30pm: Arrive Westin hotel

**TUESDAY, JULY 23, 2024
6:00 PM TO 8:00 PM**

**INDUSTRIAL EXHIBITS
RECEPTION**

CANADA HALL 1 & 2

Join us for the 2024 Industrial Exhibits Reception hosted by your NSREC exhibitors. All NSREC attendees and their registered guests are invited for complimentary drinks and a buffet dinner. Drinks will be served in Canada Hall in the Shaw Convention Center followed by a full buffet dinner with seating available. All registered attendees should be sure to visit the booths and participate in the raffles. NSREC attendees and guests must wear NSREC badges for entrance to the Exhibits and Reception.

Social Program

**WED. JULY 24, 2024
11:30 AM TO 1:00 PM**

IEEE YOUNG PROFESSIONALS LUNCHEON

**VENUE TWENTYTWO
(WESTIN HOTEL TOP
FLOOR)**



The annual IEEE Young Professionals lunch will be held on Wednesday in the TwentyTwo room high atop the Westin hotel. IEEE members who are Young Professionals (those who have graduated their first professional degree in the last 15 years; (<https://yp.ieee.org>) are especially invited to register (at no cost) for this unique event. This lunch represents an excellent opportunity to step away from the main conference floor for an hour to mingle with other early career attendees and a few veteran attendees as well.

We heard your suggestions last year, and we'll be mixing our lunch with a little more fun and games this year, not to mention enjoying a spectacular view of downtown Ottawa. Our purpose is to encourage professional development, make new friends, and grow more comfortable within this special community at NSREC. To do that, we'll have some casual games available at each table to get to know each other, and we'll have a fun exercise to work through your questions for the other Young Professionals and any veteran attendees who join us for lunch. Don't worry, you'll have time to eat, too!

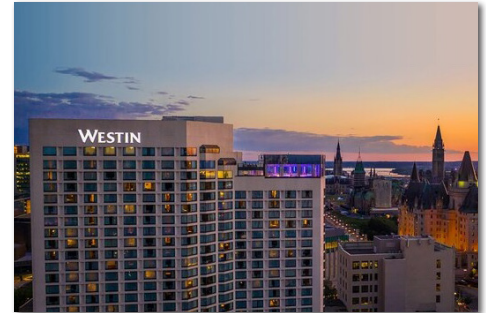


Photo Courtesy: Tripadvisor

Have a brief question you'd like to ask the group about career options, technical growth, workplace personalities, or something else? Submit it to a marked box at registration and we'll do our best to add it to a collective "Jenga tower" of questions!

Please join us atop the Westin Ottawa to enjoy lunch and make some new friends while taking in the fantastic, unique, and panoramic view of Ottawa from twenty-two floors up in the aptly named TwentyTwo.

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

**WED. JULY 24, 2024
4:45 PM TO 10:30 PM**

CONFERENCE SOCIAL CANADIAN HISTORY MUSEUM

Join your colleagues and friends for dinner, beverages, and entertainment at the **Canadian National Museum of History**. The buses will depart from the Westin hotel around 4:45pm and return starting around 9:00pm. While you are catching up with old friends and meeting new ones, explore the grounds and admire the Canadian architect, Douglas Cardinal. Tickets are not included in the conference registration so be sure to purchase them with your registration.



Photo Courtesy: History Hit

Social Program

The Canadian Museum of History is a museum of the history of Canada including the culture and heritage of its Aboriginal people, the Vikings and stories of the leaders and figures who have shaped the nation over time.

The Canadian Museum of History is the most visited Museum in Canada and welcomes over 1.2 million visitors each year to its celebrated complex in the heart of the National Capital Region. In addition to its ongoing exhibitions, including the spectacular Grand Hall and First Peoples Hall, each year the Museum presents a number of outstanding exhibitions focusing on Canadian and world history and civilisations. These exhibitions include those developed by the Museum as well as many produced by other Canadian or international institutions. The Museum is also home to the Canadian Children's Museum, a 500-seat theatre and a 295-seat movie theatre equipped with a giant 3D screen and a giant dome.

Timeline

- 4:45pm: Depart from Westin hotel to National History Museum
- 5:00pm: Arrive to museum exhibit tour (no drinks allowed in exhibit hall)
- 6:30pm: Cocktails in main hall
- 7:15pm: Seating for dinner
- 7:30pm: Plated dinner served
- 9:00pm: First bus return

THURSDAY, JULY 25, 2024
9:00 AM TO 4:30 PM

RIDEAU CANAL CRUISE & CANADIAN WAR MUSEUM

The Rideau Canal is a 202 kilometre long canal that links the Ottawa River, at Ottawa, with the Great Cataraqui River, and then at Lake Ontario at Kingston, Ontario, Canada. Its 46 locks raise boats from the Ottawa River 83 metres upstream along the Rideau River to the Rideau Lakes, and from there drop 50 metres downstream along the Cataraqui River to Kingston.



Photo Courtesy: Trip Canvas

Opened in 1832 for commercial shipping, freight was eventually moved to railways and the St. Lawrence Seaway, and it remains in use today for pleasure boating, operated by Parks Canada May to October. It is the oldest continuously operated canal system in North America, and is a UNESCO World Heritage Site. Discover the richness of the region's historical landmarks during the 90-minute cruise.

Social Program

The **Canadian War Museum** was formally established in 1942, although portions of the museum's collections originate from a military museum that operated from 1880 to 1896. The museum was operated by the Public Archives of Canada until 1967, when the National Museums of Canada Corporation was formed to manage several national institutions, including the war museum. In the same year, the war museum was relocated from its original building to the former Public Archives of Canada building. Management of the museum was later assumed by the Canadian Museum of Civilization Corporation (later renamed the Canadian Museum of History Corporation) in 1990. Plans to expand the museum during the mid-1990s resulted in the construction of a new building at LeBreton Flats. Designed by Moriyama & Teshima Architects and Griffiths Rankin Cook Architects, the new Canadian War Museum building was opened to the public in 2005.



Photo Courtesy: Dominik Gehl

The museum's collection contains over 500,000 pieces of materials related to military history, including over 13,000 pieces of military art. In addition to its permanent exhibition, the museum has hosted and organized a number of travelling exhibitions relating to Canadian military history.

Timeline

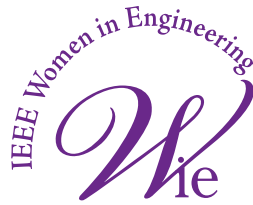
- 9:00am: Depart from Westin hotel to cruise
- 10:00am: Cruise departs
- 11:30am: Cruise returns
- 12:00pm: Lunch on canal at Elgin Restaurant
- 1:30pm: Depart to Canadian War Museum
- 2:00pm: Tour Canadian War Museum
- 4:00pm: Depart Museum and return to hotel
- 4:30pm: Arrive to Westin hotel

Social Program

**THURSDAY, JULY 25, 2024
11:30 AM TO 1:05 PM**

**WOMEN IN ENGINEERING
LUNCHEON**

**VENUE TWENTYTWO
(WESTIN HOTEL TOP
FLOOR)**



NSREC hosted its first IEEE Women in Engineering (WIE) event in 2011 in Las Vegas with general chair Kay Chesnut. Thirteen years later, the annual WIE event is going strong, and attendees have enjoyed hearing speakers from industry, academia, and government. This year we want to hear from you, our NSREC community, to shape future WIE events. Heather Quinn, general chair of the 2024 NSREC, will share her experiences as past chair of the IEEE WIE International

Leadership Conference. Join us for lunch, conversation, and networking. What do you want to experience in future NSREC WIE events? How can the IEEE WIE society positively impact your career and life balance? Let's frame the next few years together!

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

ACTIVITIES POLICIES

Participation: All participants in the NSREC activities must be conference attendees, registered guests of a conference attendee, registered exhibitors or registered guests of an exhibitor. Any children under 18 years of age must be accompanied by an adult at all times; no children will be allowed to attend any function without this adult supervision.

Cancellation: To encourage advance registration for conference social activities, NSREC will refund all activity fees for conference attendees and/or their companions who, for any reason, are unable to attend the conference as long as that notice is provided as follows. If your plans change after your Activities Registration form is submitted, simply request a refund by notifying **John Teehan** via e-mail (**j.teehan@ieee.org**) by no later than July 3rd.

Wheelchairs and Strollers: Both wheelchairs and strollers can be stored in the luggage compartment of the buses but please note that you must provide your own personnel to push these devices.

Local Activities

GENERAL INFORMATION

RIDEAU CENTRE SHOPPING MALL

The Westin is connected to the 3-level Rideau Centre Shopping Mall with 180 retailers including Nordstrom, Coach, Lacoste, Marciano, and Swarovski along with many restaurants, movies, and a food court.



Photo Courtesy: Shaw Centre



Photo Courtesy: Getty Images

BYWARD MARKET

ByWard Market is a buzzing hub of outdoor farmers' market stalls and specialty food shops selling Canadian cheese and maple-infused chocolate. It's also known for its colorful street art and hip stores filled with crafts and clothes by local designers.

- Other nearby shopping:
 - City Centre Mall
 - Ottawa Train Yards
 - St. Laurent Shopping Centre treasures as well.

Explore all 48 KC Parks fountains online and be sure to visit them in person in July!

Local Activities

MUSEUMS AND GALLERIES

THE ROYAL CANADIAN MINT

The **Royal Canadian Mint**'s headquarters occupies the same historic building in Ottawa where it was founded in 1908. Today, the facility proudly produces world-renowned collector coins, gold and silver bullion, and medals and medallions that honour those who have made a significant impact on our country.



Photo Courtesy: The Royal Canadian Mint

THE CANADIAN MUSEUM OF NATURE

The Canadian Museum of Nature is a national natural history museum based in downtown Ottawa. The museum's exhibitions and public programs are housed in the Victoria Memorial Museum Building.



Photo Courtesy: Viator

Local Activities

THE CANADIAN AVIATION AND SPACE MUSEUM

The Canadian Aviation and Space Museum houses the national aeronautical collection and Canada's national aviation history. <https://ingeniumcanada.org/aviation>



Photo Courtesy: Canadian Aviation and Space Museum

OTHER HIGHLIGHTS TO SEE:

Parliament Hill: www.parl.ca

Ottawa Locks: www.rideau-info.com/canal/locks/01-08-ottawa.html

National War Memorial: www.cdli.ca/monuments/on/nationalwar.html

National Gallery of Canada: www.gallery.ca

Notre Dame Basilica: <https://notredameottawa.com>

Ottawa Art Gallery: <https://oaggao.ca>

National Arts Centre: <https://nac-cna.ca/en/>

Canada Agriculture and Food Museum: <https://ingeniumcanada.org/agriculture>

Laurier House National Historic Site: <https://parks.canada.ca/lhn-nhs/on/laurier>

Major's Hill Park: <https://ncc-ccn.gc.ca/places/majors-hill-park>

Jacques-Cartier Park: <https://ncc-ccn.gc.ca/places/jacques-cartier-park>

Prince of Wales Falls:

<https://www.world-of-waterfalls.com/waterfalls/canada-hogs-back-falls/>

Local Activities

MONTREAL – OLD TOWN

Montreal is approximately 2 hours east of Ottawa. Explore Montreal’s cobblestoned Old Port with buildings dating to the 1700s. Visit Notre-Dame Basilica of Montreal, a 19th century masterpiece of Gothic Revival architecture with stained-glass windows depicting Montreal’s history. Rue Saint-Paul is Montreal’s oldest street and is lined with shops and restaurants.

<https://www.frommers.com/slideshows/848530-what-to-do-in-old-montr-al-if-you-have-just-one-day>



Photo Courtesy: National Geographic

GETTING AROUND

Once you’re in Canada’s Capital, getting around is easy in any season! Ottawa is a walkable city with easy access to most sites on foot. Ottawa also offers many transportation options such as public transit, light rail system, taxi services, ride sharing and more!

<https://ottawatourism.ca/en/plan-your-visit/getting-around>

Rideau metro station on the O-Train Confederation Line on Rideau Street on the border of the Sandy Hill and ByWard Market neighbourhoods in Central Ottawa. Entrance is on the lower level of the Rideau Shopping Mall.



Photo Courtesy: OC Transpo

Local Activities

Ottawa Hop-On Hop-Off Bus Sightseeing Tour

<https://www.grayline.com/tours/ottawa-24-hour-hop-on-hop-off-tour/>



Photo courtesy: Gray Line Ottawa

BIKING

<https://ottawatourism.ca/en/ottawa-insider/cycling-ottawa-region>

GOLFING

Royal Ottawa Golf Club: <https://royalottawagolfclub.com/golf/#ifg/>

Pine View: www.pineview.com/en

Ottawa Hunt Club: <https://ottawahuntclub.org>

The Marshes: www.marshesgolfclub.com

Camelot: <https://camelotgolf.ca>

CENTENNIAL FLAME: PARLIAMENT HILL



Photo Courtesy: Tripadvisor

2024 Conference Committee



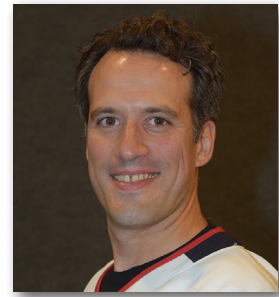
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