UNT
UNIVERSITY OF NORTH TEXAS

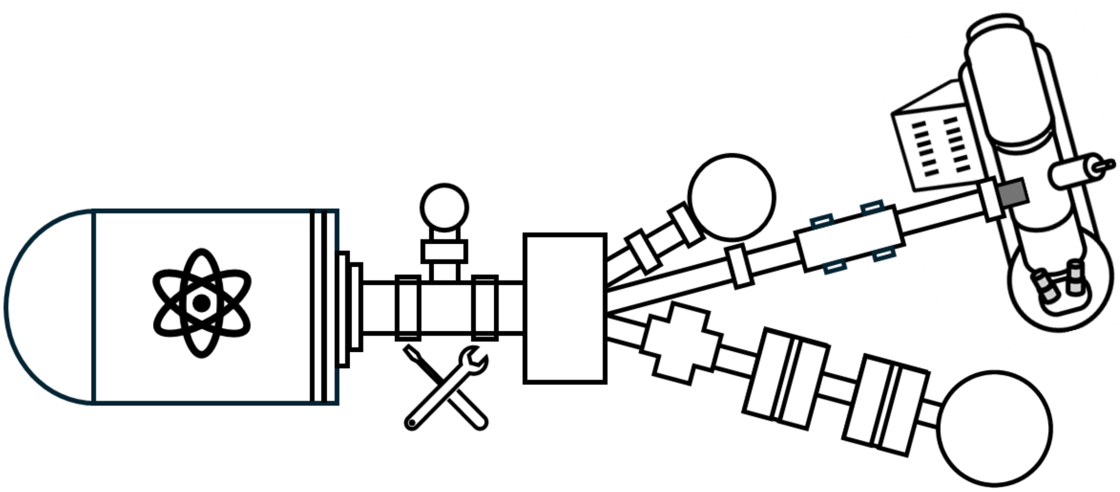
Book of Abstracts

The 28th International Conference on the Application of Accelerators in Research and Industry (CAARI),

The 57th Symposium of Northeastern Accelerator Personnel (SNEAP)

and

The 8th Workshop On TEM With In-Situ Irradiation (WOTWISI)



University Union building, 1155 Union Circle, Denton, TX 76201,
University of North Texas
September 13 through 16, 2026
Denton, Texas, USA

CAARI-SNEAP-WOTWISI 2026

September 13-16, 2026, University Union building, University of North Texas, Denton, TX, USA
www.caari.com

Welcome to the 28th International Conference on the Application of Accelerators in Research and Industry (CAARI), the 57th Symposium of Northeastern Accelerator Personnel (SNEAP), and the 8th Workshop On TEM With In-Situ Irradiation (WOTWISI)

The CAARI-SNEAP-WOTWISI 2026 conference is being hosted by the University of North Texas (UNT) and sponsored along with Sandia National Laboratories (SNL), and Los Alamos National Laboratory (LANL). The conference is also being supported by several other commercial companies involved with accelerator technology.

Our conference series brings together researchers from all over the world who use particle accelerators in both research and industrial applications. Each time the Topic Areas are reviewed and updated to reflect current research interests.

This is the 28th International Conference in the biennial series of International Conference on Application of Accelerators in Research and Industry (CAARI) that began in 1968 as a Conference on the Use of Small Accelerators for Teaching and Research in Oak Ridge National Laboratory (ORNL). When Jerry Duggan joined UNT and moved to Denton, TX in 1974, he continued the conference series and held the meeting on the UNT campus. At this time, Jerry invited Lon Morgan to join him as a co-chair. Lon Morgan brought in the industrial accelerator applications of CAARI and it became known as the *International Conference on the Application of Accelerators in Research and Industry (CAARI)*. CAARI was held in Denton for 30 years. In 2004, Jerry Duggan asked Floyd "Del" McDaniel (UNT) and Barney Doyle (SNL) to be co-chairs of the CAARI Conference Series. In 2004, Barney and Del moved the conference to Fort Worth, Texas, where it was held biennially from 2004-2012. In 2012, Yongqiang Wang (LANL) and Gary Glass (UNT) were invited to become co-chairs and the conference was held in San Antonio, TX. For the 2016 Conference, Arlyn Antolak (SNL) joined as a co-chair and the conference returned to Fort Worth, Texas. Our 2020 conference was cancelled due to the Covid pandemic. The 2022 conference was held at Denton. Again, in 2024, the conference moved back to Forth Worth Texas. This year, the conference returned to the University of North Texas, Union Building after 24 years. Bibhu Rout (UNT) and Stewart Younger-Mertz (Urenco USA) joined as CAARI co-chairs.

SNEAP started its partnership with CAARI in 2022 and will continue working side-by-side for future conferences. SNEAP is an international community of personnel involved with electrostatic particle accelerators and their use. Founded in 1968, the organization has gathered annually to discuss and exchange information to the benefit of all those who attend. Topics covered include ion sources, electrostatic and rf accelerators, telemetry and control systems, cryogenic systems, safety issues, and many other topics relevant to the operation of small to medium-sized electrostatic accelerator laboratories. Ed Stech (University of Notre Dame) currently serves as SNEAP Chair.

The International Workshop on Transmission Electron Microscopy with In-situ Ion Irradiation (WOTWISI) is a premier biannual conference series launched in 2008 at the University of Salford in UK in 2010, and focuses on combining Transmission Electron Microscopy (TEM) with ion irradiation to observe radiation damage in materials in real-time. Khalid Hattar (The University of Tennessee – Knoxville) currently serves as WOTWISI Chair.

We hope that you will find the conference intellectually stimulating and enjoy many opportunities of networking and collaborating with like-minded individuals. The conference schedule provides several opportunities to renew friendships and engage in productive discussions of current and future accelerator research, technologies, and applications. We also want to highlight the *Book of Abstracts* found at CAARI.com which contains the published abstracts submitted to the conference as well as providing a synopsis of the conference.

The CAARI-SNEAP-WOTWISI 2026 conference plans to publish a special issue in Nuclear Instruments and Methods in Physics Research: Beam Interactions with Materials and Atoms (NIMB) as the conference proceedings after the regular peer-review process. The manuscript submission will open from October 1 2026 to January 31 2027. Please refer to the Guide for Authors to prepare your manuscript, and select the article type of "**VSI: CAARI-SNEAP-WOTWISI 2026**" when submitting your manuscript online at the journal's submission platform **NIMB Proceedings Editorial Manager**. More information about the NIMB SI will be posted at CAARI.com.

If there is anything we can do to make your conference experience and stay in Denton, Texas more enjoyable, just ask Bibhu, Ed, Khalid, Stewart, Yong, Arlyn, Gary, and Barney. We are very happy you have joined us and hope you have a memorable time!

Bibhudutta Rout (University of North Texas)
Yongqiang Wang (Los Alamos National Laboratory)
Gary A. Glass (University of North Texas)
Barney L. Doyle (Sandia National Laboratories)
Arlyn Antolak (Sandia National Laboratories)
Khalid Hattar (The University of Tennessee - Knoxville)
Edward Stech (University of Notre Dame)
Stewart Younger-Mertz (Urenco USA)

Local Organizing Committee

Bibhudutta Rout (University of North Texas)
Gary A. Glass (University of North Texas)

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Khalid Hattar (The University of Tennessee - Knoxville)
Edward Stech (University of Notre Dame)
Stewart Younger-Mertz (Urenco USA)

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Joseph Bendahan (Lawrence Livermore National Laboratory)
Barney L Doyle (Sandia National Laboratories)
Jason Dugger (Sandia National Laboratories)
Gary A. Glass (University of North Texas)
Khalid Hattar (University of Tennessee - Knoxville)
Qing Ji (Lawrence Berkeley National Laboratory)
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Bibhudutta Rout (University of North Texas)
Ed Stech (University of Notre Dame)
Theva Thevuthasan (Pacific Northwest National Laboratory)
Yongqiang Wang (Los Alamos National Laboratory)
Stewart Younger-Mertz (Urenco USA)
Yanwen Zhang (Queen's University)

Session Chairs

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Anissa Bey (Washington University in St. Louis)
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Barney L Doyle (Sandia National Laboratories)
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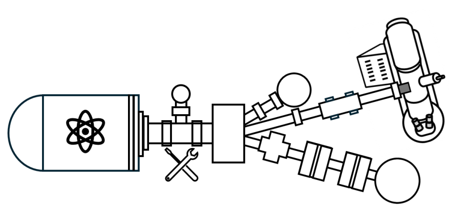
Xuan Li (Los Alamos National Laboratory)
Ming Xiong Liu (Los Alamos National Laboratory)
Wei Liu (Lawrence Berkeley National Laboratory)
Xueying Lu (Northern Illinois University & Argonne National Laboratory)
Daniel Keith Marble (Tarleton State University)
Bethany Matthews (Pacific Northwest National Laboratory)
Mohan Sai Kiran Kumar Yadav Nartu (Pacific Northwest National Laboratory)
Daniel Robertson (University of Notre Dame)
Bibhudutta Rout (University of North Texas)
Ankit Roy (Pacific Northwest National Laboratory)
Alexander Scheinker (Los Alamos National Laboratory)
Franziska Schmidt (Los Alamos National Laboratory)
Andy Smith (University of Manchester)
Theva Thevuthasan (Pacific Northwest National Laboratory)
Igor Usov (Los Alamos National Laboratory)
Yongqiang Wang (Los Alamos National Laboratory)
Duncan Lee Weathers (University of North Texas)
Douglas Wells (New Mexico Institute of Mining and Technology)
Chris Westerfeldt (Duke University & TUNL)
John Thomas Wilkinson (Lawrence Livermore National Laboratory)
Stewart Younger-Mertz (Urenco USA)



Host

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Presenters

The latest assignment of your particular session, location, and time is available in your CAARI-SNEAP-WOTWISI account at https://www.meeting247.com/caari-sneap/. To view it please sign in with the account of the owner of the presentation abstract (the account that was used to submit the abstract to the CAARI-SNEAP-WOTWISI conference).

The Guidelines for Presenters are available at https://caari-sneap.com/presentation-guidelines.

Conference schedules

The schedule of the conference events (social events, refreshments, talks, poster sessions, vendor events) is available as a two-page pdf for download at https://caari.com/session_schedule

Note: Changes happen and we republish the PDF schedule to capture the latest updates. If you are a presenter, please, always check your CAARI-SNEAP-WOTWISI account to see the latest session assignment.

The Book of Abstracts is available both in a pdf version (this file which can be downloaded from https://caari.com) and as a web app via https://www.meeting247.com/caari-sneap/ (filter the talks by day, location, topic, …)

The live schedule of all sessions without the abstracts is also available publicly (no sign-in required) at https://meeting247.com/caari-sneap/pub/program-list.action

Meals

The conference will provide light breakfast, lunch, and dinner from September 14-16, 2026, at the Emerald Ballroom 314B/C. A Welcome Reception will be held Sunday, September 13th from 6:00-8:00 PM at the Senate Chamber (332) at the University Union.

Parking

A limited number of parking passes are available for the duration of the conference. Please email Bibhudutta.rout@unt.edu for the available parking passes or reach out to the registration desk. For more information regarding parking, please visit https://transportation.unt.edu/guests.html.

Internet Connections

A limited number of guest internet accounts with password are available during the conference. Please reach out to the registration desk for the available guest internet accounts. Otherwise, please use your mobile phone carrier or institutional account via Eduroam.

Conference rooms

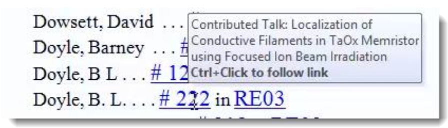
Using this Book of Abstracts

This Abstract Book contains:

1. the session summary,
2. full text of accepted abstracts, and
3. the index of authors and co-authors.

The Abstract Book can be downloaded from the conference website at https://caari-sneap.com/ and is available in several formats. All formats feature mutual hypertext links between the schedule, abstracts, and the author index.

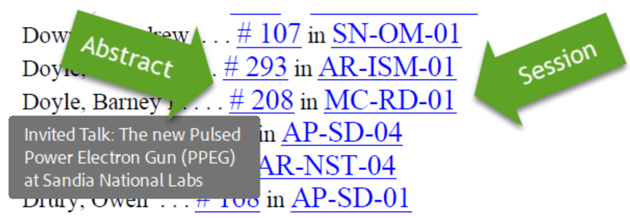
- Laptop or desktop users: the Microsoft Word version offers popup hints - to see them, please, hover the mouse over the hyperlink. Alternatively, a PDF version is also available.

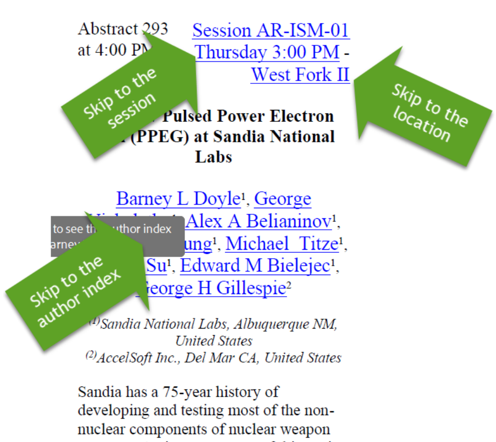


- Users of small mobile devices (tablets or smartphones): While you can certainly use the desktop Word and PDF versions if your device supports them, we have re-sized the Abstract Book to about 4“ width so that if you are viewing the book you do not need to shift the screen horizontally. The mobile version of the Adobe Reader can be downloaded from the corresponding app stores.

Depending on the type of software you chose to view this Book of Abstracts, you may be able to search for keywords in the abstracts, add your own notes, or add bookmarks.

The Book of Abstracts contains information about each presentation including all of the authors and their affiliations. If you wish to find out, for example, when Barney Doyle's talk is to be given, just look up his name in the author index at the end of this book:





Then click on the abstract number to read the full abstract or the session code to view other presentations in the same session.

When you are viewing the abstract click on the author's name to skip to the author index again or click on the session time and location to see all other presentations in this session.

In the example on the left, the abstract header lists the session code (ISM-01), session start time (3 PM), session location/room (West Fork II), abstract number (293) and the time when the talk starts (4 PM).

Hypertext content of this Abstract Book was facilitated by the Meeting247 service

Session Summary

Please note: Posters will be presented during the poster sessions – please see the Session Schedule pdf available for download from https://caari.com/session_schedule .

Disclaimer: Last minute changes happen. The session times and locations listed here may not reflect these latest changes. Before coming to the session always verify the current speaker and session schedules posted at the conference website at https://caari.com/

CA-PS-01: Plenary Session I
Chaired by: Barney L Doyle, Bibhudutta Rout
Monday at 9:00 AM in 314B/C

77 (9:00 AM) Improving gravitational wave detector mirrors: the role of IBA *by François Schiettekatte*

CA-AN-01: Foundation models in nuclear physics
Chaired by: Ming Xiong Liu
Monday at 10:00 AM in 382A

166 (10:00 AM) From Foundation Models to AI Agents for Science and Engineering *by Yihui Ren*
182 (10:30 AM) AI agents assisted real-time intelligent data collection for particle detectors *by Mia Liu*
183 (11:00 AM) Gradient-Informed Training Strategies for Neural Network Extraction of DVCS Observables *by Gerd J. Kunde*

CA-AR-01: Advanced alloy down-selection for nuclear power
Chaired by: Mohan Sai Kiran Kumar Yadav Nartu, Osman El Atwani
Monday at 10:00 AM in 332

16 (10:00 AM) Radiation Effects Beyond Displacement Damage: Ionization-Mediated Defect Evolution *by Yanwen Zhang*
37 (10:30 AM) Leveraging mechanical resonances for the selection of promising materials in complex phase spaces *by Christopher A Mizzi*
39 (11:00 AM) A Robust Alloy Design (RAD) Strategy for Next-Generation (IV) Nuclear Fission Reactors *by MOHAN SAI KIRAN KUMAR YADAV NARTU*

CA-AS-03: Industrial and Medical X-ray and UV Systems and Applications
Chaired by: Sergey V Kutsaev
Monday at 10:00 AM in 314B/C

8 (10:00 AM) Accelerator-based Light Sources for Semiconductor Lithography *by Michael Ehrlichman*
95 (10:25 AM) RadiaBeam electron linear accelerators for industrial applications *by Sergey V Kutsaev*
19 (10:50 AM) Steri-Tek's Capabilities Reach Beyond Electron Beam Sterilization *by Gustavo H.C Varca*
67 (11:15 AM) An X-ray Calibration Method for Gafchromic HD-V2 Film with Applications to Accelerator Pulsed-Beam Diagnostics *by Homeira Faridnejad*

SN-SN-01: Lab Reports I
Chaired by: John Thomas Wilkinson
Monday at 10:00 AM in 339

27 (10:00 AM) Lab Report for Notre Dame Nuclear Science Laboratory *by Edward Stech*
12 (10:15 AM) Update on the CASPAR Underground Accelerator Program *by Daniel Robertson*
61 (10:30 AM) Upgrades and Maintenance of the 3.0 MV Pelletron Tandem and Update of the Experiment Tracking System at the Michigan Ion Beam Laboratory (MIBL) *by Prashanta Niraula*
80 (10:45 AM) Brookhaven National Laboratory Tandem Van de Graaff Accelerator: Annual Operations and Facility Report *by Tom Kubley*
124 (11:00 AM) Laboratory Report discussing upgrades to the FN Tandem and installation of a new 2 MV Singletron in the newly renovated TUNL Low-Energy Nuclear Astrophysics Laboratory and the reinstallation of an upgraded 230 keV ECR accelerator. *by Chris Westerfeldt*

CA-AA-01: General IBA
Chaired by: Igor Usov
Monday at 1:30 PM in 382B

175 (1:30 PM) Characterization of Metal Hydride Targets to Improve Performance and Reliability of Fusion Neutron Generation* *by Jose L. Pacheco*
88 (2:00 PM) Verification of a Semi-implicit PIC Algorithm for Modeling Plasma-based Ion Sources at Scale *by Ryan M. Hedlof*
7 (2:30 PM) Oxygen and carbon depth profile measurements in LiH by Rutherford Backscattering Spectrometry. *by Igor Usov*
21 (2:45 PM) Self-Aligned Nanostructures Induced By Silver Ion Irradiation in Thermally Deposited Gold Thin Films *by Soumya Srotaswini Sahoo*
174 (3:00 PM) A Compact Halbach-Array Magnetic Deflector for Light Element PIXE, and the Limits of Quantitative Low-Z Analysis *by Charles Thomas Bowen*

CA-AI-01: Adaptive Generative AI with Uncertainty Quantification for Autonomous Particle Accelerator Control
Chaired by: Alexander Scheinker
Monday at 1:30 PM in 382A

123 (1:30 PM) Bridging Deep Reinforcement Learning and Adaptive Feedback for Time-Varying Systems *by Shaifalee Saxena*
144 (2:00 PM) Agentic AI for Large-Scale Accelerator User Facilities: Status and Multi-Facility Experience with Osprey *by Gianluca Martino*
112 (2:15 PM) A Foundation Model Approach to Particle Accelerator Operational Data *by Mahindra Rautela*
134 (2:30 PM) Physics-Informed Machine Learning for the FRIB Driver Linac: Surrogate Models, Automated Tuning, and Data-Driven Alignment Diagnostics *by XIlin Zhang*
173 (2:45 PM) OED and MPC for autonomous accelerator control *by Eiad Hamwi*

CA-AR-02: Radiation damage effects in nuclear materials
Chaired by: Andy Smith
Monday at 1:30 PM in 332

36 (1:30 PM) Current status and findings from in-situ irradiation creep testing *by Dave Lunt*
86 (2:00 PM) Stress-Mediated Radiation Effects and the Development of Modern Coupled Irradiation Testing *by Kevin G Field*
23 (2:30 PM) Benchmarking and Refining Machine-Learned Interatomic Potentials for Radiation Damage and Tritium Diffusion in LiAlO2 *by Ankit Roy*

164 (2:45 PM) Irradiation-Induced Mechanical Response of Polymer-Derived SiC: Linking Defect Formation to Hardening *by Harshvardhan Singh*

CA-AS-06: Analysis and Irradiation Damage Studies for Engineered Materials
Chaired by: Jay Theodore Cremer
Monday at 1:30 PM in 314B/C

59 (1:30 PM) On the understanding of the mechanical response of proton-irradiated additively manufactured materials via small-scale mechanical testing. *by Hector R. Siller*
129 (2:00 PM) A light switch for a hidden ferroic order and a case for controlled ion irradiation *by Guru Khalsa*
73 (2:20 PM) Understanding Proton Irradiation-Induced Radiation Hardening and Strain-Rate Sensitivity in LPBF 17-4 PH Stainless Steel Through Nanoindentation *by Lutfun Nipa*
31 (2:40 PM) Ion Beam Channeling Analysis of Helium-Irradiation-Induced Damage and Smart-Cut Exfoliation in Ferroelectric Single Crystals *by Darshpreet Kaur Saini*

SN-SN-04: Lab Upgrades
Chaired by: Chris Westerfeldt
Monday at 1:30 PM in 339

169 (1:30 PM) Deconstruction, Move, and Revitalization of the ASU 1.7 MV Tandetron *by Enzo Adorno*
63 (1:45 PM) Overview of the 2026 TUNL FN Tandem Injector Upgrade *by Thomas C Chappelow*
72 (2:00 PM) Commissioning of the Triton Source at FSU *by Ashton Morelock*
150 (2:15 PM) Running the UW FN Tandem at 8.8 MV for He6-CRES *by Brittney Dodson*
170 (2:30 PM) Design and Installation of a 300 kV Ion Implanter for Dual-Beam Irradiation in Coupled Extreme Environments *by Enzo Adorno*

CA-AA-03: Neutron Based Analysis
Chaired by: Jason Dugger
Monday at 3:30 PM in 382B

146 (3:30 PM) Neutron Diagnostics at Sandia National Laboratories Z-Facility *by Michael Mangan*
119 (4:00 PM) A new target hall for neutron scattering science at the Oak Ridge National Lab (ORNL) Spallation Neutron Source (SNS) *by John Francis Ankner*
125 (4:30 PM) Learning Dynamics in Thin Films from Time-Dependent Neutron Reflectivity Measurements *by Rajeev Kumar*

CA-AN-02: AI application for collider physics I
Chaired by: Xuan Li
Monday at 3:30 PM in 382A

120 (3:30 PM) Bayesian Inference for Precision Studies of the Quark-Gluon Plasma *by Yi (Luna) Chen*
153 (4:00 PM) Gauge-Equivariant Message Passing for Machine Learning of Lattice Gauge Systems *by Gia-Wei Chern*
109 (4:30 PM) AI-ready Detector Representation and Graph Neural Network Reconstruction for the ePIC Barrel Imaging Calorimeter *by Zhiwan Xu*

CA-AR-04: Radiation damage effects at coupled extremes
Chaired by: Franziska Schmidt
Monday at 3:30 PM in 332

24 (3:30 PM) Effects of Magnetic-Field-Assisted Tempering on the Microstructure, Mechanical Properties, and Irradiation Response of HT-9 Steel *by Osman Anderoglu*

167 (3:55 PM) Mapping, Not Sampling: High-Throughput Access to Coupled Extremes in a Single Ion Irradiation *by Rijul Chauhan*
133 (4:20 PM) Effect of Prior Irradiation on the Molten Salt Corrosion Behavior of 316H Stainless Steel *by Michenna Allen*
148 (4:45 PM) Reproducibility and comparability of "bulk" simultaneous irradiation-corrosion studies *by Franziska Schmidt*

CA-AS-07: Medical Applications I: Radioisotope Production
Chaired by: Anissa Bey
Monday at 3:30 PM in 314B/C

107 (3:30 PM) Place for Advancements and New Discoveries with Astatine-211 *by Lauren McIntosh*
93 (4:10 PM) Production of the Radiopharmaceutical ^{44}Sc via Photonuclear Production *by R.P. Zander*
76 (4:35 PM) Photon-Induced Production and Detection of Zirconium Medical Radiotracers: ^{88,89}Zr *by Willie Andrew Hughes*

SN-SN-03: Teaching with Accelerators
Chaired by: Daniel Keith Marble
Monday at 3:30 PM in 339

58 (3:30 PM) Undergraduate-Focused Accelerator Laboratory at Gettysburg College *by Bret E. Crawford*
118 (3:45 PM) Student Traineeship at the Cyclotron Institute at Texas A&M University *by Larry May*
135 (4:00 PM) From Bubble Rafts to Ion Beams: Developing a Pipeline for Future Accelerator Scientists *by Connor Cambria*
10 (4:15 PM) Workforce development for Accelerators: the US Particle Accelerator School *by John Byrd*
189 (4:30 PM) Open Discussion on Training, Recruitment, Education and Outreach. *by Edward Stech*

CA-AA-05: IBA Posters
Chaired by:
Monday at 5:00 PM in 314A

32 (Poster session) Compositional Depth Analysis of Gallium Oxide Films Grown by Chemical Vapor Deposition on Gallium Arsenide Substrates Using Ion Beam Techniques *by Anthony Dobis*
66 (Poster session) Simulation-Based Dynamic Surface Evolution and Degrader-Derived Contamination During Ion Implantation Through Thin Energy-Degrading Foils *by Aaron Michael Richardson*

CA-AF-04: Poster
Chaired by:
Monday at 5:00 PM in 314A

11 (Poster session) Test Facility of Compact Nuclear Microprobe. Numerical Experiment. *by Aleksandr Ponomarev*
57 (Poster session) Research of Gas Insulation of Electrostatic Accelerator *by Igor Ignatiev*
69 (Poster session) LCW Flow Induced Vibration on ALS-U 4th Generation Synchrotron Storage Ring Magnets and Beam Position Monitors *by Ryan Parker Johnson*
105 (Poster session) Update on the Performance of an Accelerator-Based BNCT Cancer Treatment Facility *by Mark Harrison*

116 (Poster session) LONG-TERM STABILITY MAGNET FOR ELECTROSTATIC ACCELERATOR X-RAY SUPPRESSION SYSTEM *by Igor Ignatiev*
158 (Poster session) Development of High and Low Temperature Dual-Beam Irradiation Capabilities at the Tennessee Ion Beam Materials Laboratory *by Connor Cambria*

CA-AN-07: Nuclear and Atomic Physics: Posters
Chaired by:
Monday at 5:00 PM in 314A

28 (Poster session) L X-ray production cross sections of Rh and Pd induced by $^{12}C^{3+}$ and $^{13}C^{3+}$ ions *by Derian Leonel Serrano-Juárez*
78 (Poster session) Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Overview of Reactions To Be Studied *by C. A. Ordonez*
84 (Poster session) Systematic studies to improve the experimental determination of helium 2P fine structure. *by Jeffrey Pound*
113 (Poster session) Using the AMOS Gateway for Low-Energy Electron-Helium Scattering *by S. J. Ward Quintanilla*

CA-AR-10: Radiation damage effects: Posters
Chaired by:
Monday at 5:00 PM in 314A

44 (Poster session) Tuning Superconductivity in FeTe Thin Films through Sulfur Ion Implantation *by Uthpalawanna Abesekera*
92 (Poster session) Microwave Properties of 3D Printed h-BN Foams for Satellite Communications using c-BN as a Pressureless Sintering Aid *by Jason M Summers*
131 (Poster session) Impact of thermomechanical processing on nanomechanical behavior in irradiated tungsten *by Blake Emad*
137 (Poster session) Modeling and Experimental Study of Irradiation of Prefabricated Silicon Nano-Tips and Analysis of Elemental distribution Using Atom Probe Tomography *by Bibhudutta Rout*
176 (Poster session) Charge-Referenced Analysis of Heavy-Ion Response in GaN MIS-HEMTs *by Andres Servando Aguirre*
179 (Poster session) Tuning the Carbon Bonding Configuration and Defect Density of Reduced Graphene Oxide Through Electron Irradiation and Thermal Annealing *by Anil Pudasaini*

CA-AS-09: AS Posters
Chaired by: Jay Theodore Cremer
Monday at 5:00 PM in 314A

65 (Poster session) Effects of Platinum Ion Implantation on the Structural, Optical, Morphological, and Interfacial Electrical Properties of TiO2 Compact Layers on FTO *by Aaron Michael Richardson*

CA-PS-02: Plenary Session II
Chaired by: Gary A. Glass
Tuesday at 9:00 AM in 314B/C

185 (9:00 AM) 50 Years with Ion Beams: Shaping, Probing, and Understanding Materials *by Thirumalai Venkatesan*

CA-AA-04: Nuclear Applications
Chaired by: Jason Dugger
Tuesday at 10:00 AM in 382B

101 (10:00 AM) PANDA-FES: Portable and Adaptable Neutron Diagnostics for Advancing Fusion Energy Science *by Amanda E Youmans*

156 (10:30 AM) Monte Carlo Techniques for Analysis of Positron Impact-Induced Secondary Electron Spectroscopy of Graphene and Graphite *by Nicholas Hancock*
143 (10:45 AM) Adding Neutron Reflectometry to your toolbox: a case study of interfacial shear *by Rebecca Welbourn*

CA-AN-03: AI applications for accelerator physics
Chaired by: Ming Xiong Liu
Tuesday at 10:00 AM in 382A

172 (10:00 AM) Toward Autonomous Accelerators: Machine Learning and Digital Twins for Optimized Beam Delivery *by Eiad Hamwi*
161 (10:30 AM) Autonomous AI Experimentation for Streaming Readout in High Luminosity Nuclear Physics *by Dmitry Romanov*
110 (11:00 AM) Bidirectional Diffusion Models Can Predict their own Rollout Errors for Digital Twins *by Alexander Scheinker*

CA-AR-03: Ion implantation to advance quantum materials research
Chaired by: Wei Liu
Tuesday at 10:00 AM in 332

127 (10:00 AM) Tuning Topological Spin Textures in FeGe via Ion Beam Modification *by Serena Eley*
141 (10:30 AM) Multi-scale reconstruction of single-ion damage tracks in diamond via nitrogen-vacancy centers *by Daniel G. Ang*
163 (11:00 AM) Silicon Spin-Photon Qubits: From Defect Engineering to Integrated Quantum Photonics *by Wayesh Qarony*

CA-PS-04: Nuclear Reactor Tutorial: Generating Electrical Power from Nuclear Fission
Chaired by: Yongqiang Wang
Tuesday at 10:00 AM in 314B/C

128 (10:00 AM) Nuclear Reactor Tutorial: Generating Electrical Power from Nuclear Fission *by Peter Hosemann*

SN-SN-02: Lab Reports II - AMS
Chaired by: Daniel Robertson
Tuesday at 10:00 AM in 339

30 (10:00 AM) Update on the National Ocean Sciences Accelerator Mass Spectrometry Facility *by Kevin T. Macon*
83 (10:15 AM) Center for Accelerator Mass Spectrometry Status Report *by John Wilkinson*
47 (10:30 AM) CAIS-AMS status report *by Gurazada Ravi Prasad*
188 (10:50 AM) Open Discussion and Business Meeting *by Edward Stech*

CA-AA-02: IBA for Fusion/Fission R&D
Chaired by: Stewart Younger-Mertz
Tuesday at 1:30 PM in 382B

40 (1:30 PM) Tri-structural ISOtropic (TRISO) degradation by fission products *by Lyudmila V Goncharova*
103 (2:00 PM) Ion beam analysis for inertial confinement fusion *by S O Kucheyev*
140 (2:30 PM) Ion Beam Analysis of plasma-facing materials for fusion energy development at MIT *by Kevin Benjamin Woller*

CA-AF-01: Accelerator Technology Development

Chaired by: Xueying Lu
Tuesday at 1:30 PM in 339

121 (1:30 PM) High energy x-rays from a compact, accelerator source based on Inverse Compton Scattering *by Gerard Andonian*
122 (2:00 PM) Versatile RFQ Operation for Dual-Species Acceleration and Short-Pulse Beam Generation *by Haoran Xu*
149 (2:30 PM) dCARA: A Compact Driver for High-Fluence Neutron Sources *by Yong Jiang*

CA-AR-05: Radiation damage effects in materials I
Chaired by: Ankit Roy
Tuesday at 1:30 PM in 332

15 (1:30 PM) Ion Irradiation Effects in High-Entropy Oxides *by William J Weber*
115 (2:00 PM) Quantifying What Ions Leave Behind: An AI/ML-Driven Multi-Scale Analysis of Heavy Ion-Irradiated GaN *by Bethany Matthews*
177 (2:30 PM) Radiation effects on the structure and properties of glass and amorphous materials: insights from atomistic simulations *by Jincheng Du*
99 (2:45 PM) Phase Stability of a Zr-Ru BCC+B2 Eutectic Refractory Alloy during Annealing and Proton Irradiation *by Nasim Mahmud Polash*

CA-AS-08: Medical Applications II: Radioisotope Production and Particle Therapy
Chaired by: Anissa Bey
Tuesday at 1:30 PM in 314B/C

34 (1:30 PM) Advanced Porous Materials for Enhancing Target Functionality: An At-211 Case Study *by Ashley M Hastings*
74 (1:55 PM) Dosimetric Characterization of a Preclinical Synchrocyclotron FLASH Platform *by Anissa Bey*
33 (2:20 PM) Physical Separation of ^{18}F via $^{19}F(\gamma,n)^{18}F$ and Kinematic Recoil with Electron Linear Accelerators *by Mariana Baca*
68 (2:40 PM) Development and Geant4 Validation of a Gafchromic HD-V2 Film Dosimetry Method for Low-Energy Proton Cell Irradiation at ECU Accelerator Lab *by Homeira Faridnejad*

WT-WT-01: Workshop on TEM with In-site Irradiation I
Chaired by: Khalid Hattar
Tuesday at 1:30 PM in 382A

38 (1:30 PM) Microscope and Ion Accelerators for Materials Investigations (MIAMI-2) Facility *by Jonathan A Hinks*
181 (2:00 PM) The in situ dual ion beam TEM at JANNuS-Orsay: recent updates and perspectives *by Aurelie Gentils*
45 (2:30 PM) IVEM-Tandem Facility: Overview and Capability Update *by Wei-Ying Chen*

CA-AF-02: Accelerator Facilities and Research I
Chaired by: Qing Ji
Tuesday at 3:30 PM in 339

85 (3:30 PM) BeamNetUS: Accelerating Beam-Based Research *by Tom Kubley*
29 (4:00 PM) Advancing particle accelerator technology and control at High Voltage Engineering *by Alessandra Palazzo*
98 (4:20 PM) Progress Report on the High-Current Electron-Beam Ion Source Charge Breeder for the ReAccelerator at the Facility for Rare Isotope Beams *by Hyock-Jun Son*
100 (4:40 PM) Progress in in-situ Positron Beamline Development at Los Alamos National Laboratory *by Thai hang Chung*

CA-AR-06: Radiation damage effects in materials II
Chaired by: THEVA THEVUTHASAN, Satya Kushwaha
Tuesday at 3:30 PM in 332

22 (3:30 PM) Multiscale Modeling of Radiation Damage and Tritium Transport in Lithium Aluminate Ceramics *by Ankit Roy*
145 (4:00 PM) Preferential Void Swelling Along Cellular Walls in Additively Manufactured 316L Stainless Steel Under Fe Self-Ion Irradiation *by Alec Curtis Pfundheller*
25 (4:30 PM) Influence of Initial Damage State and Electronic Energy Loss on Ionization-Induced Damage Recovery in Silicon Carbide *by William Lenouvel*
139 (4:45 PM) Floating-Zone Growth of SiC Single Crystals and Prospects for Ion-Beam Modifications *by Satya K Kushwaha*

CA-AS-01: Security & Defense Applications I: Accelerator-Based Systems
Chaired by: Joseph Bendahan
Tuesday at 3:30 PM in 314B/C

4 (3:30 PM) Advanced Compact Linear Accelerator Concepts and New Developments at Varex Imaging Corporation *by Andrey Valentinovich Mishin*
41 (4:00 PM) Commissioning and Initial Demonstrations of the Tunable Inverse Compton Scattering X-Ray Source at RadiaBeam *by Robert Berry*
81 (4:20 PM) Demonstration of Battery-Operated 3 MV Linac for Threat Detection *by Kirk Bertsche*
20 (4:40 PM) High-Energy Tomographic Scanner for Inspection of Contraband in Air Cargo *by Joseph Bendahan*

CA-PS-05: Ion Beam Analysis Tutorial
Chaired by: Bibhudutta Rout, Satya Kushwaha
Tuesday at 3:30 PM in 382B

142 (3:30 PM) A Tutorial on Rutherford Backscattering Spectrometry: Concurrent Depth Profiling and Radiation Evaluation of Perovskite Solar Cells *by Mritunjaya Parashar*
154 (4:15 PM) A Tutorial on Particle-Induced X-ray Emission (PIXE) Spectroscopy: From Concentration Analysis to Elemental Mapping *by Darshpreet Kaur Saini*

WT-WT-02: Workshop on TEM with In-situ Irradiation (II)
Chaired by: Khalid Hattar
Tuesday at 3:30 PM in 382A

43 (3:30 PM) Irradiation induced phase transformation in Fe2O3 and Cr2O3and its impact on irradiation induced-loop formation through the use of in-situ TEM and spatially resolved EELS spectroscopy *by Djamel Kaoumi*
184 (4:00 PM) In-Situ Approaches for Structural and Chemical Analysis in Extreme Environments *by Christopher M Smyth*
178 (4:30 PM) Proton-Irradiation Response of Laser Powder Bed Fused W and W-5Re Alloy *by Krishna Kamlesh Verma*

CA-PS-06: Vendor Road show-Dinner talk
Chaired by: Bibhudutta Rout
Tuesday at 6:30 PM in 314B/C

187 (6:30 PM) Vendor Roadshow *by Bibhudutta Rout*

CA-PS-03: Plenary Session III
Chaired by: Yongqiang Wang

Wednesday at 9:00 AM in 314B/C

130 (9:00 AM) Starting the Fusion Fuel Cycle Without a Fusion Reactor: A New Supply of Commercial Tritium *by Terence J. Tarnowsky*

CA-AF-03: Accelerator Facilities and Research II
Chaired by: Qing Ji
Wednesday at 10:00 AM in 339

52 (10:00 AM) A Generalized Principle of Resonant Coupling *by James M. Potter*
152 (10:20 AM) An Ion Track You Can Aim: A Quasi-Bessel Laser Platform for Depth-Controlled Single-Event Effects Testing *by Rodolfo Antonio Rodriguez Davila*
79 (10:40 AM) Capabilities and Infrastructure Upgrades at the Michigan Ion Beam Laboratory (MIBL) *by Prashanta Niraula*
104 (11:00 AM) Overview of the University of North Texas Ion Beam Laboratory for Materials Modification and Microanalysis *by Todd Byers*

CA-AN-04: AI applications for collider physics II
Chaired by: Xuan Li
Wednesday at 10:00 AM in 382A

160 (10:00 AM) Machine Learning in Lattice QCD for EIC Physics *by Huey-Wen Lin*
151 (10:30 AM) Calorimeter-only collision-vertex reconstruction at sPHENIX with a Vision Transformer *by Hanpu Jiang*
136 (11:00 AM) SIDERIUS: Resource-Aware AI Agents for Particle and Nuclear Physics *by Aobo Li*

CA-AR-07: Radiation damage effects in materials III
Chaired by: Bethany Matthews
Wednesday at 10:00 AM in 332

108 (10:00 AM) Advancing Reliable Ion Irradiation Studies Through Refined DPA Calculations and Artifact Control *by Yan-Ru Lin*
162 (10:30 AM) Mitigating Heavy-Ion Irradiation Artifacts through Neutron and Proton Preconditioning *by Yinyin Hong*
62 (11:00 AM) A new tool to unlock the capabilities of SRIM: Investigating the ability of ion beams to emulate neutron irradiation *by Noah Miggiani*

CA-AS-04: Compact Accelerator-Based Systems for Geo-Physical Applications
Chaired by: Weijun Guo, Jay Theodore Cremer
Wednesday at 10:00 AM in 314B/C

114 (10:00 AM) Replacing Americium-Beryllium-based Well Logging Tools *by Paul Groth*
132 (10:30 AM) Energy Transition- A Potential Role for Accelerators? *by Ahmed Badruzzaman*
26 (11:00 AM) Experimental Characterization and Particle-in-Cell Modeling of a Penning Ion Source for Compact D-T Neutron Generators *by Valentin Chalancon*

CA-AN-05: Nuclear reactions for isotope applications
Chaired by: Douglas Wells, Xuan Li
Wednesday at 1:30 PM in 382A

157 (1:30 PM) Edge AI for feature streaming of radiation detectors *by Maxx Lowy*
82 (2:00 PM) Photonuclear Production Yields for Radioisotopes of Terbium *by Aidan Villa*
6 (2:15 PM) Measurement of photonuclear cross-section and production yields of ^{100}Mo(g,x)^{99}Mo, ^{100}Mo(g,np)^{98m}Nb, and ^{59}Co(g,xn; x=1-4) $^{58\text{-}55}$Co reactions with 50-70 MeV bremsstrahlung *by Md Shakilur Rahman*

87 (2:30 PM) Precise cross-section measurement of the 11B(p,α)$\alpha\alpha$ resonance using the inverse kinematics technique *by Jorden K. Matty*
94 (2:45 PM) Research and Education using Photonuclear Reactions for Isotope Production *by Douglas Wells*

CA-AR-08: Radiation effects in functional materials I
Chaired by: Bibhudutta Rout, Satya Kushwaha
Wednesday at 1:30 PM in 332

35 (1:30 PM) Laser Impulse Dependence on Scale, Laser Intensity and Tamper Materials *by F N Beg*
147 (2:00 PM) Impact of Ion Implantation of Bolometric Properties of VOx Films. *by Alia Naciri*
97 (2:15 PM) Dynamic, Temperature Dependent Radiation Induced Conductivity Analysis of Dielectric Materials *by Tyler Heggenes*
90 (2:30 PM) Instrumentation for Radiation Induced (RIC) and Constant Voltage (CVC) Conductivity Measurements *by Jenny Rebecca Whiteley*
155 (2:45 PM) Engineering Amorphous Vanadium Oxide Thin Films for Infrared Radiation Detection through Control of Growth Conditions *by James Abraham*

CA-AS-02: Security & Defense Applications II: Accelerator-Based Systems and Detectors
Chaired by: Joseph Bendahan
Wednesday at 1:30 PM in 314B/C

171 (1:30 PM) A Laser-Plasma-Accelerator-Driven Pump-Probe Platform for Time-Resolved Studies of Transient Defects in Scintillators *by Weronika Wiktoria Wolszczak*
75 (2:00 PM) Characterization of Proton and Ion Quenching in GAGG:Ce Crystals *by Nicholas Floyd*
106 (2:20 PM) Compact neutron source and high throughput detector for portable active interrogation missions *by Christopher Cooper*
42 (2:40 PM) A Portable SSA-Driven Linac for Radiography *by Connor Gunter*

WT-WT-03: Workshop on TEM with In-situ Irradiation (III)
Chaired by: Khalid Hattar
Wednesday at 1:30 PM in 339

56 (1:30 PM) Tracing Ionization-Driven Aion Void Lattice Self-Organization in CaF_2 by In Situ Electron Irradiation *by Lingfeng Zhou*
55 (1:45 PM) Intermittent 3D Reconstruction in In-Situ Irradiation TEM experiments: Toward Unified Spatial-Temporal Characterization of Defect Evolution *by Hangyu Li*
165 (2:00 PM) Installation of an in situ Ion Gun on a JEOL JEM-2100 Plus for Dual-Beam Transmission Electron Microscopy at the Tennessee Ion Beam Materials Laboratory *by Harshvardhan Singh*
53 (2:15 PM) Towards a Deployable Automated In Situ TEM Drift Correction and 3D Reconstruction System *by Ian L Steigerwald*
54 (2:30 PM) Precipitate dissolution in advanced RAFM steel recorded during in situ TEM dark-field heavy-ion irradiation *by Ethan M. Polselli*
168 (2:45 PM) Design and Development of the Tennessee Ion In Situ Scanning Electron Microscope *by Enzo Adorno*
186 (3:00 PM) Discussion of the Future of TEM and Coupled Ion Accelerators *by Lewys Jones*

CA-AN-06: Accelerator advances for basic physics research
Chaired by: Duncan Lee Weathers, Ming Xiong Liu
Wednesday at 3:30 PM in 382A

111 (3:30 PM) TexNAAM: Texas NaI(Tl) Array for Astrophysical Measurements *by Marina Barbui*
70 (3:45 PM) Design and Testing of Magnetic Analyzers for X-Pinch Accelerated Electron and Ion Beams *by Aspen Wagner*
17 (4:00 PM) Characterization of Forward-directed Neutrons from the Inverse-Kinematics $^{1}H(^{7}Li,n)^{7}Be$ Reaction for the development of a Lithium-Beam-Driven Neutron Source *by Toshiro Sakabe*
50 (4:15 PM) Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Intense Charge-Neutralized Ion Beam Development *by Kelly Wood*
89 (4:30 PM) Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Charged Particle Diagnostics and Coincidence Measurements *by Luke P Claycomb*
64 (4:45 PM) Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Neutron Diagnostics and Target-Temperature Control *by Daniel Khalil Brown*

CA-AR-09: Radiation effects in functional materials II
Chaired by: Yongqiang Wang
Wednesday at 3:30 PM in 332

180 (3:30 PM) The Silicon Color Center Zoo and its Applications to Quantum Information Processing *by Cody Fan*
96 (4:00 PM) Mechanical Properties of Low-Energy Electron-Irradiated Graphene: Modeling the Two-Stage Response Using a Local Defect Activation Model *by Jose Perez*
49 (4:15 PM) Scanning Tunneling Microscopy of Hydrogenated Highly Oriented Pyrolytic Graphite After Electron Irradiation in Ultra High Vacuum *by Franklin Talbert*
91 (4:30 PM) Ambient-Air Electron Irradiation as a Simple Route for Defect Engineering and Surface Functionalization of Graphene for Functional Device Applications *by Thineth Bandara Jayamaha*
46 (4:45 PM) Low-Energy Electron Irradiation Effects in Polycrystalline Chemical Vapor Deposition Graphene Under Ultra-High Vacuum *by Jacob Hardin*

CA-AS-05: Advances in Accelerator-Based Sterilization Systems and Blood/Food Irradiators
Chaired by: Md Kamrul Hasan
Wednesday at 3:30 PM in 314B/C

18 (3:30 PM) Steri-Tek - Who We Are, What We Do, and How We can Help *by Brian Potts*
117 (3:52 PM) Accelerator-Based Irradiation as a Response to Rising Foodborne Illness: Engineering Advancements That Safely Support Pathogen Control *by Michael Christofaro*
48 (4:14 PM) An Integrated Database and AI Expert for Radiation Compatibility of Medical Device Polymers *by Yelin Ni*
60 (4:36 PM) Material Compatibility and Functional Performance of Greiner Bio-One Blood Collection Tubes Following Gamma, Electron Beam, and X-ray Sterilization *by Md Kamrul Hasan*

Posters
Will be presented on poster boards during the Poster Sessions

CA-AA-05 # 32 Compositional Depth Analysis of Gallium Oxide Films Grown by Chemical Vapor Deposition on Gallium Arsenide Substrates Using Ion Beam Techniques *by Anthony Dobis*
CA-AA-05 # 66 Simulation-Based Dynamic Surface Evolution and Degrader-Derived Contamination During Ion Implantation Through Thin Energy-Degrading Foils *by Aaron Michael Richardson*
CA-AF-04 # 11 Test Facility of Compact Nuclear Microprobe. Numerical Experiment. *by Aleksandr Ponomarev*
CA-AF-04 # 57 Research of Gas Insulation of Electrostatic Accelerator *by Igor Ignatiev*
CA-AF-04 # 69 LCW Flow Induced Vibration on ALS-U 4th Generation Synchrotron Storage Ring Magnets and Beam Position Monitors *by Ryan Parker Johnson*
CA-AF-04 # 105 Update on the Performance of an Accelerator-Based BNCT Cancer Treatment Facility *by Mark Harrison*
CA-AF-04 # 116 LONG-TERM STABILITY MAGNET FOR ELECTROSTATIC ACCELERATOR X-RAY SUPPRESSION SYSTEM *by Igor Ignatiev*
CA-AF-04 # 158 Development of High and Low Temperature Dual-Beam Irradiation Capabilities at the Tennessee Ion Beam Materials Laboratory *by Connor Cambria*
CA-AN-07 # 28 L X-ray production cross sections of Rh and Pd induced by $^{12}C^{3+}$ and $^{13}C^{3+}$ ions *by Derian Leonel Serrano-Juárez*
CA-AN-07 # 78 Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Overview of Reactions To Be Studied *by C. A. Ordonez*
CA-AN-07 # 84 Systematic studies to improve the experimental determination of helium 2P fine structure. *by Jeffrey Pound*
CA-AN-07 # 113 Using the AMOS Gateway for Low-Energy Electron-Helium Scattering *by S. J. Ward Quintanilla*
CA-AR-10 # 44 Tuning Superconductivity in FeTe Thin Films through Sulfur Ion Implantation *by Uthpalawanna Abesekera*
CA-AR-10 # 92 Microwave Properties of 3D Printed h-BN Foams for Satellite Communications using c-BN as a Pressureless Sintering Aid *by Jason M Summers*
CA-AR-10 # 131 Impact of thermomechanical processing on nanomechanical behavior in irradiated tungsten *by Blake Emad*
CA-AR-10 # 137 Modeling and Experimental Study of Irradiation of Prefabricated Silicon Nano-Tips and Analysis of Elemental distribution Using Atom Probe Tomography *by Bibhudutta Rout*
CA-AR-10 # 176 Charge-Referenced Analysis of Heavy-Ion Response in GaN MIS-HEMTs *by Andres Servando Aguirre*
CA-AR-10 # 179 Tuning the Carbon Bonding Configuration and Defect Density of Reduced Graphene Oxide Through Electron Irradiation and Thermal Annealing *by Anil Pudasaini*
CA-AS-09 # 65 Effects of Platinum Ion Implantation on the Structural, Optical, Morphological, and Interfacial Electrical Properties of TiO2 Compact Layers on FTO *by Aaron Michael Richardson*

CAARI-SNEAP-WOTWISI Abstracts

Abstract 77 at 9:00 AM — Session CA-PS-01 Monday 9:00 AM - 314B/C

Improving gravitational wave detector mirrors: the role of IBA

François Schiettekatte

Département de physique , Université de Montréal, Montreal Quebec, Canada

The quest for the detection of gravitational wave detection has been one of reducing noises to the point where the instruments are sensitive to the displacement by less than 1 attometer of mirrors separated by a few km. Current detectors are limited in their most sensitive frequency range (around 100 Hz) by thermally activated atomic reorganizations in the amorphous coatings of their mirrors, which make the coating thickness fluctuate. Many efforts are undertaken to identify materials, architectures or synthesis and post-treatment strategies that result in less coating thermal noise while complying with other constraints such as sub-ppm absorbance, few ppm scattering and sub-nm layer uniformity. In this presentation, we will review these efforts, showing how ion beam analysis has been instrumental in characterizing the composition of these coatings, detecting impurities and measuring their density, but also to understand the transport in these materials, in that quest for lower coating noise.

Abstract 166 at 10:00 AM — Session CA-AN-01 Monday 10:00 AM - 382A

From Foundation Models to AI Agents for Science and Engineering

Yihui Ren

AI Department, Brookhaven National Laboratory, Upton NY, United States

Artificial intelligence is rapidly changing how we approach scientific discovery and engineering design. However, realizing the potential of modern AI in scientific domains requires going beyond simply applying models developed for natural language: scientific data have distinct structures, and scientific workflows often require tight integration among learned representations, domain knowledge, simulation, and numerical optimization.

In this talk, I will present two recent efforts that explore complementary directions for building AI systems for science and engineering. First, FM4NPP investigates whether the foundation-model paradigm can scale to experimental nuclear and particle physics. Using more than 11 million particle-collision events, we develop a self-supervised learning framework for sparse detector data and demonstrate scaling up to 188 million parameters. The resulting representations generalize across diverse downstream tasks and enable data-efficient adaptation with lightweight task-specific components.

Second, I will present AutoSizer, an LLM-driven framework for automatic sizing of analog and mixed-signal circuits. Rather than asking an LLM to perform numerical optimization directly, AutoSizer uses the LLM as a reasoning and orchestration layer that interprets circuit behavior, analyzes simulation feedback, and adaptively refines the optimization process.

Together, these studies illustrate two complementary roles for modern AI in scientific workflows: learning reusable representations from complex scientific data and reasoning over computational tools to guide challenging design and optimization problems. I will discuss the lessons from these efforts and opportunities toward more general, scalable, and reusable AI systems for science and engineering.

Abstract 182 at 10:30 AM — Session CA-AN-01 Monday 10:00 AM - 382A

AI agents assisted real-time intelligent data collection for particle detectors

Mia Liu

Purdue University, West Lafayette IN, United States

Advances in artificial intelligence over the past decade can significantly enhance the discovery potential of modern scientific experiments. Integrating AI into the data-generation and processing pipelines of large, complex scientific instruments opens new pathways toward discoveries that are currently inaccessible. To harness proton-proton collisions at unprecedented energies and rates at the Large Hadron Collider (LHC), paradigm-shifting search strategies and innovative instrumentation with embedded AI capabilities are being developed and deployed. I will highlight several of these opportunities and the associated technological challenges in processing LHC data. I will also discuss emerging work at the Electron-Ion Collider (EIC), including the use of AI agents to coordinate and optimize scientific workflows and the development of intelligent streaming-readout systems for continuous, real-time data processing. Together, these efforts demonstrate synergistic advances across experimental physics and other scientific domains.

Abstract 183 at 11:00 AM — Session CA-AN-01 Monday 10:00 AM - 382A

Gradient-Informed Training Strategies for Neural Network Extraction of DVCS Observables

Liliet Calero Diaz, James L. Amarel, Ben J. Migliori, Gerd J. Kunde

Los Alamos National Laboratory, Los Alamos NM, United States

As AI becomes an established tool in nuclear physics, machine learning workflows must be adapted to the structure of experimental data. Here measurements arrive as correlated kinematic set, fixed (k, Q^2, x_B, t) configurations scanned in azimuthal angle φ, rather than the independent samples assumed by standard deep learning practice.
We present a systematic study of training methodologies for deep neural network regression of Deeply Virtual Compton Scattering cross sections across 300+ kinematic sets, framed as multi-task learning with each set as a related task. Our baseline combines full-batch optimization with a per-set loss that weights every kinematic configuration equally regardless of point count. Against it, we compare structure-based batching (random, set-based, φ-based), which exposes a tension between global kinematic coverage and preserving the harmonic φ-dependence within each set, and five gradient-informed strategies. Using per-set gradient similarities and magnitudes, these either **partition** the data—clustering, dynamic sampling, magnitude stratification—or **modulate** a global objective—uniqueness-based loss weighting and curriculum scheduling.

Abstract 16 at 10:00 AM — Session CA-AR-01 Monday 10:00 AM - 332

Radiation Effects Beyond Displacement Damage: Ionization-Mediated Defect Evolution

Yanwen Zhang[1], William J. Weber[2]

(1)Mechanical and Materials Engineering, Queen's University, Kingston Ontario, Canada
(2)Materials Science & Engineering, University of Tennessee, KNOXVILLE Tennessee, United States

Radiation effects have traditionally been interpreted primarily in terms of ballistic collisions that displace atoms and generate vacancies, interstitials, defect clusters, dislocation loops, gas bubbles, and irradiation-induced phase changes. However, energetic particles also deposit substantial energy into the electronic subsystem through excitation and ionization. The resulting electronic and atomic processes are strongly coupled and can drive materials far from thermodynamic equilibrium. Understanding these coupled nuclear and electronic energy-deposition pathways[1,2] is therefore essential for predicting and potentially controlling the long-term evolution of materials.
This presentation focuses on how ionization-mediated processes influence defect production, recombination, clustering, and phase stability in three representative classes of nuclear materials: predominantly covalent silicon carbide, largely ionic oxides, and chemically complex metallic alloys. These systems provide contrasting bonding environments and electron-phonon coupling strengths. In SiC, ballistic collision cascades generate local disorder, yet electronic excitation can promote athermal defect recombination and dynamic recovery when energy is transferred sufficiently rapidly from excited electrons to the lattice. Such ionization-assisted healing reduces surviving defects and delay amorphization, although the outcome depends strongly on temperature, initial disorder, stopping power, and the spatial and temporal overlap between electronic and nuclear energy deposition. These effects are directly relevant to predicting SiC performance in advanced fission fuels, fusion systems, and radiation-resistant electronic components. In oxides, ionization may produce a different response. Intense electronic energy deposition can generate localized spikes, reshape existing defect structures, and either promote recovery or produce new damage morphologies, such as amorphous ion tracks. Examples involving materials such as

$SrTiO_3$ and Ga_2O_3 illustrate how electronic excitation can alter disorder accumulation, defect redistribution, and phase stability in materials relevant to dielectric components, optical systems, sensors, and harsh-environment electronics for nuclear instrumentation. By contrast, in metallic alloys, rapid electronic energy transport and relatively weak electron-phonon coupling modify the spatial and temporal development of collision cascades. Chemical disorder in concentrated solid-solution alloys and high-entropy alloys further changes defect migration pathways, energy dissipation, and the probability of defect recombination, producing irradiation responses that can differ substantially from those of conventional dilute alloys.

These examples suggest that radiation tolerance cannot be predicted from displacement events alone.[1,2] It must also account for bonding characteristics, chemical complexity, electronic energy transport, and the ability of the local atomic structure to reorganize after collision cascades. By combining tunable ion irradiation, quantitative **in situ** measurements, advanced microscopy, and physics-based modeling, our ongoing research seeks to move beyond describing radiation damage toward identifying practical control parameters for steering microstructure evolution.

References:

1. Y. Zhang and W.J. Weber, Ion irradiation and modification: the role of coupled electronic and nuclear energy dissipation and subsequent nonequilibrium processes in materials, Applied Physics Review, 7, 041307 (2020).
2. Y. Zhang, G. Velişa, W.J. Weber, Ion beam analysis of nuclear materials: insights into radiation damage and defect dynamics, Nucl. Instrum. & Meth. B 575 (2026) 166105.

Abstract 37 at 10:30 AM — Session CA-AR-01 Monday 10:00 AM - 332

Leveraging mechanical resonances for the selection of promising materials in complex phase spaces

Christopher A Mizzi

National High Magnetic Field Laboratory, Los Alamos National Laboratory, Los Alamos NM, United States

High-entropy alloys (HEAs) have garnered much attention, especially in nuclear applications, owing to their exceptional properties and high tunability. However, HEA composition and microstructure optimization remains a significant challenge due to the size of the materials design space, and is a case study in the quintessential materials science problem: using finite resources to explore ever-expanding composition-microstructure spaces to find novel materials with superior functionality. Suites of high-throughput computational tools have been developed to address this problem, but there is a compelling need to inform these models with fast, economical, non-destructive, and versatile experimental guidance.

In this talk, I will describe how measurements of the mechanical resonances of samples via resonant ultrasound spectroscopy (RUS) address these needs and augment more common materials characterization techniques as a high-throughput benchmark for materials design. RUS can non-destructively determine the entire elastic constant tensor and ultrasonic attenuation from a single measurement with high accuracy and precision. This approach is amenable to all high-entropy materials, from metals to ceramics, compatible with any amount of crystalline anisotropy or texture, and capable of providing actionable feedback on defects, mechanical performance, and interatomic bonding in novel high-entropy materials within minutes . As such, RUS is an enticing platform to rapidly down-select the most promising high-entropy candidates, examine functional properties in novel classes of high-entropy materials, and identify key physics to incorporate in predictive models. Measurements on a range of refractory HEAs at ambient conditions will be used to exemplify the identification of promising high-entropy compounds for further study. Then, temperature-dependent RUS measurements will demonstrate the effects of composition on strength, ductility, and anharmonicity. These results are compared with theoretical predictions.

Abstract 39 at 11:00 AM — Session CA-AR-01 Monday 10:00 AM - 332

A Robust Alloy Design (RAD) Strategy for Next-Generation (IV) Nuclear Fission Reactors

MOHAN SAI KIRAN KUMAR YADAV NARTU, SUPAKUL SKYE, SHALINI TRIPATHI, ISHTIAQUE KARIM ROBIN, OSMAN EL ATWANI

NUCLEAR SCIENCES DIVISION, PACIFIC NORTHWEST NATIONAL LABORATORY, RICHLAND WA, United States

Next-generation nuclear reactors demand structural materials capable of withstanding extreme conditions, including high temperatures, intense neutron flux, and corrosive environments. Multi-Principal Element Alloys(MPEAs) have emerged as promising candidates due to their exceptional radiation tolerance, thermal stability, and compositional flexibility. This study introduces a versatile and customizable Robust Alloy Design(RAD) strategy for systematically designing MPEAs for GEN-IV reactor fuel cladding. The RAD framework integrates nuclear-relevant selection criteria, empirical parameter assessments, and high-throughput CALPHAD simulations to efficiently narrow compositional space and identify stable alloys. A unified RAD score developed for the first time, combines key performance metrics, including fuel-clad chemical interaction(FCCI), neutron absorption cross-section(NAC), valence electron configuration(VEC), and melting point factor(MPF), into a flexible ranking system adaptable to reactor-specific priorities. Among 724 candidates, V555 emerged as the top alloy, validated experimentally with a homogeneous BCC microstructure and superior mechanical properties (nano-indentation: 3.389±0.258 GPa; Vickers hardness: 240±6.7 HV), significantly outperforming Zircaloy-4 and V-4Cr-4Ti. Preliminary in-situ TEM thermal irradiation (1 MeV and Kr^{2+} ions) experiments revealed excellent irradiation tolerance for V555 and will be presented. Nanoscale recrystallized grains formed during thermal ramp-up (700-800 °C) remained stable throughout irradiation at 650 °C, further underscoring the alloy's robustness under reactor-relevant conditions.

Abstract 8 at 10:00 AM

Session CA-AS-03 Monday 10:00 AM - 314B/C

Accelerator-based Light Sources for Semiconductor Lithography

Michael Ehrlichman

Accelerator Research Division, SLAC National Accelerator Laboratory, Menlo Park California, United States

Lithography techniques based on accelerator-based light sources have proven difficult to industrialize. Accelerators utilizing potentially viable light generation methods are typically housed at universities and national laboratories, which prioritize fundamental scientific discovery over economic and operational considerations like cost efficiency and 24/7 availability. EUV lithography in semiconductor manufacturing relies on laser-produced plasma (LPP) sources - a compact and mature technology, but whose limited output power and inability to operate at shorter wavelengths constrain the industry. An accelerator-based EUV light source would be transformative for the industry, but efforts to date have yet to yield a practical solution. This talk reviews past and ongoing attempts to develop accelerator-based light sources for semiconductor manufacturing. It also introduces a concept under exploration at SLAC National Accelerator Laboratory, induction cell storage rings, which may enable coherent emission of EUV light via steady-state microbunching (SSMB).

Abstract 95 at 10:25 AM

Session CA-AS-03 Monday 10:00 AM - 314B/C

RadiaBeam electron linear accelerators for industrial applications

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Linear accelerators (linacs), which produce electron or X-ray radiation in the MeV range, are critical tools for industrial irradiation, medical device sterilization, food pasteurization, non-destructive testing, security, medical applications, and other. Many of these applications require compact and flexible radiation sources. In this paper, we present new technologies for small-scale electron linear accelerators and examples of their practical implementations. These developments include low-energy accelerators with self-shielding options and form factors, ranging from cabinet-size to hand-portable generators; medium-energy accelerators for novel radiotherapy and security applications, and high-energy 10 MeV linacs capable of reaching 20-35 kW beam power for emerging industrial and phytosanitary applications.

Abstract 19 at 10:50 AM Session CA-AS-03 Monday 10:00 AM - 314B/C

Steri-Tek's Capabilities Reach Beyond Electron Beam Sterilization

Hannah Busard, Bradley Ross, Sandra Ramirez, Afeefa Haji, Johnathan Henkel, Brian Potts, Gustavo H.C Varca

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As both a contract service provider and R&D center, Steri-Tek has positioned itself as one of the industry leaders in innovation and growth. Our electron beam processing options have grown from a terminal sterilization path, to now including multiple pathways for bio-reduction, cross-linking, and more depending on the customer's specific needs. Steri-Tek is diligently working to roll out an official bio-reduction pathway, allowing customers who may not require sterilization but decontamination to have access to a quicker route from beginning to routine production. With the expansion into our Dallas facility, Steri-Tek's capabilities also expanded to include X-Ray irradiation. Using a tantalum screen in addition to the LINAC system, we can induce bremsstrahlung effects, converting electrons to photons for X-Ray processing. This enables us to treat high-density, intricately designed products with similar penetration as gamma irradiation without the need for a radioactive source. Steri-Tek has developed internal processes for the irradiation of gemstones, known to improve color, clarity, and more without impacting structural integrity. Harnessing the full power of our dual-beam LINAC systems, the opportunity for material research and testing is endless. An additional pathway in development is material modification, from cross-linking to chain-scission. Using either electron beam or X-ray, we can dose products with high levels of radiation to change material properties. This presentation outlines Steri-Tek's capability for R&D innovations.

Abstract 67 at 11:15 AM Session CA-AS-03 Monday 10:00 AM - 314B/C

An X-ray Calibration Method for Gafchromic HD-V2 Film with Applications to Accelerator Pulsed-Beam Diagnostics

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Introduction
Radiochromic films are widely used for high-resolution dosimetry because of their wide dynamic dose range and excellent spatial resolution. Accurate calibration is essential, particularly for high-dose applications where the absorbed dose within the film may differ from machine-reported air-kerma values. This study developed an X-ray calibration method for Gafchromic HD-V2 film using Monte Carlo-based dose correction and evaluated its performance for 70 keV electron-beam dosimetry at Sandia National Laboratories.
Materials and Methods
HD-V2 films were calibrated using a Precision X-Ray XRAD-350 irradiator operated at 320 kVp with 2 mm aluminum filtration over a dose range of 0.127-1200 Gy. Films were scanned 24 hours after irradiation with an Epson Expression 11000XL scanner, and red-channel gray values were analyzed using ImageJ. A three-parameter nonlinear calibration function was generated in Wolfram Mathematica.
Because the XRAD-350 reports air kerma rather than the absorbed dose within the HD-V2 active layer, PENELOPE Monte Carlo simulations were performed to calculate the ratio of energy deposited in the film active layer to that deposited in air under the same irradiation geometry. This ratio was used as a conversion factor to transform the machine-reported doses into absorbed doses within the HD-V2 active layer before constructing the final calibration curve.
The corrected calibration was then applied to HD-V2 films irradiated with 70 keV electron beams at Sandia National Laboratories and compared with independent PENELOPE dose calculations.
Results
The simulations showed that the energy deposited in the HD-V2 active layer was 3.18 times greater than that deposited in air under the calibration conditions. Accordingly, this film-to-air energy-deposition ratio was applied to the nominal XRAD-350 doses to obtain the absorbed dose within the active layer.

Film-derived doses showed excellent agreement with independent PENELOPE calculations for the 70 keV electron irradiations. For most measurements, relative differences remained within approximately 4-13%, with larger deviations observed only at the lowest dose levels where film-response uncertainty was greatest. Both approaches demonstrated consistent dose-response trends across the investigated exposure range.

Discussion and Conclusion

Monte Carlo correction significantly improves the physical accuracy of HD-V2 film calibration by accounting for energy deposition within the active layer rather than relying on nominal air-kerma values. Independent validation with Sandia electron-beam measurements confirmed the robustness of the proposed methodology.

This work supports passive beam diagnostics for the Pulsed Power Electron Gun under development at Sandia's Ion Beam Laboratory, where severe electromagnetic interference limits conventional electronic detectors. These results demonstrate that Gafchromic HD-V2 film is a reliable passive dosimeter for high-dose, low-energy electron beams and a promising diagnostic tool for future PPEG beam characterization.

*Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, for the U.S. Department of Energy's National Nuclear Security Administration under Contract DE-NA0003525

Abstract 27 at 10:00 AM — Session SN-SN-01 Monday 10:00 AM - 339

Lab Report for Notre Dame Nuclear Science Laboratory

Edward Stech

Physics and Astronomy, University of Notre Dame, Notre Dame Indiana, United States

A summary of significant events and developments over the past year in the NSL will be presented. Extended tank openings on both the 5U and FN accelerators will be discussed as well as the first production runs using the recently installed alphatross ion source for the FN. An overview of the lab operations and a brief update on the Nautilus system will also be included.

Abstract 12 at 10:15 AM — Session SN-SN-01 Monday 10:00 AM - 339

Update on the CASPAR Underground Accelerator Program

Daniel Robertson

Department of Physics and Astronomy, University of Notre Dame, Notre Dame INDIANA, United States

The Compact Accelerator System for Performing Astrophysical Research (CASPAR) is a deep underground accelerator laboratory located at the Sanford Underground Research Facility in Lead, SD. The system is at the 4850 ft level of the old Homestake gold mine and is based on a 1 MV JN model VdG accelerator producing protons and alphas for nuclear astrophysics reactions of interest. The newly recommissioned system began operations again this year after a 5 year hibernation period. Presented here will be the challenges encountered during recommissioning, operational parameters and current status. Some focus will be given to the challenges in maintaining necessary performance levels moving forward.

Abstract 61 at 10:30 AM — Session SN-SN-01 Monday 10:00 AM - 339

Upgrades and Maintenance of the 3.0 MV Pelletron Tandem and Update of the Experiment Tracking System at the Michigan Ion Beam Laboratory (MIBL)

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The 3.0 MV Pelletron tandem accelerator is a cornerstone of the research infrastructure at the Michigan Ion Beam Laboratory (MIBL), serving four of the facility's seven target stations, including a specialized multi-beam chamber for radiation effects studies. To enhance MIBL's versatility and performance, a dual TORVIS ion source capable of high-current proton or helium irradiation has recently been installed and demonstrated on the Pelletron, adding helium production capability.
This presentation covers the installation, integration, and performance of the newly acquired TORVIS system, focusing on its integration into MIBL's existing control and monitoring architecture via NI devices, LabVIEW, and shared network variables. Additionally, this session provides an update on MIBL's web-based experiment tracking system, highlighting how experimental and equipment data are logged for troubleshooting and data recovery. Finally, we discuss maintenance conducted during the most recent tank opening. The highlight of this maintenance was the replacement of the sheave rims on both the terminal and drive ends of the Pelletron charging system. These hardware improvements and routine maintenance are vital for ensuring the long-term reliability and stability of the charging system.

Abstract 80 at 10:45 AM Session SN-SN-01 Monday 10:00 AM - 339

Brookhaven National Laboratory Tandem Van de Graaff Accelerator: Annual Operations and Facility Report

Tom Kubley, Dannie Steski

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The Brookhaven National Laboratory (BNL) Tandem Van de Graaff Accelerator serves as a versatile ion beam facility supporting research in nuclear physics, materials science, radiation effects, detector development, and accelerator technology. This report summarizes facility operations, maintenance activities, and system performance during the reporting period, with emphasis on maintaining reliable beam delivery, high vacuum performance, and safe operation. Major activities included accelerator tuning, cryogenic and vacuum system maintenance, beamline configuration, instrumentation upgrades, and support for user experiments. Preventive maintenance and equipment improvements were performed to enhance operational reliability, minimize downtime, and ensure compliance with laboratory safety and work control requirements. Beam performance, vacuum system integrity, and operational readiness were verified through commissioning, diagnostic testing, and routine monitoring. The results demonstrate that the Tandem facility continues to provide stable, high-quality ion beams while supporting a diverse scientific user program through effective maintenance practices, rigorous safety protocols, and continuous system improvements

Abstract 124 at 11:00 AM Session SN-SN-01 Monday 10:00 AM - 339

Laboratory Report discussing upgrades to the FN Tandem and installation of a new 2 MV Singletron in the newly renovated TUNL Low-Energy Nuclear Astrophysics Laboratory and the reinstallation of an upgraded 230 keV ECR accelerator.

Chris Westerfeldt

Physics, Duke University, Durham North Carolina, United States

Triangle Universities Nuclear Laboratory, Duke University Physics Department, Durham NC 27708, United States[1]
Laboratory Report discussing upgrades to the FN Tandem and installation of a new 2 MV Singletron in the newly renovated TUNL Low-Energy Nuclear Astrophysics Laboratory and the reinstallation of an upgraded 230 keV ECR accelerator.
The Triangle Universities Nuclear Laboratory (TUNL) is a Department of Energy funded "Center of Excellence" operated by a consortium of local Universities: Duke University, North Carolina Central University, North Carolina Central University and UNC- Chapel Hill. Together we operate six electrostatic accelerators on the Duke University Campus for basic research and external applied programs. Terminal potentials range from 40 kV to 10 MV.
Upgrades have been funded by the DOE for improvements to the FN tandem including: two refurbished accelerator tubes and replacement of the 1970's ion sources with two new NEC sources (a SNICSII and a TORVIS) and injection beamline. These were all completed since the last meeting in 2025. In LENA the DOE funded a new HVEE 2 MV

Singletron which is installed and being used for Low-Energy Nuclear Astrophysics Research. The existing TUNL-Constructed 200 keV ECR High-Current Proton accelerator is licensed and operational for research.
1 Supported by the U.S. Department of Energy, Office of High Energy and Nuclear Physics, Under Grant No. DE-FG02-97ER41033, DE-FG02-97ER41041, & DE-FG02-97ER41042.

Abstract 175 at 1:30 PM

Session CA-AA-01 Monday 1:30 PM - 382B

Characterization of Metal Hydride Targets to Improve Performance and Reliability of Fusion Neutron Generation*

Jose L. Pacheco, Barney L. Doyle

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Optimized beam-solid target production of fusion neutrons—via deuterium-deuterium (DD) or deuterium-tritium (DT) reactions—depends critically on achieving the highest possible hydrogen isotope to metal ratio (HI/M). However, impurities and occluder metal poisoning significantly limit hydrogen isotope absorption, posing a major obstacle to system performance.

Achieving high HI/M requires careful control of fabrication processes, including the preparation of high purity occluder metals and precise hydrogen isotope loading through controlled exposure to isotopic gases. Multiple fabrication parameters influence the quality of hydride formation and the resulting hydrogen isotope uptake, making it essential to understand and optimize these factors.

To address these challenges, ion beam analysis (IBA) techniques have been applied to characterize metal hydride systems in detail to verify occluder film properties against specifications. The precise quantification of hydrogen isotope concentrations, detection and characterization of contaminants, and in-depth assessment of occluder film quality are all necessary assessments to ensure these targets perform optimally. The techniques used for these assessments include low and high energy He-ERD for detection of H-isotopes, (3He, p) NRA to measure C, N, and O, concentration, and RBS analysis of the metal films. These IBA results have elucidated underlying causes of poor-performing occluder films such as variability in metal film thicknesses (not meeting specification), high concentrations of Oxygen in the metal films and high concentrations of Hydrogen. In this manner, IBA analysis provides critical insights that guide improvements in fabrication and loading processes. Further, Hydrogen and Oxygen contamination are key fabrication details that often go undetected by existing analytical methods. In this presentation, we will discuss advanced neutron generating-target designs, fabrication process for these, analysis results that elucidate underlying issues as well as future work to further develop our IBA techniques to quantify HI/M ratios, contaminant concentrations, as well as measurements to verify these targets continue to meet specifications.

In this manner, our IBA infrastructure allows us to obtain information that is essential for enhancing neutron production efficiency and ensuring the reliability of fusion neutron sources in future applications.
*Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, for the U.S. Department of Energy's National Nuclear Security Administration under Contract DE-NA0003525. SAND2026-25393A.

Abstract 88 at 2:00 PM

Session CA-AA-01 Monday 1:30 PM - 382B

Verification of a Semi-implicit PIC Algorithm for Modeling Plasma-based Ion Sources at Scale

Ryan M. Hedlof, Thomas M. Smith, Zakari Eckert, Russell Hooper

Sandia National Laboratories, Albuquerque NM, United States

Kinetic particle-in-cell (PIC) simulations are an important tool for modeling plasma ion sources, but conventional explicit PIC methods can become prohibitively expensive for high-density systems due to the need to resolve the electron plasma period and Debye length. This work presents a verification study of a semi-implicit electrostatic PIC algorithm that relaxes these constraints by introducing a spatially dependent effective permittivity in the field solve. The method suppresses high-frequency plasma oscillations without artificially modifying the electron mass, enabling larger time steps and mesh sizes while retaining relevant kinetic physics.The algorithm is assessed through code-to-code comparisons, theoretical benchmarks, and representative plasma simulations relevant to ion-source modeling. Results show that the method remains

stable beyond traditional explicit PIC limits and accurately captures the relevant low-frequency plasma response when the distribution function and problem-specific spatiotemporal scales are adequately resolved.

Abstract 7 at 2:30 PM — Session CA-AA-01 Monday 1:30 PM - 382B

Oxygen and carbon depth profile measurements in LiH by Rutherford Backscattering Spectrometry.

Igor Usov

MST-8, Los Alamos National Laboratory, Los Alamos NM, United States

Growing demand for low-cost and environmentally friendly technologies for electrical energy production and storage has stimulated interest in various metal hydrides, among which lithium hydride (LiH) possesses many attractive physical and nuclear properties, including low density, high hydrogen content, good thermal stability, fast neutron shielding and moderation capabilities, and tritium breeding potential.
The main limitation of LiH is its extreme chemical reactivity with water vapor and carbon dioxide during exposure to air, resulting in transformation into lithium oxide (Li_2O), lithium hydroxide (LiOH), lithium carbonate (Li_2CO_3), and hydrogen (H_2) gas. Consequently, LiH must be stored and handled under an inert atmosphere, which significantly increases processing costs and complicates investigation of its properties.
In this study, we present Rutherford Backscattering Spectrometry (RBS) analysis of changes in the near-surface chemical composition of LiH caused by transfer of the material from an inert-atmosphere glove box to the ion beam analysis vacuum chamber. It was determined that a thin layer enriched with O and C atoms formed on the LiH surface despite efforts to minimize exposure to air. This reacted surface layer is likely a mixture of Li_2O, LiOH, and Li_2CO_3 phases, which could not be unambiguously identified using RBS measurements alone.
Both H^+ and He^+ incident ion beams were employed, enabling measurement of O and C depth profiles with excellent sensitivity and a probing depth of up to approximately 20 μm. Specific aspects of LiH RBS measurements, as well as recommendations for LiH packaging and transfer procedures, will be discussed.

Abstract 21 at 2:45 PM — Session CA-AA-01 Monday 1:30 PM - 382B

Self-Aligned Nanostructures Induced By Silver Ion Irradiation in Thermally Deposited Gold Thin Films

Soumya Srotaswini Sahoo[1], Darshpreet Kaur Saini[1], Mohin Sharma[1], Mritunjaya Parashar[1], Todd A. Byers[1], Anil Pudasaini[2], Jose Perez[2], Manas Kumar Dalai[1], Bibhudutta Rout Rout[1]

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Surface nanopatterning is an emerging technology that has been developed significantly over the last few decades (1)Nowadays, various nanopatterning tools are available, such as nanoimprint lithography, nanosphere lithographic techniques, soft lithographic methods, focused ion beam (FIB) techniques, tip-induced oxidation, and tip-induced e-beam lithography, etc (2)Among various approaches, self-organized pattern formation by ion beam sputtering is considered an efficient and powerful technique (3-5)The advantages of the ion beam technique include the generation of patterns over a large area within a short period of time, low processing cost, and precise patterns through controllable processing parameters (Such as ion energy, ion fluences, angle of incidence, etc.) (6,7)Another advantage of this technique is the production of a regular array of quantum dots on a semiconductor surface in a single processing step (8)These nanostructure patterns have a wide range of applications from optoelectronic to biomedical (9)
In this work, we investigate the formation of self- aligned nanostructures on a 20 nm Au thin film deposited on a Si Substrate using low-energy ion beam irradiation. The samples were irradiated with 30 keV Ag ions of fluences 1.2×10^{16} ions/cm^2. Surface morphological changes by ion sputtering were characterized using Atomic Force Microscopy (AFM), while compositional depth profiling and elemental thickness analysis were carried out using Rutherford Backscattering Spectrometry (RBS). In addition, the experimental observations were compared with a full-dynamic ion-solid interaction simulation (TRIDYN-1D) study.
AFM analysis revealed that the self-organized nanoarrays formed on the surface have dimensions of a few hundred nanometers. The observed pattern formation is due to the coupling between the topography of the surface and a surface

layer of altered composition (10)TRIDYN-1D simulation results showed that nearly 60% of Au atoms sputter more rapidly under irradiation, and the surface becomes enriched in Si at this fluence. This strongly supports the experimental findings.
In conclusion, the present study demonstrates that low-energy Ag ion irradiation is an effective approach for producing self-organized nanostructures on Au thin films. The resulting nanopatterns are expected to exhibit unique physical properties, such as quantum confinement effects and superconducting behavior. These properties make them attractive for future nanoelectronics and quantum device applications.

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Abstract 174 at 3:00 PM

Session CA-AA-01 Monday 1:30 PM - 382B

A Compact Halbach-Array Magnetic Deflector for Light Element PIXE, and the Limits of Quantitative Low-Z Analysis

Charles Thomas Bowen, Todd A. Byers, Darshpreet K Saini, Mohin Sharma, Mritunjaya Parashar, Bibhudutta Rout, Gary A. Glass

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Particle-induced X-ray emission (PIXE) analysis of low-Z elements is conventionally constrained by the absorber or filter required to shield the X-ray detector from high energy backscattered protons. Because the absorbing media that stops MeV protons also strongly attenuate ultra-low-energy photons, most PIXE analysis is limited to analyzing elements heavier than sodium or aluminum. A prototype magnetic deflection system developed at the IBL deflected protons up to ~1.4 MeV but was hampered by a low solid angle (1)We present the design, simulation, and initial performance of a new improved, compact permanent-magnet deflector employing a custom Halbach array, which allows the use of higher energy incident proton beam up to 2.0 MeV. The Halbach geometry was selected for its intrinsic field enhancement within the working aperture combined with near total cancellation of external flux, permitting high field density in a physically compact assembly while minimizing the stray field that must be shielded. The magnetostatic design proceeded in two stages: 1) Finite Element Method Magnetics (FEMM) simulation software was used for rapid two-dimensional prototyping of initial Halbach cylinder designs and 2) the selected configuration was then modeled in three dimensions in COMSOL Multiphysics to capture fringing fields, end effects, and the full spatial field distribution. Proton trajectories were integrated through the mapped field for a range of incident energies and entrance angles. Simulated field distributions were validated against direct Hall probe measurement of the fabricated array.
The fabricated array achieves a peak measured flux density of approximately 2 T. Deflection performance was demonstrated using a 2 MeV proton beam incident on a gold target and measuring the backscattering yield at a 135° scattering angle. Characteristic X-rays are collected by an Amptek FAST SDD with a C2 ultra-thin window at an effective

geometric solid angle of 10 msr, a configuration that preserves transmission below 300 eV and permits detection of K-shell emission from boron at 185 eV with no intervening absorbing media.
Removing the absorber shifts the limiting factor in quantitative PIXE from detector shielding to the physics of soft X-ray production and transport. Qualitatively, the system permits simultaneous survey of light and medium-Z constituents within a single spectrum, extending routine PIXE coverage to elements otherwise inaccessible to conventional PIXE setups; including carbon, nitrogen, and oxygen, which neither PIGE nor EBS offers a practical route at 2 MeV. Quantitatively, removal of the absorber eliminates the dominant and often poorly characterized transmission correction from analysis, but also introduces new challenges specific to light element analysis. We discuss three in particular: soft X-ray self absorption within the sample with as low as sub-micron attenuation lengths; secondary electron bremsstrahlung, and the substantial uncertainty in tabulated fluorescence yields and ionization cross sections for $Z < 11$. Together, these define the realistic accuracy limits of unfiltered light element PIXE. These advancements in the development of compact and powerful magnetic deflector systems for PIXE measurements offer unprecedented advantages for detecting light elements and mapping elements in various studies related to biomedicine, corrosion, and microelectronics.
[1] T.A. Byers, D.K. Saini, C.T. Bowen, B. Rout, G.A. Glass, Nucl. Instrum. Methods B 567 (2025) 165837

Abstract 123 at 1:30 PM — Session CA-AI-01 Monday 1:30 PM - 382A

Bridging Deep Reinforcement Learning and Adaptive Feedback for Time-Varying Systems

Shaifalee Saxena[1,2], Rafael Fierro[2], Alexander Scheinker[1]

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Deep reinforcement learning (DRL) can quickly control high-dimensional systems within the training distribution, but its performance can degrade when time-varying dynamics produce unseen observations. Bounded extremum seeking (ES) provides a robust, model-independent adaptive control approach that can respond to such changes without requiring an accurate model of the system. We consider a combined ES-DRL controller, where DRL provides fast in-distribution actions and ES provides robust model-independent control under out-of-distribution (OOD) operation. The key challenge is deciding when to switch. We train a variational autoencoder (VAE) on in-distribution beam-profile observations and use Mahalanobis distance in the VAE latent space to detect out-of-distribution (OOD) beam profiles at test time. This OOD decision sets a binary switch that selects either the DRL controller or the ES controller. We evaluate the approach in safety-critical particle accelerator control. In this setting, spatial magnet motion creates OOD beam profiles that were not seen during DRL training. Visualization of the VAE latent space shows that the proposed method identifies this OOD scenario and provides an interpretable signal for switching between DRL and ES in the combined controller.

Abstract 144 at 2:00 PM — Session CA-AI-01 Monday 1:30 PM - 382A

Agentic AI for Large-Scale Accelerator User Facilities: Status and Multi-Facility Experience with Osprey

Gianluca Martino, Thorsten Hellert, Simon C. Leemann

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Osprey is an open-source agentic AI framework for safety-critical control systems, developed at Lawrence Berkeley National Laboratory and in production at the Advanced Light Source (ALS). It translates natural-language operator requests into explicit, inspectable execution plans and executes those plans through tools covering control-system access, archival data retrieval, technical documentation search, and isolated execution of generated analysis code. Tool capabilities are declared and bounded per session: one granted read-only or simulator scope cannot reach the live machine, and every hardware action requires explicit operator approval.
The framework is now deployed at several large-scale accelerator facilities, and the same architecture is in use at scientific facilities outside the accelerator domain. Here, we report on this deployment experience and the operational lessons learned, especially what it takes for a new facility to adopt the framework; in practice this reduces to facility-specific connectors and configuration on top of an unchanged core.
A central focus is the integration of agentic reasoning with numerical optimization for operator-supervised autonomous tuning. The agent assesses machine state, decides what to optimize, and configures a bounded optimizer run, which within

this workflow is the only write path to the machine. Uncertainty quantification enters the loop through Bayesian optimization over Gaussian-process surrogates in the Xopt optimization package, and the agent uses the structured summary of each run to decide whether to refine, re-scope, or conclude. We report on tuning campaigns at three facilities with increasing planning autonomy: free-electron laser tuning at the Linac Coherent Light Source (LCLS), where the agent translates a natural-language request into a complete optimizer configuration; injector startup at FACET-II, where the agent supervises a sequence of optimizer-driven startup stages, deciding when each has converged; and agent-planned injector tuning at the ALS, where the agent composes tuning plans from live machine state. In the ALS sessions, agent-composed runs roughly doubled the delivered injector charge, with operator involvement reduced to plan review, run dispatch, and post-run accept or revert. These campaigns show that this pattern transfers across facilities and machine types. The plugin boundaries at every layer are intended to make adoption at the next facility, including smaller machines without dedicated machine-learning staff, a configuration exercise rather than an integration project.

Abstract 112 at 2:15 PM — Session CA-AI-01 Monday 1:30 PM - 382A

A Foundation Model Approach to Particle Accelerator Operational Data

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Large-scale scientific facilities, such as particle accelerators, are complex systems composed of thousands of interacting components that must operate collectively to support diagnostics and control and to ensure safe, reliable operation. These facilities rely on extensive sensor networks that generate large volumes of heterogeneous and noisy data, often sampled at different rates across subsystems. In this paper, we adopt the foundation-model paradigm to learn general-purpose sensor representations from historical accelerator data through self-supervised pretraining. We introduce SensOFormer, a denoising masked transformer with a Perceiver-style encoder-decoder architecture designed to handle variable sensor sets, accommodate variable sampling rates, and learn robust representations from noisy measurements. The model is pretrained on multiple particle-accelerator datasets and transferred to downstream tasks, including missing-data imputation, anomaly detection, cavity identification, and fault identification. Through extensive evaluations and comparisons, we demonstrate that a single self-supervised model can learn reusable representations for diverse operational tasks in large-scale scientific facilities.

Abstract 134 at 2:30 PM — Session CA-AI-01 Monday 1:30 PM - 382A

Physics-Informed Machine Learning for the FRIB Driver Linac: Surrogate Models, Automated Tuning, and Data-Driven Alignment Diagnostics

XIlin Zhang

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Machine learning is becoming a practical tool for operating and understanding large superconducting linacs. This talk surveys the machine-learning activities of our group at the Facility for Rare Isotope Beams (FRIB), organized around a common principle: use exact accelerator physics where it is reliable, and statistical learning only where the problem is genuinely under-determined. We describe fast surrogate models (data-driven "digital twins") that emulate the linac's beam response for online prediction and virtual studies, and automated tuning methods (Bayesian optimization and related schemes) that shorten beam setup for matching and loss control. As a worked example, we present in more detail a physics-informed inference of quadrupole and beam-position-monitor misalignments from routine trajectory data: a fixed physics model supplies the response, while regularized estimation with resampling recovers the alignment errors the data actually constrain, together with honest uncertainties. The approach is validated across ion species and beam rigidities—including a held-out uranium beam—demonstrating a transferable, survey-free alignment diagnostic. We close with lessons learned and an outlook for combining these tools into an integrated, uncertainty-aware model of the machine.

Abstract 173 at 2:45 PM Session CA-AI-01 Monday 1:30 PM - 382A

OED and MPC for autonomous accelerator control

Eiad Hamwi

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Autonomous accelerator control requires not only an accurate model of the machine, but a principled way to decide when to learn and when to act. Focusing on strings of beam-position monitors in long beamlines, we study a generic framework combining optimal experimental design (OED) with model predictive control (MPC). OED selects machine perturbations that reduce uncertainty in model parameters, while MPC embeds these informative actions within a receding-horizon control problem that balances information gain, beam performance, and operational constraints. The resulting controller can interrogate the machine when uncertainty limits performance and transition toward regulation as that uncertainty shrinks. By making assumptions about diagnostics, actuators, uncertainties, and constraints explicit, this framework provides a facility-agnostic approach for studying the instrumentation and control capabilities required for autonomous commissioning and maintenance.

Abstract 36 at 1:30 PM Session CA-AR-02 Monday 1:30 PM - 332

Current status and findings from in-situ irradiation creep testing

Dave Lunt[1,2], Samir de Moraes Shubeita[2], Laurence Skidmorre[2], Ben Poole[1], Philipp Frankel[2], Ed Pickering[2], Chris Hardie[1]

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Nuclear materials performance under synergistic irradiation-temperature-stress environments is the primary component life-limiting factor to account for in materials qualification; this environment is known to have a significant impact on materials, leading to changes in microstructure, composition and mechanical performance. However, there is a lack of understanding on the impact that this harsh environment will have on the structural integrity of candidate materials for nuclear fusion devices. Testing in a synergistic environment provides a realistic assessment of the expected in-service performance preventing materials for fusion applications being considered for longer than necessary. Here, we exploit the recent commissioning of an in-situ ion irradiation-thermal-mechanical materials testing capability at the UK's Dalton Cumbrian Facility, where novel methods have been developed to quantify the resulting deformation and damage at multiple length scales.
The main goal of these experiments is to understand the difference between the synergistic response and more traditional sequential testing campaigns, with a focus on irradiation-enhanced creep as a critical failure mode to capture for timely qualification of high temperature structural materials for nuclear fusion power plant build. Here, we present a series of experiments on a ferritic-martensitic steel focussed on understanding the deformation behaviour across both tensile and creep testing conditions. These results demonstrate the importance of testing time dependent mechanisms simultaneously. Future developments and potential for collaborative testing programmes across facilities will be discussed.

Abstract 86 at 2:00 PM Session CA-AR-02 Monday 1:30 PM - 332

Stress-Mediated Radiation Effects and the Development of Modern Coupled Irradiation Testing

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Structural materials in fission, fusion, and space systems operate under coupled irradiation, thermal, and mechanical environments. Recent work at the Michigan Ion Beam Laboratory (MIBL) has demonstrated that applied stress can significantly alter point-defect transport and radiation-induced segregation (RIS), highlighting limitations in treating mechanical loading separately from irradiation. Specifically, ion-thin, proton-irradiated 316L stainless steel specimens tested between 79 and 316 MPa and 450-550 °C showed that tensile stress fundamentally changes solute redistribution. At 550 °C, stressed specimens exhibited Fe depletion, Cr enrichment, and Ni depletion at grain boundaries, while unstressed material showed little to no segregation. This response differs from the classical higher-dose RIS behavior of Cr depletion and Ni enrichment. Segregation was also strongly dependent on grain-boundary orientation and local sink structure, with boundaries aligned with the tensile axis exhibiting the strongest response. At dislocation densities above approximately 10^{15} m^{-2}, grain-boundary segregation was suppressed as dislocations increasingly competed for mobile defects. These results indicate that stress biases vacancy and interstitial transport and can shift RIS toward a more interstitial-dominated mechanism.

These initial experiments used relatively simple static dead-weight loading, motivating development of more controlled coupled-environment testing for increased fidelity and flexibility in coupled irradiation testing. Beamline 1 at MIBL has therefore been upgraded with an instrumented mechanical testing system for tensile, creep, and related tests conducted concurrently with ion irradiation. This presentation will then discuss the successes and challenges encountered during development and commissioning of this capability, including specimen geometry, fabrication of mechanically robust ion-thin test sections, and thermal management under high-current proton beams. MeV proton irradiation can generate substantial beam heating, coupling ion current directly to specimen temperature and, in turn, the mechanical response. In a recent commissioning experiment nominally conducted at 450 °C, a loaded specimen reached approximately 0.05 dpa before fracture, with preliminary analysis indicating that a beam-current excursion may have produced a coupled thermal and load perturbation derived from the control system software. These outcomes, together with our recent scientific understanding of stress-mediated point-defect diffusion, are guiding improvements in specimen design, beam monitoring, temperature control, and mechanical testing protocols as MIBL progresses toward increasingly realistic coupled irradiation-mechanical experiments.

Abstract 23 at 2:30 PM Session CA-AR-02 Monday 1:30 PM - 332

Benchmarking and Refining Machine-Learned Interatomic Potentials for Radiation Damage and Tritium Diffusion in LiAlO2

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Accurate interatomic potentials are essential for molecular dynamics (MD) simulations of radiation damage and gas diffusion in nuclear ceramics like LiAlO2 under extreme conditions relevant to tritium production. We benchmark six machine-learned interatomic potentials (MLIPs)—moment tensor potential (MTP), Gaussian approximation potential, deep potential for MD (DeepMD), atomic cluster expansion (ACE), message-passing ACE (MACE, pretrained), and MACE (trained from scratch), all trained on a shared density functional theory dataset including tritium. Evaluation criteria include energy accuracy, density, thermal equilibration, threshold displacement energy, tritium diffusivity, and computational cost. MTP achieves the best balance of accuracy and efficiency, while ACE and MACE models show unphysically high displacement energies, and deep potential underestimates them due to excessive repulsion. All models overestimate tritium diffusion, though pretrained MACE remains physically reasonable up to 500 K. Only MTP outperforms empirical potentials computationally. Building on these results, we apply active learning to iteratively refine MTP, yielding continuous improvement in tritium diffusion accuracy.

Abstract 164 at 2:45 PM Session CA-AR-02 Monday 1:30 PM - 332

Irradiation-Induced Mechanical Response of Polymer-Derived SiC: Linking Defect Formation to Hardening

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Ceramic matrix composites (CMCs) that use polymer-derived ceramics (PDCs) to form their SiC matrices are promising candidates for hypersonic vehicles, advanced fission and fusion energy systems, and other radiation-intensive extreme environments. The PDC route also offers attractive processing advantages over conventional chemical vapor infiltration and sintering, including low-temperature shaping of complex geometries and tailorable chemistry. However, PDC SiC also produces a microstructure unlike that of conventional SiC. Depending on pyrolysis and crystallization conditions, polymer-derived SiC can retain nanocrystalline grains, residual free carbon, and is synthesized amorphous, all of which are expected to alter how the material creates, traps, and annihilates radiation-induced defects. While the irradiation response of high-purity CVD SiC has been studied extensively for nuclear applications, it remains unclear whether polymer-derived SiC develops a distinct, defect-driven mechanical response under the same exposure conditions. Because the grain boundaries, free-carbon domains, and disordered regions inherent to PDC processing can act as both defect sinks and defect nucleation sites, extrapolating from the conventional SiC literature is not straightforward. The question must be answered experimentally, and accelerator-based ion irradiation and mechanical testing provides the means to do so.
This talk presents an ion-beam-driven study, conducted at the Tennessee Ion Beam Materials Laboratory (TIBML) at the University of Tennessee, Knoxville, that establishes the post-formation defect and hardening response of polymer-derived SiC. Carbon-fiber-reinforced SiC (C/SiC) coupons with polymer-derived SiC matrices were fabricated, infiltrated via vacuum assisted resin transfer molding (VARTM), pyrolyzed, and then irradiated with 11 MeV Au^{3+} ions to nominal damage levels of 1, 10, and 100 displacements per atom (dpa), spanning the range from the onset of defect accumulation through saturation of the defect microstructure. Heavy-ion irradiation was selected to build displacement damage efficiently within a well-defined near-surface volume, with damage profiles and dose rates informed by SRIM calculations to place the peak damage region within the depth interrogated by subsequent mechanical probing. The irradiated coupons were characterized by Rockwell mechanical testing. Future work includes more in-depth mechanical data collection post irradiation through the means of in-situ nanoindentation and irradiation. The literature on conventional SiC reports pronounced hardening at low doses as point defects and small clusters impede dislocation activity, followed by amorphization at higher damage levels, 2-5 MeV. Using nanoindentation and advanced analysis for post irradiated samples we seek to decipher analogous trends in our samples, while quantifying how the PDC-specific microstructure shifts the dose thresholds, hardening magnitude, and disorder accumulation relative to conventional SiC baselines.
Building on this ex-situ foundation, upcoming experiments at TIBML will move the measurement into the transient regime where defect populations form and hardening and elasticity decrease. In situ nanoindentation will investigate the mechanical response of irradiated material directly, and low-fluence irradiation studies will track the earliest stages of defect generation and mechanical change in real time, capturing when and how polymer-derived SiC hardens rather than inferring it from post-irradiation end states. Together, the dose-series baseline and the in-situ campaign are designed to link specific defect populations to the measured mechanical evolution, providing the mechanistic connection between processing route, defect landscape, and property change.

Abstract 59 at 1:30 PM Session CA-AS-06 Monday 1:30 PM - 314B/C

On the understanding of the mechanical response of proton-irradiated additively manufactured materials via small-scale mechanical testing.

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Understanding the irradiation response of additively manufactured (AM) alloys is essential for qualifying structural materials for advanced nuclear energy systems. To mitigate the risk of material failure or damage during service, AM radiation-resistant engineering alloys must withstand the temperatures and radiation levels found in operational conditions; therefore, studying microstructure and micro-mechanical properties under irradiation is mandatory for effective materials qualification. In the case of a particular AM process, Laser Powder Bed Fusion (PBF-LB), pores, impurities, and unmelted powder particles are responsible for poor behavior, but there is also the influence of the nature of the microstructure: columnar and cellular grain microstructures are formed together at complex cyclic thermal history, which includes directional heat extraction, repeated melting, and rapid solidification of powder particles on the same layer. To sum up, the influencing factors in the microstructure affecting mechanical response involve crystallographic texture, lack-of-fusion defects, grain morphology, phase transformation, heterogeneous recrystallization, layer building, and microstructural coarsening among others. The different qualification methods in AM materials, rely on the use of standardized specimens at different orientations on the powder bed, and with different configurations of process parameters like laser power, laser scanning speeds, layer thicknesses, hatching distances, and others. These tests can capture most of the mechanical characteristics but are unable to discover intrinsic material properties of irradiated materials at low surface depths. The use

of high-throughput small-scale testing (HT-SST) becomes an alternative and is complementary to elucidating the effect of irradiation on changes in mechanical properties, which ultimately would be impactful in the durability of structural integrity in new generations of additively manufactured components used in advanced and small modular reactors. Our proposed HT-SST method would require the assessment of its reliability at different strain rates to reveal its effect on the predictability of the real mechanical performance during service.
Our previous studies explored the effect of proton irradiation in AM materials, namely 17-4 PH stainless steels, using nanoindentation and micropillar compression testing to develop novel models to understand the mechanical response at different strain rates, finding interesting behavior: The irradiation makes the alloy harder in terms of nano-hardness and contributes to an increase in the maximum shear strength, affecting the yield and shear strength. Our recent studies focus on the combined mechanical response of AM materials subjected to irradiation and a postprocessing technique using hot isostatic pressing (HIP) to mitigate porosity defects. This presentation will integrate these approaches and include final remarks on future work and industry insights.

Abstract 129 at 2:00 PM Session CA-AS-06 Monday 1:30 PM - 314B/C

A light switch for a hidden ferroic order and a case for controlled ion irradiation

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Ferroaxial order is the least explored member of the ferroic family. Its order parameter is an axial vector, for example, composed of loops of local electric dipoles, that is invariant under both spatial inversion and time reversal. Ferroaxial domains therefore carry no stray or depolarizing fields, which is attractive for dense nonvolatile memory, but for the same reason they are insensitive to static electric and magnetic fields. This has long made ferroaxial domains difficult to detect and impossible to pole. Until recently, ferroaxial materials met only two of the three requirements of a ferroic phase: they break symmetry and form domains, but hysteretic switching had never been demonstrated. We recently predicted that circularly driven infrared-active phonons provide an effective conjugate field for ferroaxial order [1] and Zeng et al. confirmed this experimentally in $RbFe(MoO_4)_2$, selectively and reversibly switching domains with single terahertz pulses of controlled helicity (2)Deterministic control by a conjugate field elevates ferroaxiality to a true ferroic phase.
Control of domains immediately raises the question that governs every ferroic in application: how do domains interact with defects? In ferroelectrics and ferromagnets, point defects, dislocations, and irradiation-induced disorder set coercive fields, pin domain walls, and produce fatigue. But in the ferroaxial case, essentially nothing is known experimentally. Ion irradiation is the natural tool for this question: it introduces defects of a chosen type, concentration, and depth, decoupled from growth chemistry, and the damage level can be tuned continuously across orders of magnitude.
The talk will review recent developments in ferroaxial materials, outline their technological potential, and argue that studies of controlled defects are timely.
[1] Z. He and G. Khalsa, Optical control of ferroaxial order, Phys. Rev. Research 6, 043220 (2024). https://doi.org/10.1103/PhysRevResearch.6.043220
[2] Zeng et al., Photo-induced nonvolatile rewritable ferroaxial switching, Science (2025). https://doi.org/10.1126/science.adz5230

Abstract 73 at 2:20 PM Session CA-AS-06 Monday 1:30 PM - 314B/C

Understanding Proton Irradiation-Induced Radiation Hardening and Strain-Rate Sensitivity in LPBF 17-4 PH Stainless Steel Through Nanoindentation

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Understanding the irradiation response of additively manufactured (AM) alloys is essential for qualifying structural materials for advanced nuclear energy systems. This study investigates the effects of proton irradiation on laser powder bed fusion (LPBF) fabricated 17-4 PH stainless steel by systematically comparing the irradiation response of as-printed (AP) and hot isostatic pressed (HIP) conditions with their irradiated counterparts (AP-IR and HIP-IR). Electron backscatter

diffraction (EBSD) was employed to quantify microstructural evolution and phase distribution, while nanoindentation was performed over multiple strain rates to evaluate irradiation-induced changes in hardness, elastic modulus, radiation hardening, and strain-rate sensitivity (SRS). Prior to irradiation, HIP significantly reduced porosity, promoted a more homogeneous martensitic microstructure with improved phase stability, resulting in a 31% increase in hardness and a 52% increase in elastic modulus compared with the AP condition. Proton irradiation produced significant radiation hardening in the AP material, increasing nanoindentation hardness and elastic modulus by 26.2% and 34.3%, respectively, while strain-rate-dependent increases from 5.720 to 9.836 GPa and 269.915 to 315.765 GPa demonstrated enhanced strain-rate sensitivity (SRS) through irradiation-induced defect-dislocation interactions. In contrast, the HIP-IR condition exhibited a comparatively lower irradiation-induced mechanical response, with hardness and elastic modulus of 10.204 GPa and 347.974 GPa, respectively, remaining below the corresponding HIP values of 11.94 GPa and 383.508 GPa, while maintaining a more stable strain-rate-dependent deformation response than the AP-IR condition. These findings establish direct process-microstructure-irradiation-property relationships, demonstrating that tailoring the initial microstructure through post-processing is an effective strategy for improving irradiation resistance in additively manufactured alloys. Furthermore, the resulting insights provide a foundation for the design and qualification of radiation-tolerant AM materials for next-generation nuclear energy applications.

Abstract 31 at 2:40 PM

Session CA-AS-06 Monday 1:30 PM - 314B/C

Ion Beam Channeling Analysis of Helium-Irradiation-Induced Damage and Smart-Cut Exfoliation in Ferroelectric Single Crystals

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Ferroelectric single crystals such as barium titanate ($BaTiO_3$) and lithium niobate ($LiNbO_3$) are attractive for integrated photonics, electro-optic modulation, and biosensing owing to their high refractive indices and strong nonlinear optical response. $BaTiO_3$ exhibits the largest Pockels coefficient of any oxide ferroelectric ($r_{42} \approx 1300$ pm/V, more than an order of magnitude above $LiNbO_3$) [1], making it a leading material for next-generation silicon-photonic modulators in high-speed data-center and AI interconnects and driving demand for reliable integration of single-crystal $BaTiO_3$ films on silicon. The Smart-Cut (ion-slicing) technique enables this integration by using light-ion implantation to form a buried damage layer that is later exfoliated by thermal treatment, a route well established for $LiNbO_3$ and now being extended to $BaTiO_3$. Realizing high-quality films by this approach requires quantifying the implantation-induced damage and its thermal recovery, the focus of this work.
In this work, $BaTiO_3$ single crystals were implanted with 1 MeV He^+ ions at fluences from 2.5×10^{15} to 1×10^{17} ions/cm² using the 3 MV (9SH) Pelletron accelerator at the Ion Beam Laboratory, University of North Texas. SRIM simulations predicted a buried damage peak at ~2 μm depth (4)The resulting lattice disorder was probed nondestructively by Rutherford Backscattering Spectrometry in channeling mode (RBS/C) with a 1 MeV He^+ analyzing beam [2,3], complemented by Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), optical microscopy, and depth profilometry.
The minimum channeling yield (χ_{min}) increased monotonically with fluence, from ~2% at 2.5×10^{15} ions/cm² to ~21% at 1×10^{17} ions/cm², tracking the transition from isolated point defects toward extended defect clusters and partial amorphization. Raman spectra showed broadening and a red-shift of the ~297 to 300 cm^{-1} tetragonal mode after implantation, consistent with the channeling results. Post-implantation annealing near the Curie temperature progressively recovered the crystallinity, with χ_{min} improved to ~14% after annealing at 100 to 125 °C and to ~2.8% for a sample annealed at 125 °C, indicating more effective recovery at the higher temperature. Raman measurements confirmed partial restoration of the tetragonal phase after annealing, consistent with reports of thermal recovery of ion-sliced $BaTiO_3$ crystallinity (4)
For layer transfer, implanted crystals were solvent- and RCA-cleaned, surface-activated by Ar/O_2 reactive ion etching, and pre-bonded to a handle substrate at room temperature, followed by annealing to drive exfoliation. Optical microscopy revealed crystallographically aligned cracking, and a Zygo optical profilometry confirmed localized exfoliation depths in close agreement with the SRIM projected range, validating the damage-layer cleavage mechanism. XPS of virgin, plasma-etched, and exfoliated surfaces tracked processing-induced changes in surface chemical state, where an increase in the reduced Ti^{3+} component after etching and exfoliation points to surface oxygen deficiency introduced during processing. Using this bonding-assisted Smart-Cut route, a lithium niobate film of approximately ~600×400 μm² was transferred, and a PMMA-adhesion variant exfoliated a larger barium titanate region of approximately ~1.2 mm × 130 μm.

These results establish ion beam channeling as a direct, quantitative probe linking implantation fluence, lattice disorder, and thermal recovery in $BaTiO_3$, and show that helium implantation combined with near-Curie-temperature annealing is a viable route for single-crystal ferroelectric thin-film transfer onto silicon. Correlating the XPS surface-chemistry trends with the structural recovery is expected to guide processing conditions that preserve interface and surface quality for bonding and optical performance. Ongoing work targets improved charge dissipation to suppress cracking, refined fluence and annealing windows for uniform millimeter-scale exfoliation, and correlation of post-transfer structural recovery with ferroelectric and electro-optic performance for photonic and biosensor platforms.

References:
[1] M. Zgonik et al., "Dielectric, elastic, piezoelectric, electro-optic, and elasto-optic tensors of $BaTiO_3$ crystals," Phys. Rev. B 50, 5941 (1994).
[2] D. K. Saini et al., "Investigation of helium-irradiation induced damage in ferroelectric single crystals through ion beam channeling analysis," Proc. SPIE 13899, 1389907 (2026).
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Abstract 169 at 1:30 PM

Session SN-SN-04 Monday 1:30 PM - 339

Deconstruction, Move, and Revitalization of the ASU 1.7 MV Tandetron

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In the fall of 2025, the Ion Beam Analysis of Materials (IBeAM) laboratory at Arizona State University was decommissioned, and its 1.7 MV Tandetron accelerator went to auction. We acquired the system and removed it over three week-long trips, working from a valuation based on photographs and video alone. This talk describes that operation: what we planned for, what actually happened, and what we would advise others facing a similar system.
Upon arrival, the accelerator was still under high vacuum. The laboratory's operator had left the university, so no one on site retained detailed knowledge of the machine, and the university needed the roughly 190 square meter basement cleared on a very short timeline. We documented the process as we went, filming the entire room at several stages and labeling every beamline component, feedthrough, and cable with the intention of relocating and reassembling the system later.
The two highest-risk steps were removing the high-voltage supply and the accelerating columns. The 1.7 MV Cockcroft-Walton multiplier inside the SF6 pressure vessel consists of hundreds of nested conical capacitors with precisely maintained gaps between them; any rough handling could displace them, requiring a full disassembly to re-gap each one. For the two 1.8 m glass accelerating columns, embrittled by four decades of irradiation, no fully documented removal procedure existed. After speaking with several SNEAP colleagues operating similar machines, we received a video from Ovidiu Toader at MIBL showing the columns being removed from this same system two decades ago. Working from that video, we built a custom adjustable wooden table to slide the columns onto, together with a rolling scissor lift inside the tank to support the center of each column. Extraction and disassembly ran 16 continuous hours and were completed without damage.
The 4500 kg SF6 tank required a rigging contractor and an 18 m boom crane to disassemble and hoist out of the basement. Over two days we directed a crew of approximately 15 people through tank disassembly, lifts of irregular and load-sensitive equipment, and the packing and crating of all remaining components.
The operation finished roughly on schedule and at exactly the cost estimated at the outset. All ancillary components from the laboratory are now inventoried, packaged, and available to the accelerator community, and the Tandetron and beamlines are available as a complete package, so that a system that would otherwise have been scrapped can return to service elsewhere. We present the column extraction method, the planning and inventory model, and what we would do differently a second time. Facility closures are increasingly common, and the knowledge required to move these machines safely is not well recorded.

Abstract 63 at 1:45 PM

Session SN-SN-04 Monday 1:30 PM - 339

Overview of the 2026 TUNL FN Tandem Injector Upgrade

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In early 2026, the National Electrostatics Corporation (NEC) installed a new beam injection system for the Triangle Universities Nuclear Laboratory (TUNL) 10 MV FN tandem accelerator. Both the direct extraction negative ion source (DENIS) and helium source previously used were replaced with an NEC toroidal volume ion source (TORVIS). Possibilities for both implantation and beam injection into the tandem were expanded with the additional installation of an NEC source of negative ions by cesium sputtering (SNICS II). Both sources were coupled to the FN via a new pre-acceleration beamline. 2 ns pulsed beam is achieved with a new 4 species chopper and buncher system. Boasting higher achievable beam currents, improved emittances, and an expanded range of species out of which to produce pre-acceleration beam, this recent upgrade represents a significant step forward for experimental capability in the TUNL tandem lab. Operating principles and major figures of merit for the new injector will be discussed.

Abstract 72 at 2:00 PM — Session SN-SN-04 Monday 1:30 PM - 339

Commissioning of the Triton Source at FSU

Ashton Morelock[1], Miguel Madurga-Flores[1], Ingo Wiedenhoever[2], Lagy Baby[2], Alex Conley[2], Alfredo Galindo-Uribarri[3], Augusto Macchiavelli[3]

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Florida State University, in collaboration with the University of Tennessee Knoxville and Oak Ridge National Laboratory, has installed a Multi-Cathode Source of Negative Ions by Cesium Sputtering (MC-SNICS), dedicated to the production of triton beams at the John D. Fox Laboratory. Triton beams have successfully been produced, and preliminary results were obtained for reactions ^{49}Ti(t,p) and ^{12}C(t,α). A discussion of safety precautions, tritium commissioning results and future plans will be presented.

Abstract 150 at 2:15 PM — Session SN-SN-04 Monday 1:30 PM - 339

Running the UW FN Tandem at 8.8 MV for He6-CRES

Brittney Dodson, Mason Newman, Clint Wiseman

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The University of Washington's FN Tandem has provided beams for nuclear physics research since the 1960's, routinely reaching 9 MV in its heyday. In recent years, its main user has been the He6-CRES Collaboration, which seeks to measure beyond Standard Model physics in the ratio of the beta-decay spectra of 19Ne and 6He. Producing the 6He isotope in sufficient quantities requires operating the UW FN near its 9 MV limit. This has proven difficult in recent years as longtime engineers have retired and maintenance was deferred. In 2024, a new team began efforts to revitalize the machine, refurbishing its aging tank gas compressor along with its vacuum and control systems. The machine initially faced significant difficulty reaching voltages over 8 MV, with excessive tank sparking preventing stable operations. After a major effort in cleaning the FN, maintenance on its Pelletron chains, and overhauling the tank gas system, in August 2026 the machine ran successfully at 8.8 MV for the first time since June 2023, providing a stable 7-9 uA beam for 90 hours of science data taking. In this talk, we discuss the various challenges faced along the road to bring the UW FN up to this high voltage for the successful science run.

Abstract 170 at 2:30 PM — Session SN-SN-04 Monday 1:30 PM - 339

Design and Installation of a 300 kV Ion Implanter for Dual-Beam Irradiation in Coupled Extreme Environments

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The Tennessee Ion Beam Materials Laboratory (TIBML) at the University of Tennessee, Knoxville is expanding its testing capability in coupled extreme environments, in which irradiation is applied simultaneously with other stimuli such as temperature, mechanical load, or a background magnetic field. To support this direction, TIBML initiated the purchase of a 300 kV NEC ion implanter in March 2023. The implanter is colocated with the laboratory's NEC 3 MV Pelletron tandem accelerator for dual-beam irradiation across a wide range of ion species, energies, and dose rates.
The system is being built with several end stations, each addressing a different coupled condition. A cryogenic dual-beam stage reaching 30 K supports fundamental studies of radiation defect interactions and damage accumulation. A high-temperature dual-beam chamber covers the opposite regime, using a 400 W laser to hold samples at 1000 °C, conditions relevant to reactor and aerospace service environments. A high-flux station is dedicated to elevated dose rates, reaching high damage levels within practical beam time. Finally, an in situ scanning electron microscope end station provides real-time surface and microstructural observation during irradiation.
Installation began in November 2025, and commissioning is ongoing. Several unforeseen challenges called for iterative engineering solutions, some of which may be useful in other systems. The wooden shipping crates the implanter arrived in were repurposed as the high-voltage deck platforms. Components recovered from the decommissioned UC Berkeley and Arizona State University accelerators were incorporated into the beamline, cutting cost and lead time. An RBD Instruments 9103 picoammeter has been a valuable addition, reading slit and Faraday cup currents with excellent stability from either an internal 90 V battery bias or an external supply. It logs and exports data and exposes a Python API, matching our longer-term goal of bringing every machine in the laboratory into a common data store for tracking and diagnostics. We also added PCB accelerometers spanning 0.5 Hz to 10 kHz, mounted on each turbomolecular pump to record radial vibration, so that frequency analysis can track bearing health and identify failure modes before a pump is lost. Accelerometers on the SEM are under consideration as well, since the deck generators produce noise and vibration that affect image resolution.
Two subsystems received particular attention. The deck vacuum system was upgraded with an Agilent IDP-7 dry scroll pump on a custom electrically isolated stand, roughly tripling the backing throughput; pump-down times fell substantially, foreline pressure improved by roughly two decades to 0.4 Pa (3 mTorr), and the rigid mount markedly reduced vibration transmitted into the turbopumps. On the Danfysik 921A ion source, we developed a set of in situ diagnostics: using the analyzing magnet as a residual gas analyzer to verify plasma composition, and tracking extraction efficiency as drain current per arc amp, which held at 0.13-0.18% across the machine's operating history. These diagnostics traced a change in source output after a filament replacement to the cathode itself, rather than to contamination or extraction optics; we are working with NEC to finalize the filament specifications.

Abstract 146 at 3:30 PM | Session CA-AA-03 Monday 3:30 PM - 382B

Neutron Diagnostics at Sandia National Laboratories Z-Facility

Michael Mangan

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Sandia National Laboratories (SNL) has an experimental inertial confinement fusion program at the Z-Facility and is exploring the Magnetized Liner Inertial Confined Fusion (MagLIF) concept. Neutrons resulting from target fuel fusion provide key metrics for assessing the target plasma conditions during stagnation. Several neutron diagnostics are currently used at the facility and others are under development.
In this presentation a brief overview of the Z-facility and MagLIF concept will be given to motivate the utility and needs of neutron diagnostics at the Z-facility followed by a more detailed description of the current and developmental neutron diagnostics at the facility.
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.
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Abstract 119 at 4:00 PM

Session CA-AA-03 Monday 3:30 PM - 382B

A new target hall for neutron scattering science at the Oak Ridge National Lab (ORNL) Spallation Neutron Source (SNS)

John Francis Ankner

Second Target Station Project, Oak Ridge National Laboratory, Oak Ridge Tennessee, United States

The Spallation Neutron Source (SNS) at the Oak Ridge National Laboratory (ORNL) has for the past 20 years employed the world's most powerful proton accelerator to generate neutron beams to carry out structural and spectroscopic studies in/of quantum materials, materials science, engineering, chemistry, catalysis, soft matter, polymers, and biological systems. A second target station (STS) is currently under construction, featuring brighter neutron beams over a larger wavelength bandwidth that will enable scientific studies over dramatically broader length, time, and energy scales. I will discuss construction progress and timelines, and present examples of the new science STS will make possible.

Abstract 125 at 4:30 PM

Session CA-AA-03 Monday 3:30 PM - 382B

Learning Dynamics in Thin Films from Time-Dependent Neutron Reflectivity Measurements

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Neutron reflectometry (NR) is a unique characterization technique for studying the structure of thin films due to its high spatial resolution, nondestructive nature, and the sensitivity of neutrons to both isotopes and spin. With advances in data acquisitions and analysis, the NR measurements can be performed in the time domain, with a resolution of seconds. These necessitate interpretation of time-dependent NR data in an unconventional manner and require development of automated data analysis for learning dynamics in thin films. In this talk, I will introduce the time-dependent NR measurements collected at the liquids reflectometer at the Spallation Neutron Source, ORNL, followed by our effort in developing data analysis framework based on neural networks and Bayesian method. As a toolkit, this set of workflows represent a step forward towards facilitating the analysis, interpretation, and prediction of NR signals, paving the road to automatization.

Abstract 120 at 3:30 PM

Session CA-AN-02 Monday 3:30 PM - 382A

Bayesian Inference for Precision Studies of the Quark-Gluon Plasma

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Relativistic heavy-ion collisions provide a unique opportunity to study the quark-gluon plasma (QGP), a strongly interacting state of matter governed by quantum chromodynamics. Extracting its microscopic properties, however, requires confronting complex dynamical models with a growing collection of experimental measurements while consistently accounting for theoretical and experimental uncertainties. Bayesian inference provides a framework for addressing this inverse problem, complementary to many other AI/ML approaches.
In this talk, I will discuss the use of Bayesian methods to constrain the properties and dynamics of the QGP from heavy-ion collision data. Modern analyses combine computational models, surrogate emulators, and multiple experimental observables to infer model parameters and quantify their uncertainties. The analysis is also proven to be a useful tool for model studies. Current challenges, including model dependence and correlated systematic uncertainties will also be discussed. These developments help transform heavy-ion phenomenology from qualitative model comparisons toward quantitative, precision inference of the properties of strongly interacting matter.

Abstract 153 at 4:00 PM Session CA-AN-02 Monday 3:30 PM - 382A

Gauge-Equivariant Message Passing for Machine Learning of Lattice Gauge Systems

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Gauge theories provide the fundamental framework for describing interactions across high-energy, nuclear, and condensed-matter physics, but their local symmetry also presents a distinctive challenge for machine learning. Generic neural-network architectures do not automatically respect gauge covariance and often require extensive data augmentation or gauge fixing. In this talk, I will discuss our development of gauge-equivariant graph neural networks (GNNs) that incorporate local gauge symmetry directly into the message-passing architecture.
In this framework, lattice sites and links form a natural graph representation, with matter and gauge degrees of freedom encoded as node and edge features. Message-passing operations are constructed to transform covariantly under local gauge transformations, while gauge-invariant physical observables are obtained at the output. The resulting architecture provides a systematic way to build symmetry-preserving machine-learning models for lattice gauge systems. Importantly, repeated message passing naturally generates increasingly extended gauge-covariant paths and closed Wilson-loop structures, establishing a direct connection between network depth, receptive field, and the hierarchy of gauge-invariant correlations represented by the model.
I will present applications to several Abelian and non-Abelian lattice gauge models, including U(1), SU(2), and SU(3) systems, where gauge-equivariant networks accurately learn energies, local observables, and generalized forces while maintaining the underlying local symmetry. These results illustrate how gauge equivariance can provide both strong inductive bias and a physically interpretable organization of learned representations.
More broadly, symmetry-preserving message-passing architectures offer a route toward scalable machine-learning representations of gauge-field dynamics and many-body systems. I will discuss their potential role in accelerating large-scale simulations and in developing transferable AI/ML approaches for problems involving gauge fields in condensed-matter, nuclear, and high-energy physics.

Abstract 109 at 4:30 PM Session CA-AN-02 Monday 3:30 PM - 382A

AI-ready Detector Representation and Graph Neural Network Reconstruction for the ePIC Barrel Imaging Calorimeter

Zhiwan Xu

Physics Division, Argonne National Laboratory, Lemont IL, United States

Future experiments at the Electron-Ion Collider (EIC) demand reconstruction and analysis methods that can fully leverage the fine-grained information delivered by modern detector technologies. In this work, we introduce an AI-oriented data framework constructed from low-level detector readout simulations and designed to support a broad class of detector systems, with a specific focus on the Barrel Imaging Calorimeter (BIC) in the ePIC experiment. The BIC employs a hybrid readout architecture that integrates high-granularity AstroPix tracking layers with silicon sensors and Pb/scintillating-fiber sampling layers for calorimetric energy measurement, providing a compelling testbed for machine learning studies. Using this representation, we develop a Graph Neural Network (GNN)-based end-to-end reconstruction pipeline that operates directly on the AI-ready detector data and addresses key tasks including particle clustering and event classification.

Abstract 24 at 3:30 PM Session CA-AR-04 Monday 3:30 PM - 332

Effects of Magnetic-Field-Assisted Tempering on the Microstructure, Mechanical Properties, and Irradiation Response of HT-9 Steel

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Ferritic/martensitic steels are leading candidate structural materials for advanced nuclear energy systems due to their excellent swelling resistance, favorable thermal properties, and high-temperature mechanical performance. In this work, we investigate the influence of magnetic-field-assisted tempering under magnetic fields up to 9 T on the microstructural evolution and mechanical behavior of HT-9 steel. EBSD, TEM, and mechanical testing reveal that magnetic-field-assisted tempering modifies carbide precipitation behavior and local strain distributions while producing measurable improvements in yield strength. Thermodynamic analysis suggests that applied magnetic fields alter ferrite/carbide interfacial energies, providing a plausible mechanism for carbide refinement. While low-dose light-ion irradiation resulted in irradiation-induced softening and a change in deformation behavior, heavy-ion irradiation produced an increased cavity density with increasing magnetic field strength. These observations are attributed to magnetic-field-induced changes in carbide stability and dislocation density. The results demonstrate that magnetic-field-assisted tempering offers a promising pathway for tailoring the microstructure and performance of ferritic/martensitic steels for advanced nuclear applications.

Abstract 167 at 3:55 PM Session CA-AR-04 Monday 3:30 PM - 332

Mapping, Not Sampling: High-Throughput Access to Coupled Extremes in a Single Ion Irradiation

Rijul Chauhan[1,2], Zhihan Hu[2], Kenneth Cooper[2,3], Benjamin Mejia-Diaz[2], Anthony Cecchini[2], David Lu[2], Nathaniel Thomas[2], Yongchang Li[2], Andres Morell-Pacheco[2], Jana Howard[4], Kaustubh Bawane[4], Mukesh Bachhav[4], Frank Garner[2], Lin Shao[2]

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Ion irradiation offers a powerful route for accelerating radiation-damage studies, yet conventional experiments still commonly evaluate one condition per ion irradiation. This point-by-point approach becomes increasingly inefficient when radiation response must be mapped over a large matrix of conditions. Compounding this, a campaign of separate beam runs carries run-to-run variations in beam current, dose rate, temperature, and vacuum quality that can obscure the very trends the campaign was designed to resolve. This talk describes an alternative approach in which specimen geometry is deliberately engineered to encode an additional variable within a single ion exposure, allowing irradiation response to be mapped rather than sampled. Two implementations are presented. In the first, an array of additively manufactured 316L stainless-steel pillars of differing height shared a common heated base, so that each pillar reached a distinct steady-state irradiation temperature and several temperatures were probed within one exposure. In the second, a specimen held in four-point bending was irradiated in cross-section. The bending geometry generated a continuous stress field across the specimen, from compression through the neutral axis to tension, so that stress-dependent microstructural evolution could be evaluated under an identical irradiation history. Results from both approaches will be presented, together with the microstructural trends they reveal and the practical limits that constrain how finely such response maps can be resolved.

Abstract 133 at 4:20 PM Session CA-AR-04 Monday 3:30 PM - 332

Effect of Prior Irradiation on the Molten Salt Corrosion Behavior of 316H Stainless Steel

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The effect of prior proton irradiation on the corrosion behavior of 316H stainless steel in FLiNaK was investigated using a sequential irradiation-corrosion approach. Three specimens were irradiated with 2 MeV protons at 360 °C while the beam was progressively expanded to produce nominal damage levels of 0.06, 0.26, and 0.46 dpa, ensuring identical irradiation and thermal conditions for all specimens. Approximately one-third of each specimen was masked during irradiation, allowing direct comparison between irradiated and unirradiated regions after corrosion in FLiNaK at 700 °C for 100 h. Prior irradiation increased the corrosion depth under all irradiation conditions. The average corrosion depth increased from approximately 10 µm in the unirradiated regions to 10.8, 11.8, and 14.5 µm for the 0.06, 0.26, and 0.46 dpa specimens, respectively. Scanning electron microscopy (SEM) and scanning transmission electron microscopy (STEM) revealed enhanced intergranular corrosion, increased Cr depletion, and more extensive elemental redistribution in irradiated regions. A mechanism based on irradiation hardening and increased local stress concentration at corrosion fronts is proposed to explain the observed corrosion acceleration.

Abstract 148 at 4:45 PM — Session CA-AR-04 Monday 3:30 PM - 332

Reproducibility and comparability of "bulk" simultaneous irradiation-corrosion studies

Franziska Schmidt[1], Matthew Chancey[1], Kayla Yano[2], Ben Derby[4], Hyosim Kim[1], Peter Hosemann[3], Blas Uberuaga[1], Yongqiang Wang[1]

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The safety and reliability of a Gen-IV nuclear reactor concept hinges on its materials selection. This selection process suffers from the absence of easily accessible test reactors, in which candidate materials could be exposed to the simultaneous extremes of neutron irradiation and a Gen-IV coolant, such as liquid PbBi eutectic. In recent years, laboratory-scale simultaneous beamline irradiation-corrosion experiments (ICE) have partially filled this gap, both for the purposes of testing engineering materials as well as studying model alloys to generate data for advanced materials modeling.
Additionally, advances in measurement techniques, data acquisition, and data analysis tools over the last few decades have greatly increased the amount of potential information that can be extracted from such studies. Yet, despite the relative simplicity compared with in-reactor tests, beamline ICE still suffer from a variety of experimental uncertainties and unknowns as well as reporting inaccuracies, which affect the interpretability and comparability of results across different experiments with different conditions. In particular in an age where experimental data are supposed to train and be interpreted by a growing number of large language models to assist in nuclear reactor materials selection, data quality appears to be more crucial than quantity.
This talk will highlight some of the reproducibility concerns arising from the scientific literature, discuss possible solutions, and present our attempts at standardizing the reporting of data from ICE III at Los Alamos National Laboratory.

Abstract 107 at 3:30 PM — Session CA-AS-07 Monday 3:30 PM - 314B/C

Place for Advancements and New Discoveries with Astatine-211

Lauren McIntosh[1], Shayden Fritz[1,2], Christine Lawrence[1], Marcus Le[1,2], Elizabeth Schnorrenberg[1,2], Peyton Schuldheiss[1,2], Gabriel Tabacaru[1], Jonathan D Burns[3], Sherry J Yennello[1,2]

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[(3)] *Department of Chemistry, The University of Alabama at Birmingham, Birmingham AL, United States*

At-211 is an isotope with great potential for targeted alpha therapy (TAT) radiopharmaceutical applications. Its production is currently limited by the small number of accelerators capable of producing the requisite alpha beam for bombardment of Bi

targets. TAMU is one of the few facilities where At-211 can be produced, which means it is one of a limited number of facilities where the chemistry of At can be investigated without transportation delays. We have developed a procedure to dissolve irradiated Bi targets and trap the At-211 on a column for shipment to other facilities. This At-211 can be reduced and removed from the column to be utilized in various potential contexts. Due to the short half-life of At-211, it may be advantageous to have a method of separation that involves fewer steps before adding a targeting vector for TAT. Current status and future prospects will be explored.

Abstract 93 at 4:10 PM Session CA-AS-07 Monday 3:30 PM - 314B/C

Production of the Radiopharmaceutical ^{44}Sc via Photonuclear Production

R.P. Zander[1], D.P. Wells[1], V. Romero[1], W.A. Hughes[1], R. Bentley[3], G. Santistevan[4], M. Baca[1], J.C. Sandusky[1], C. Gustafson[1], A. Villa[1], D.S. Dale[2], T. Forrest[2], K. Martinac[2], R. Staub, B. Rasmussen, E. Cardenas, M. Reichenberger

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This study presents an investigation of a proposed experimental photo-production method for the medical radioisotope Scandium-44 (^{44}Sc). We used an electron linear accelerator (LINAC) to generate bremsstrahlung photons, which were then used to initiate the photonuclear reaction ^{45}Sc (γ,n) ^{44}Sc. Electron beam energies varied from 20 to 23 MeV, in steps of 1 MeV. The neutron emission, in turn, causes the kinematic recoil of ^{44}Sc, which may enable isotopic separation. ^{44}Sc is of medical interest because it is a positron-emitting isotope with a short half-life of 3.97 hours, along with its ability to conjugate with organic compounds for radiolabeling. Furthermore, its nontoxic decay product, Calcium-44 (^{44}Ca), makes it an ideal candidate for positron emission tomography. Scandium oxide encased in an aluminum foil was used as the target and placed in the bremsstrahlung beam. A bremsstrahlung converter at the end of an electron LINAC was employed to produce the necessary gamma photon flux for the (γ,n) reactions. To extract the isotope, a potential separation technique could use kinematic recoil, because chemical separation of the ^{44}Sc and target material ^{45}Sc is not feasible. In principle, this process would physically separate the ^{44}Sc from the ^{45}Sc because the daughter neutron emission from the parent isotope will cause a recoil of the daughter from the matrix it is embedded in, which can then be caught with a catcher material. Experimental data were taken from a May 2026 experiment conducted at the Idaho Accelerator Center (IAC) and are compared against simulated data using the FLUKA Monte Carlo simulation. Future work will extend these measurements to a broader range of bremsstrahlung end-point energies to enable the measurement of excitation functions and cross sections, and to measure the efficiency of kinematic recoil to separate ^{44}Sc from ^{45}Sc.
Acknowledgements: This work was supported by the U.S. Department of Energy grant number DE-SC0023665.

Abstract 76 at 4:35 PM Session CA-AS-07 Monday 3:30 PM - 314B/C

Photon-Induced Production and Detection of Zirconium Medical Radiotracers: ^{88,89}Zr

Willie Andrew Hughes[1], Douglas Wells[1], Van Romero[1], Robert Bentley[1], Geno Santistevan[1], Mariana Baca[1], Catherine Zeiger[1], Jacob Sandusky[1], Jack Nation[1], Cody Gustafson[1], Ryan Zander[1], Aidan

Villa[1], Brandon Tso[1], Daniel Hojnowski[1], Daniel Dale[2], Tony Forest[2], Kean Martinic[2], Robert Staub[2], Bryan Rasmussen[2], Edna Cardenas[3], Michael Reichenberger[3]

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ABSTRACT
We investigated the potential of bremsstrahlung-photon induced activation of naturally-occurring Zirconium isotopes ($^{NAT}Zr = ^{90, 91, 92, 94, 96}Zr$) to produce medically-relevant radioisotopes. The photo-activation of ^{90}Zr is known to produce at least two medically-relevant radiotracers used for diagnostic positron emission tomography (PET) imaging, namely ^{89}Zr ($t_{1/2}$ = 78.4-hrs) a short-lived radiotracer and ^{88}Zr ($t_{1/2}$ = 83.4-days) a long-lived radiotracer. Data tables report photon activation of ^{89}Zr from the 1n nuclear channel, [^{90}Zr (g, 1n) ^{89}Zr], at an activation threshold E_{thr} ~ 11.97-MeV, and ^{88}Zr from the 2n nuclear channel, [^{90}Zr (g, 2n) ^{88}Zr], at an E_{thr} ~ 21.29-MeV. Bremsstrahlung beams were produced using a variable-energy electron linac and a tungsten/aluminum bremsstrahlung "converter". We measured photo-activation using bremsstrahlung beams of end-point energies between the 8 - 23-MeV, in increments of 1-MeV. The photo-production of both ^{89}Zr (909-keV) and ^{88}Zr (392.51-keV) were confirmed via high-purity germanium (HPGe) detection, and gamma-spectroscopy using PeakEasy (version: 4.99.4). We report on experimental ^{89}Zr photo-production yields and excitation functions. ^{88}Zr photo-production has been determined at 22- and 23-MeV energies only, due to the high (g, 2n) reaction threshold of approximately 21-MeV. Planned future work will extend bremsstrahlung end-point energies to 40-MeV and use these excitation functions to extract cross sections. In addition, we are pursuing measurements of the kinematic recoil of the daughters of these photonuclear reactions, due to the relatively large momentum of the emitted neutrons, as a possible method for isotopic separations.
Acknowledgements:
This work was supported by the U.S. Department of Energy grant number: DE-SC0023665.

Abstract 58 at 3:30 PM — Session SN-SN-03 Monday 3:30 PM - 339

Undergraduate-Focused Accelerator Laboratory at Gettysburg College

Bret E. Crawford

Physics, Gettysburg College, Gettysburg Pennsylvania, United States

The Student Proton Accelerator laboratory at Gettysburg College has been built and maintained by students and faculty to provide rich hands-on research experiences using techniques from nuclear physics. The laboratory centers on a 1960s era PN250 Van de Graaff accelerator and includes the usual associated equipment: vacuum systems, particle detection, thermal evaporator, and data acquisition electronics as well as manual and computer control of the accelerator. The lab provides a wealth of opportunities for students to apply physics knowledge and learn new skills. The accelerator is primarily used during our Cross Disciplinary Science Institute at Gettysburg (X-SIG) summer research program and in senior capstone projects. This talk will describe the facilities, how the lab fits into our curriculum, and some of the student projects.

Abstract 118 at 3:45 PM — Session SN-SN-03 Monday 3:30 PM - 339

Student Traineeship at the Cyclotron Institute at Texas A&M University

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The Cyclotron Institute at Texas A&M University maintains a variety of undergraduate and graduate student traineeship programs. Three separate summer undergraduate research opportunities (the NSF-funded Cyclotron REU, the DOE-NP-funded TREND program and a DOE-IRP-funded HIPPO summer research experience) combine together for the 'Tron Summer Scholars program each summer - a combined cohort of 15-20 students who participate in 8-10 weeks of full-time

research work with a Cyclotron Institute PI and research group. How these programs work together to enhance the student experience will be discussed. Recent progress in establishing a Masters in Physics specializing in Radiation Effects will also be discussed.

Abstract 135 at 4:00 PM Session SN-SN-03 Monday 3:30 PM - 339

From Bubble Rafts to Ion Beams: Developing a Pipeline for Future Accelerator Scientists

Connor Cambria, Kip Wheeler, Logan Howard, Micah Jones, Trevor Michelson, Hayden Sutton, Cameron Carney, Luke Van Herik, Enzo Adorno, Alexis Devitre, Khalid Hattar

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Particle accelerators are essential tools for a variety of fields including materials research, nuclear science, medicine, and industrial applications; however, few undergraduate students are even aware of the existence of accelerator-based science before entering college. During summer 2026, the Tennessee Ion Beam Materials Laboratory (TIBML) at the University of Tennessee, Knoxville partnered with the Appalachian STEM Academy at Oak Ridge to introduce six high school sophomores to material science, ion accelerators, and nuclear engineering ion beams for scientific study. The weeklong program combined laboratory tours, technical instruction and a hands-on bubble-raft experiment intended to make concepts of atomistic processes tangible.
Throughout the week, students were given presentations exploring the wide areas of research being conducted at TIBML. Graduate and undergraduate students alike presented active research projects in materials research and nuclear engineering to the high school students. To give the students a better understanding of the utility and accuracy of the bubble raft experiment, presenters connected the student's bubble raft lab observations of vacancies, interstitials, grain boundaries, and crystal formation to atomic displacement, irradiation damage, and the need to develop materials capable of surviving extreme nuclear environment. Students collected images from multiple experimental procedures, manually annotated individual bubbles, and trained a YOLOv8 machine-learning model to identify bubble positions.
We will discuss how inexpensive, visually intuitive experiments coupled in tandem with tours of accelerator laboratories can be used as an engaging introduction for high school students in radiation material science. We will also demonstrate how programs of this type provide an accessible pathway into understanding radiation material science and can contribute to a future pipeline of accelerator users, operators, researchers, and engineers.

Abstract 10 at 4:15 PM Session SN-SN-03 Monday 3:30 PM - 339

Workforce development for Accelerators: the US Particle Accelerator School

John Byrd

US Particle Accelerator School, Batavia IL, United States

The U.S. Particle Accelerator School (USPAS) is a national program, sponsored by the DOE Office of Science, that provides training and workforce development in the science, engineering and technology of charged particle accelerators and associated systems. Particle accelerators are recognized as vital tools in discovery science and high technology industry. Present and future anticipated shortfalls in the accelerator workforce result in many exciting job opportunities in this field. USPAS courses provide training that helps prepare our students to work in this diverse, exciting, and high-impact field. A broad variety of students at all stages of their careers attend our sessions. We welcome students from from universities, laboratories, private companies, medical facilities, government, and the military.
I will present an overview of the USPAS and how we are adapting the curriculum to serve the expanding accelerator community, especially for industrial accelerators.

Abstract 189 at 4:30 PM Session SN-SN-03 Monday 3:30 PM - 339

Open Discussion on Training, Recruitment, Education and Outreach.

Edward Stech

Physics and Astronomy, University of Notre Dame, Notre Dame Indiana, United States

Everyone is welcome to join in on an open discussion about training, education, recruitment and outreach involving accelerators and accelerator facilities. This free flowing discussion will cover both things that have worked as well as challenges faced by the community as a whole.

Abstract 185 at 9:00 AM — Session CA-PS-02 Tuesday 9:00 AM - 314B/C

50 Years with Ion Beams: Shaping, Probing, and Understanding Materials

Thirumalai Venkatesan

Departments of Physics and ECE, University of Oklahoma, Norman OK, United States

For nearly five decades, ion beams have been a recurring thread throughout my scientific journey—from keV to MeV energies, and from fundamental ion-matter interactions to materials modification, fabrication, and analysis. In this talk, I will share some of the adventures, discoveries, surprises, and serendipitous connections that emerged across institutions in the United States and abroad.

The journey began at Bell Labs, where, with Walter Brown and Al Wagner, we were among the early investigators of liquid-metal gallium focused ion beams. We explored field ionization through optical emission from the source and investigated ion-beam-sensitive resists for materials patterning. This led to studies of ion-polymer interactions, where we discovered that irradiation could transform a wide range of carbon-containing polymers into highly conducting carbon phases. This universality enabled direct patterning of conducting structures from polymer precursors. We traced the remarkable conductivity to nanometer-scale graphite islands, with carrier densities exceeding 10^{23} cm^{-3}. Ion-beam-induced decomposition also enabled the formation of SiC-like materials from polysiloxane precursors. Ion channeling in graphite subsequently led to studies with M Dresselhaus of structural regrowth and our demonstration of pulsed-laser melting of carbon.

At Bellcore, these efforts expanded into materials modification and characterization. When our division moved to Rutgers University, we established a surface modification center that continues to operate today. Ion-beam analysis, particularly Rutherford Backscattering Spectrometry (RBS), played an important role in these developments and in the emergence of pulsed laser deposition (PLD) for producing thin films and heterostructures.

At the University of Maryland, ion channeling provided a sensitive probe of structural changes in YBCO single crystals. We observed significant modifications well above the superconducting transition temperature, suggesting intriguing structural precursors to superconductivity.

Later, at the National University of Singapore, space constraints led to an unusual solution: we relocated the RBS system developed in Maryland to the Inter-University Accelerator Centre (IUAC) in New Delhi, where it became an important RBS facility serving the Indian materials research community.

Now, at the University of Oklahoma, the journey continues with our study of CeO_2 as a quantum material. Ion channeling has shown that even at 10% concentration, rare-earth ions are predominantly substitutional in this host. We are also launching the development of an Extra-Low Velocity Ion Source (ELVIS), aimed at generating focused ion beams at exceptionally low energies and enabling new ion energy-loss measurements of surfaces and near-surface phenomena.

From understanding how ions are generated, to using them to sculpt materials, and finally exploiting them as sensitive probes of structure and composition, this has been a 50-year journey in which the ion beam has been both **a tool for making materials and a window into understanding them**.

Abstract 101 at 10:00 AM — Session CA-AA-04 Tuesday 10:00 AM - 382B

PANDA-FES: Portable and Adaptable Neutron Diagnostics for Advancing Fusion Energy Science

Amanda E Youmans, James M Mitrani, Drew P Higginson

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The Portable Adaptable Neutron Diagnostic Advancing Fusion Energy Science (PANDA-FES) system[1] was developed over the course of a few years by a collaboration of scientists from national labs, universities, and industry. The private fusion energy industry has received an influx of investment capital which provides opportunity for advances in plasma physics and understanding of high energy density plasmas. Fusion energy companies are working to scale up concepts to produce electricity on the grid. Proof of concept experiments are often done using deuterium-only plasma on a small scale. Then, the concept will be scaled up if it looks promising. One of the ways to evaluate the scalability of a fusion concept is to determine if the fusion is thermonuclear, occurring with the reactants in equilibrium, or not. The goal of this project was to develop a platform-agnostic system that can quantify neutron output and determine if there is thermonuclear fusion happening in the plasma. Neutrons are a product of deuterium fusion that can be measured from outside of a vacuum chamber and indicate the state of the plasma within. High energy neutrons, like those emitted from fusion plasmas, are difficult to measure because they do not interact in most materials. In order to measure high quality data from sources over many orders of magnitude of neutron flux, two types of detectors are used: plastic scintillators coupled with photomultiplier tubes (PMT) and neutron activation detectors. Proton recoil detectors use neutron scattering with hydrogen to result in a moving proton that produces light in a scintillator material. Fast plastic scintillator detectors with different sizes, gains, and analysis methods were selected for this system so they can be tailored to different platforms or setups. The selected isotopes in the activation detectors utilize an inelastic scattering threshold reaction to measure high energy neutron energies emitted from fusion sources with a fluence range between 5.0E2 and 1.0E6 n/cm^2.Both these detector types were well-characterized before deploying them at fusion energy company testbeds. The timing of the plastic scintillator detectors was measured as a function of the bias voltage on the PMT. The gain of the scintillator detectors is nonlinearly related to the bias voltage, so each PMT was adjusted to equalize the gain in all the PMTs in use in each experiment. The activation detectors were cross calibrated using a fusion source at LLNL and a calibrated beryllium neutron activation detector. By accurately characterizing the individual components of the diagnostic, the systematic uncertainty is reduced and results are transferable from one location to another. The system was simulated with radiation transport codes to discover more about the underlying physics of what was measured. Scattered signal was predicted using simulations of a vacuum vessel with a fusion source inside to determine the best placement of plastic scintillator detectors. Simulations were also used in a forward fit methodology to determine the energy of deuterium ions that best replicated measured data. The PANDA-FES diagnostic system has been fielded at four different facilities to characterize the neutron emission from different deuterium fusion sources. This has helped fusion energy companies develop their own diagnostic capabilities and improve neutron source characterization techniques.
[1] A. E. Youmans **et al.**, "PANDA-FES: Portable and Adaptable Neutron Diagnostics for Advancing Fusion Energy Science," in **IEEE Transactions on Plasma Science**, vol. 52, no. 10, pp. 4833-4841, Oct. 2024, doi: 10.1109/TPS.2024.3396427.
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Abstract 156 at 10:30 AM Session CA-AA-04 Tuesday 10:00 AM - 382B

Monte Carlo Techniques for Analysis of Positron Impact-Induced Secondary Electron Spectroscopy of Graphene and Graphite

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We present a Monte Carlo simulation framework for analyzing and deconvolving the effects of positronium (Ps) emission on measured Positron-Impact-Induced Secondary Electron (PIISE) spectra. PIISE measurements conducted using a magnetic-bottle time-of-flight (ToF) spectrometer at the University of Texas at Arlington (UTA) are influenced by gamma rays arising from the emission and subsequent annihilation of Ps. To characterize this influence, we perform a Monte Carlo simulation of the emitted Ps atoms to determine the probability distribution of their annihilation positions and lifetimes. This distribution, together with the energy and angular distributions of the annihilation gamma rays, are used in a GEANT4 simulation of the positron beam system to determine the gamma-ray detection-time distribution. The simulated Ps-annihilation gamma-ray detection-time distribution is then used to remove the effect of Ps from experimental PIISE spectra of graphene, graphite, and copper via an iterative deconvolution method. The resulting PIISE lineshapes and secondary electron yields (SEYs) differ substantially from each other, revealing the material-specific nature of the underlying positron-impact-induced secondary-electron emission process. The deconvolution procedure also enabled determination of the fraction of positrons that are re-emitted as Ps after impacting graphene, graphite, and copper surfaces.

Abstract 143 at 10:45 AM | Session CA-AA-04 Tuesday 10:00 AM - 382B

Adding Neutron Reflectometry to your toolbox: a case study of interfacial shear

Rebecca Welbourn

Neutron Sciences, Oak Ridge National Laboratory, Oak Ridge TN, United States

Neutron reflectometry is an excellent technique for measuring interfacial layers, including under changing conditions and at buried interfaces. It provides sub-nanometer resolution of structure perpendicular to the interface, with good sensitivity to lighter elements and isotopic variation, making it highly complementary to x-ray and light probes. Neutron penetration also enables a variety of **in-situ** sample environment chambers for **operando** measurements, such as changes in flow, confinement, temperature, pressure, humidity, magnetic field and pH. The technique has been applied to a wide range of questions across energy and the environment, biophysics, advanced materials, soft-matter, and beyond. The impact of results can be enhanced when combined with complementary measurements or modelling. This talk will introduce the technique, highlighting capabilities and limitations, followed by specific examples at the solid-liquid interface where adsorbed layers are subjected to flow or shear conditions.

Changes in adsorbed layers under shear are generally out-of-equilibrium, requiring **in-situ** observation to understand the processes occurring. However, surfaces are typically a very small signal compared to the bulk and the buried solid-liquid interface is challenging to reach, meaning there are limited options for investigating these systems. Neutron reflectometry is one such possibility where, depending on the system and regime required, varied sample environment approaches can be used. Results will be presented spanning from laminar flow cells, to **in-situ** rheology, and tribology.

Abstract 172 at 10:00 AM | Session CA-AN-03 Tuesday 10:00 AM - 382A

Toward Autonomous Accelerators: Machine Learning and Digital Twins for Optimized Beam Delivery

Eiad Hamwi, Weijian Lin, Kevin Brown

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Advances in machine learning (ML) techniques are creating new opportunities to improve the performance, reliability, and efficiency of particle accelerators. The EIC-BeamAI collaboration is developing and experimentally testing approaches that combine physics-based models, machine learning, and accelerator controls to optimize beam delivery: including higher brightness, reduced beam losses, and improved reproducibility at experimental end stations.

This talk will highlight recent progress in ML-based beam optimization and the development of digital twins that connect accelerator models with operating machines. We will discuss applications across the Brookhaven hadron injector complex, including efforts toward a digital twin of the NASA Space Radiation Laboratory (NSRL). These efforts illustrate a broader path toward increasingly intelligent and autonomous accelerator operations for nuclear physics, materials irradiation, and other accelerator-based experiments.

Abstract 161 at 10:30 AM [Session CA-AN-03 Tuesday 10:00 AM - 382A]

Autonomous AI Experimentation for Streaming Readout in High Luminosity Nuclear Physics

Dmitry Romanov

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Modern high-luminosity nuclear physics experiments, including the Electron-Ion Collider (EIC) and upcoming experiments at Jefferson Lab, generate continuous, unsegmented detector data. Finding rare physics signals amid extreme background and pileup makes traditional discrete event triggers increasingly inadequate. To overcome this bottleneck, facilities are transitioning to a streaming readout paradigm. This approach eliminates the hardware trigger and delivers the complete detector output directly to software, shifting background rejection and event selection entirely onto real-time algorithms.
To develop these algorithms, we employ automatic experimentation, in which autonomous AI agents design, execute, and evaluate experiments under a strict written scientific protocol. Agents test one hypothesis at a time; every change is gated on measured results, often strictly bit-exact; and open questions are escalated to human developers. These workflows manage the complete cycle, from building datasets and training models to integrating production code and reporting quantified gains.
This strategy delivers improvements across both ML pipelines and production software. For the ePIC detector at the EIC, an agent developed CNN and attention pipeline isolates interaction time windows within streaming frames dominated by synchrotron background. It achieves up to a 97% noise reduction while retaining 99% of signal hits, accelerating track finding by 6.5x. The same methods were successfully applied to a DNN selector that identifies far forward Λ decays, and to an event level network that separates signal events from deep inelastic scattering physics background with high accuracy using only leading momentum reconstructed particles. Applied to real beam data from streaming readout tests at Jefferson Lab, agent driven optimization of the raw data time frame processing chain increased throughput from 95 MB/s to over 4 GB/s, a 44x gain.
This talk will present the methods, the measured results, and the protocol that makes autonomous AI experimentation reliable for the streaming readout era in nuclear physics.

Abstract 110 at 11:00 AM [Session CA-AN-03 Tuesday 10:00 AM - 382A]

Bidirectional Diffusion Models Can Predict their own Rollout Errors for Digital Twins

Alexander Scheinker

Instrumentation and Controls Group, Los Alamos National Laboratory, Los Alamos NM, United States

Learned surrogates and generative models increasingly stand in for numerical solvers across computational science, and as digital twins of physical systems such as particle accelerators, plasmas in tokamaks, weather, and even human videos. In these cases, they are often deployed autoregressively and as each prediction feeds the next, small errors compound, and at deployment there is no ground truth to check against. The model cannot tell you how far into the future it can still be trusted. This talk presents our recently developed self-supervised approach to quantifying error in roll out predictions without access to the unknown ground truth (1)We train a single conditional latent diffusion model that steps a dynamical system forward or backward in physical time via a direction flag, so one network is both a surrogate solver and an inverse solver. The method is model-agnostic and can be applied in the same way to a wide class of generative autoregressive models, including flow models, UNets, and transformer-based neural operators. The main idea is that an accurate model composed with its own inverse is the identity, therefore rolling forward i steps and backward i steps must return to the start, and the size of the round trip error becomes a self-supervised measurement-free, test-time error signal. Across turbulent magnetohydrodynamics, an astrophysical mixing layer, a public Navier-Stokes benchmark, and natural video, and charged particle beam dynamics simulations, this signal predicts the true rollout error of held-out trajectories, flags out-of-distribution dynamics immediately in exactly the regime where standard sampling-spread uncertainty fails, and lets a single model approach a ten-model ensemble's accuracy at a tenth of the training cost. One additional finding is that bidirectional training of a single model beats two direction-specialist models, in both directions. A simple theory explains this improved performance: the check certifies error only while the learned inverse remains well-conditioned, it dissolves for strongly information-destroying dynamics, and both regimes can be identified offline with representative training data. I will close with the path from error detection to error correction, which closes the loop with model-free adaptive feedback, and a set of open problems well suited to collaboration.

[1] Preprint: arXiv:2608.00675

Abstract 127 at 10:00 AM Session CA-AR-03 Tuesday 10:00 AM - 332

Tuning Topological Spin Textures in FeGe via Ion Beam Modification

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Magnetic skyrmions are nanoscale, swirling spin textures stabilized by chiral interactions in non-centrosymmetric magnets. Their small size and topological stability make them promising candidates for next-generation, low-energy spintronic memory and logic. Realizing skyrmion-based devices requires understanding how these textures interact with defects: how skyrmions navigate intrinsic disorder, and how disorder can be deliberately engineered to control device behavior. Here, we show that ion irradiation offers a tunable route to both goals in epitaxial B20-phase FeGe films, using heavy Au^{4+} and lighter Ne^{2+} ion irradiation to introduce distinct defect landscapes. Irradiating with 2.8 MeV Au^{4+} ions introduces amorphous regions within the crystalline matrix. Low-temperature transport and magnetization measurements reveal a strong topological Hall effect with a double-peak feature, a signature of a skyrmion-antiskyrmion system. In contrast, 400 keV Ne^{2+} irradiation introduces smaller, nanoscale point-defect clusters, dramatically extending the temperature stability of the topological Hall phase: while pristine films show the signal only from 280 to 80 K, most irradiated samples retain it down to 4 K, with roughly double the signal amplitude. Together, these results establish ion-beam disorder engineering as a versatile route to both creating topological spin textures and extending their operating range into the cryogenic regime relevant to quantum-hybrid architectures.

Abstract 141 at 10:30 AM Session CA-AR-03 Tuesday 10:00 AM - 332

Multi-scale reconstruction of single-ion damage tracks in diamond via nitrogen-vacancy centers

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Understanding particle-induced damage tracks in solid-state materials underpins emerging applications in rare-event detection and quantum defect engineering. Resolving these tracks requires multi-scale readout, from event localization at the millimeter scale to track-morphology reconstruction at the nanoscale. Nitrogen-vacancy (NV) centers in diamond provide such a platform, combining optical localization with quantum sensing of track morphology. In this talk, I will present results from our recent study, where we implant sub-MeV carbon ions into nitrogen-rich diamond and detect individual recoil events via spatially localized NV formation. We develop a simulation framework that explains the observed NV yield and predicts that directional information is retained in the NV distribution after annealing. Machine learning further recovers much of the information lost to defect diffusion and limited NV yield, improving head-tail classification to a level comparable to pre-annealed vacancy tracks. Measurements of NV spin coherence indicate compatibility with nanoscale track reconstruction via NV strain mapping and magnetic gradient-based techniques. These results identify promising pathways toward NV-diamond directional detectors for rare events, while the track-modeling framework has broader implications for paleodetection and quantum material synthesis. I will also present our ongoing work on developing 1) a light sheet quantum diamond microscope for large-scale scanning of diamond to detect damage tracks from rare events, and 2) ML-driven, GPU-accelerated molecular dynamics simulations of damage cascades in diamond.

Abstract 163 at 11:00 AM

Session CA-AR-03 Tuesday 10:00 AM - 332

Silicon Spin-Photon Qubits: From Defect Engineering to Integrated Quantum Photonics

Wayesh Qarony[1,2,3]

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(3)CREOL, The College of Optics and Photonics, University of Central Florida, Orlando Florida, United States

Silicon offers a mature and scalable platform for quantum technologies, combining advanced semiconductor manufacturing with the potential for monolithic integration of quantum emitters, photonic circuits, and electronic control. Emerging silicon spin-photon defects further combine telecom-band optical transitions with long-lived electron and nuclear spin coherence, providing promising building blocks for on-chip quantum processing, communication, networking, and quantum memory. In this invited talk, I will discuss our efforts to engineer silicon spin-photon qubits through ion implantation, thermal processing, and femtosecond-laser-based defect control. I will highlight emerging telecom-band defects, deterministic creation, modification, and erasure of individual quantum emitters, and how materials processing influences their optical and spin properties. Finally, I will discuss their integration with nanophotonic cavities with a very high atom-cavity coupling efficiency and quantum photonic circuits for enhanced light-matter interaction and on-chip quantum-optical functionality, providing a pathway from controlled defect synthesis to scalable silicon quantum photonic systems.

Abstract 128 at 10:00 AM

Session CA-PS-04 Tuesday 10:00 AM - 314B/C

Nuclear Reactor Tutorial: Generating Electrical Power from Nuclear Fission

Peter Hosemann

Nuclear Engineering and Mechanical Engineering, University of California at Berkeley, Berkeley California, United States

Currently, nuclear power contributes approximately 18% of the United States' electricity production, with 94 operational power reactors. For the past 60 years, nuclear fission has provided substantial benefits, and today, more advanced nuclear reactor concepts are being developed for the future. But how is electricity generated from fission, and why is there a push to develop new reactor concepts? What differentiates thermal and fast reactors, and how is the heat produced that eventually transforms into electricity?
This lecture will cover the fundamental concepts of nuclear fission as it stands today and explores the various types of reactors that have operated in the past and are operational now. Additionally, we will discuss historical issues that have occurred in nuclear power plants and the lessons learned to improve the design and safety of future plants. Furthermore, we will discuss how accelerators can play a vital role to help address the issues associated with nuclear power generation.
Brief Bio
Peter Hosemann is Professor in the Department for Nuclear Engineering, Material Science and Engineering and Mechanical Engineering at the University of California Berkeley and director of Manufacturing 360 research center and the associated shared user facility. Professor Hosemann received his PhD in Material Science from the Montanuniversität Leoben, Austria in 2008 while he conducted the research on lead bismuth eutectic corrosion, ion beam irradiations and microscale mechanical testing was carried out at Los Alamos National Laboratory. He continued his research at Los Alamos National Laboratory and joined the UC Berkeley faculty in 2010. Professor Hosemann has authored more than 300 per reviewed publications since 2008. In 2014 he won the best reviewer of the journal of nuclear materials award, the ANS literature award and in 2015 he won the TMS early career faculty fellow award and the AIME Robert Lansing Hardy award, was awarded the E. S. Kuh Chair of the college of Engineering at UCB and won the TMS-Brimacombe medal 2022.

Abstract 30 at 10:00 AM

Session SN-SN-02 Tuesday 10:00 AM - 339

Update on the National Ocean Sciences Accelerator Mass Spectrometry Facility

Kevin T. Macon, Jeffrey Girts, Sean Sylva, Mark L. Roberts

NOSAMS, Woods Hole Oceanographic Institution, Woods Hole MA, United States

The National Ocean Sciences Accelerator Mass Spectrometry facility is a radiocarbon measurement laboratory focused on producing high-quality data for the ocean and Earth sciences communities. The facility features two routinely operating ^{14}C AMS systems utilizing cesium sputter negative-ion sources and tandem accelerators. A modified 134-sample NEC SNICS source is used with our 500 kV NEC Pelletron system, and a hybrid graphite/CO_2 source is used with our 200 kV vacuum-insulated MICADAS system. Current capabilities, operational details, and technical experiences with both accelerator systems will be presented.

Abstract 83 at 10:15 AM | Session SN-SN-02 Tuesday 10:00 AM - 339

Center for Accelerator Mass Spectrometry Status Report

John Wilkinson

Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory, Livermore CA, United States

The Center for Accelerator Mass Spectrometry (CAMS) hosts three tandem accelerators. A facility status report will be discussed including gas pad upgrades, gas-filled magnet beamline development and recent calibration efforts. Prepared by LLNL under Contract DE-AC52-07NA27344 and supported by the LLNL-LDRD Program under Project No. 26-LW-028.

Abstract 47 at 10:30 AM | Session SN-SN-02 Tuesday 10:00 AM - 339

CAIS-AMS status report

Gurazada Ravi Prasad

Center for Applied Isotope Studies, University of Georgia, Athens GA, United States

At the Center for Applied Isotope Studies, University of Georgia, we have two NEC accelerators dedicated to the Accelerator Mass Spectrometry of radiocarbon. In this status report, we present the performance of the units, the occasional issues and troubleshooting.
Recent changes include replacement of a broken Pfeiffer turbopump with an Agilent turbopump inside the SF6 tank of the CAMS accelerator that required necessary electrical and mechanical modifications; and upgrade of the control and data acquisition systems of the SSAMS accelerator.

Abstract 188 at 10:50 AM | Session SN-SN-02 Tuesday 10:00 AM - 339

Open Discussion and Business Meeting

Edward Stech

Physics and Astronomy, University of Notre Dame, Notre Dame Indiana, United States

Everyone is welcome to join an open discussion on the challenges of operating an accelerator facility. Topics may include sourcing of parts, maintenance questions or anything else of interest to the accelerator community as a whole. Potential host sites for the 2027 SNEAP Meeting will also be discussed.

Abstract 40 at 1:30 PM | Session CA-AA-02 Tuesday 1:30 PM - 382B

Tri-structural ISOtropic (TRISO) degradation by fission products

Lyudmila V Goncharova[1], Shamim Pourrahimi[2], Dylan Condotta[1], Jonas Hedberg[3], Samantha M Gateman[2], James J Noel[2,3]

[(1)]*Physics and Astronomy, Western University, London Ontario, Canada*
[(2)]*Chemistry, Western University, London Ontario, Canada*
[(3)]*Surface Science Western, Western University, London Ontario, Canada*

With nuclear energy gaining importance as a reliable, low-carbon power source, small modular reactors (SMRs) are growing in popularity because they can be factory-prefabricated and offer greater design and placement flexibility. Many SMR concepts use TRi-structural ISOtropic (TRISO) particles as fuel. TRISO particles consist of a ceramic fuel kernel with four pyrolytic carbon (PyC) and silicon carbide (SiC) coating layers, forming a multilayer barrier to contain fission products during operation and decommissioning. Although TRISO provides benefits, it is less common than uranium fuel pellets. There is a knowledge gap regarding how the TRISO structure degrades in deep geological repositories and how long its coatings prevent radionuclide leakage.

We designed and performed a- and γ-irradiation experiments under different scenarios mimicking repository-relevant conditions and further examined the physical and chemical properties of TRISO materials to identify irradiation-induced degradation, as well as release of fission products (5)Alpha irradiation was performed using a high-energy ion beam accelerator with multi-energy implantation of multiple ions: Au (80 keV-10 MeV), He (50-600 keV) - to achieve a target damage level of approximately 1 dpa over a similar depth range in the SiC layer. We also implanted Ag (60-400keV) and Pd (60-400keV) to better understand the effects of TRISO particle degradation and its detrimental impact on the structural integrity of SiC layers.

Both Au and He ion irradiations resulted in atomic-scale structural alterations and amorphization within ~1-3 µm of the PyC and SiC layers, consistent with the ion implantation range (Fig. 2). Gamma irradiation was performed using a Nordion Co-60 source, with a total dose of 276 kGy. Although no significant changes in atomic structure were detected after gamma irradiation, nanoindentation measurements showed a softer mechanical response in both SiC and PyC layers. These changes in material characteristics could potentially influence barrier performance under repository-relevant conditions.

Rutherford Backscattering Spectroscopy (RBS), complemented by Secondary Ion Mass Spectrometry (SIMS), was used to investigate the diffusion and segregation of Ag and Pd fission reaction products in a surrogate TRISO particle with a yttria-stabilized zirconia core. In addition to the cross-sectioned surrogate TRISO particles, nuclear- grade graphite and pure SiC sheets were implanted at room temperature and annealed (600-1000^{o}C). Our results indicate that, in addition to thermally driven diffusion, segregation was detected for elemental Ag and confirmed by electron microscopy images of the cross-section.

[1] G.F. L'Her, R.S. Kemp, M.D. Bazilian, M.R. Deinert, Potential for small and micro modular reactors to electrify developing regions, Nat Energy 9 (2024) 725-734.

[2] G. Locatelli, C. Bingham, M. Mancini, Small modular reactors: A comprehensive overview of their economics and strategic aspects, Progress in Nuclear Energy 73 (2014) 75-85.

[3] IAEA Small Modular Reactors: Advances in SMR Developments 2024, International Atomic Energy Agency, 2024.

[4] P.A. Demkowicz, B. Liu, J.D. Hunn, Coated particle fuel: Historical perspectives and current progress, Journal of Nuclear Materials 515 (2019) 434-450.

[5] H. Wen, I.J. van Rooyen. Distribution of fission products Pd, Ag, Ce, and Cs in the uncorroded regions of the locally corroded SiC layer of a neutron-irradiated TRISO fuel particle. Journal of the European Ceramic Society 37 (2017) 3271-8.

Abstract 103 at 2:00 PM — Session CA-AA-02 Tuesday 1:30 PM - 382B

Ion beam analysis for inertial confinement fusion

S O Kucheyev, L B Bayu Aji, S J Shin

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Inertial confinement fusion (ICF) and closely related inertial fusion energy (IFE) involve a rapid implosion of heavy hydrogen nuclear fuel to temperatures and pressures when nuclei undergo a nuclear fusion reaction. Resurgent interest in ICF and IFE has been stimulated by a recent breakthrough of the demonstration of ignition at the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory (LLNL). Ongoing, post-ignition work is focused on the development of a robust burning plasma platform to study matter in the high energy density physics regime and to develop intense fusion neutron sources that are scalable for energy production. In all these endeavors, the development of materials for ICF targets is key. Here, we describe how ion beam analysis (IBA) plays an enabling role in the development of new materials for ICF

and IFE targets at LLNL. Examples include IBA of materials for next-generation ablators (carbides and borides) and hohlraums (heavy metal high entropy alloys).
This work was performed under the auspices of the U.S. DOE by LLNL under Contract DE-AC52-07NA27344.

Abstract 140 at 2:30 PM Session CA-AA-02 Tuesday 1:30 PM - 382B

Ion Beam Analysis of plasma-facing materials for fusion energy development at MIT

Kevin Benjamin Woller

Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge Massachusetts, United States

Throughout the history of fusion materials research, ion beam analysis (IBA) has been at the forefront of assessing and diagnosing what happens to the surfaces exposed to plasma due to numerous physical and chemical interactions that take place. The ion accelerator lab of the Massachusetts Institute of Technology has been operating since 2006 utilizing a 1.7 MV Tandetron accelerator to apply the suite of IBA techniques to fusion materials. One unique target chamber and area of study has been focused on applying IBA techniques in situ and in operando to high flux plasma exposure of surfaces. Elastic Recoil Detection Analysis (ERDA) has been applied to helium uptake in hot tungsten surfaces (~1000K) undergoing fuzz growth and to study He, Li, and O carbon substrates. Nuclear Reaction Analysis (NRA) is used to monitor D, C, and Li on tungsten surfaces for both liquid and solid applications in fusion environments. Rutherford Backscattering Spectroscopy (RBS) has been applied to study the erosion of multilayered refractory materials and the coverage of molten salt on nickel mesh material. The erosion study was also coupled with implanted depth markers for a cross-comparison of various techniques for erosion study in fusion devices. This presentation provides insights from these experiences.

Abstract 121 at 1:30 PM Session CA-AF-01 Tuesday 1:30 PM - 339

High energy x-rays from a compact, accelerator source based on Inverse Compton Scattering

Gerard Andonian[1], Daniel Matteo, Maksim Kravchenko

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[(2)]University of California, Los Angeles, Los Angeles CA, United States

There is a significant demand for compact, high-energy X-ray sources capable of supporting advanced medical diagnostics, cargo security, and industrial non-destructive testing. To meet this need, RadiaBeam is developing a specialized accelerator facility which uses Inverse Compton Scattering (ICS) to generate high-energy photons. The approach incorporates innovative manufacturing techniques and beamline advances, which significantly improve performance and portability. Furthermore, there is an effort to transition the research prototypes into reliable commercial solutions. This presentation will describe some recent results and technical advancements of the compact, high-energy ICS-based source.

Abstract 122 at 2:00 PM Session CA-AF-01 Tuesday 1:30 PM - 339

Versatile RFQ Operation for Dual-Species Acceleration and Short-Pulse Beam Generation

Haoran Xu, Petr M Anisimov, Kip A Bishofberger, Dimitre A Dimitrov, Dmitry V Gorelov, Sergey S Kurennoy, John W Lewellen, Lawrence J Rybarcyk, Salvador I Sosa Guitron, R Tyler Thornton

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A radio-frequency quadrupole (RFQ) was designed at 201.25 MHz for accelerating a proton (H+) beam and negative hydrogen ion (H-) beams from 65 keV to 2.1 MeV, for the LANSCE Accelerator Modernization Project (LAMP). The RFQ operates with a wide range of beam currents, from sub-mA currents for beamline tuning to 55 mA when producing high-charge bunches. To support a variety of experimental areas, the RFQ produces these beams with distinct timing patterns. In particular, the WNR facility requires one short-pulse H- bunch every 1.8 μs, calling for a unique operating mode of the

RFQ for producing a ~50-ns beam pulse. To accommodate the diverse operating modes while maintaining optimized beam quality and meeting the performance requirements of the project, the LAMP beamline also incorporates a dual-mode H- ion source, low-energy beam transport (LEBT) with multi-chopper beam control, and a specially designed medium-energy beam transport (MEBT).

Abstract 149 at 2:30 PM

Session CA-AF-01 Tuesday 1:30 PM - 339

dCARA: A Compact Driver for High-Fluence Neutron Sources

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A growing class of particle accelerator applications, including fusion reactor materials testing, medical isotope production, tritium breeding and nuclear waste transmutation, demands neutron fluence substantially beyond the reach of conventional compact accelerator-driven neutron sources (CANS).
We present a novel CANS driver concept, deuteron cyclotron auto-resonance accelerator (dCARA), offering the potential for high beam current and high duty-factor ion acceleration, within a compact cost-effective system. By exploiting the cyclotron auto-resonance condition, dCARA continuously accelerates deuterons injected from an ion source at a current as high as 140 mA, reaching 40 MeV within two meters, using a single rotating-dipole-mode cavity immersed in a multi-tesla solenoidal magnetic field. We provide a comprehensive overview of the current theoretical, computational, and engineering readiness of dCARA as a CANS driver. Simulated beam behavior shows close agreement with analytical predictions, supporting confidence in the underlying acceleration mechanism. We further assess the technology readiness of the major subsystems required to realize dCARA, drawing on specifications of hardware already demonstrated in related accelerator and magnet applications. This includes large-bore multi-tesla superconducting magnets, high-power radiofrequency amplifier systems, and high-current deuteron ion sources. The status of ongoing engineering design efforts and planned experimental validation activities is also reported.
Successful development of dCARA would extend CANS technology into high neutron fluence regimes previously accessible only to large-scale spallation or reactor facilities. This work is presented to solicit community feedback and identify collaboration opportunities as dCARA moves from concept toward experimental demonstration.

Abstract 15 at 1:30 PM

Session CA-AR-05 Tuesday 1:30 PM - 332

Ion Irradiation Effects in High-Entropy Oxides

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High-entropy oxides (HEOs) have recently gained recognition for their unique electrical, magnetic, thermal, and optical characteristics with diverse potential applications. The addition of compositional diversity in these oxides with five or more cations on a given lattice site offers the opportunity for property engineering by taking advantage of the high compositional disorder, lattice distortions, mass fluctuation, cation size variations, and integration of diverse cation species. High entropy oxides have the potential to revolutionize applications in areas such as energy storage, electronics, and photonics, as well as in high radiation environments. Ion beam modification provides another opportunity to further tune or pattern the functionalities of HEOs. However, little is known about the response of HEOs to high energy ion beams. The irradiation response of several high-entropy pyrochlores, perovskites and garnets to a range of ions and energies has been characterized by several in situ techniques, including Transmission electron microscopy, Rutherford backscattering spectrometry, Raman spectroscopy, and ionoluminescence, which reveal the production and evolution of atomistic and electronic defects, as well as phase transitions. The results of these studies will be presented.

Abstract 115 at 2:00 PM

Session CA-AR-05 Tuesday 1:30 PM - 332

Quantifying What Ions Leave Behind: An AI/ML-Driven Multi-Scale Analysis of Heavy Ion-Irradiated GaN

Bethany Matthews[1], Kayla Yano[1], Jenna Bilbrey[1], Skye Supakul[1], Xin Zhang[1], Mike Holden[1], Kathy Nwe[1], Christina Doty[1], Miguel Crespillo[2], Khalid Hattar[2]

(1) Pacific Northwest National Laboratory, Richland Washington, United States
(2) Department of Nuclear Engineering, University of Tennessee Knoxville, Knoxville Tennessee, United States

Accelerator irradiation facilities provide unique control for investigating radiation damage mechanisms in a variety of materials, enabling precise selection of ion species, energy, and dose, often with additional environmental controls such as heating or biasing, that cannot be replicated via passive environmental exposure. Utilizing such capability, we apply sequential heavy ion (11 MeV Ni^{3+}/Cu^{3+}) and proton (2 MeV H^{+}) irradiation of $Al_{0.26}Ga_{0.74}N$/GaN HEMT heterostructures at the Tennessee Ion Beam Materials Laboratory, targeting three total dose regimes spanning three orders of magnitude. Wide-bandgap heterostructures like these are leading candidates for radiation-hardened electronics in space and defense environments yet understanding how irradiation modifies their microstructure, chemistry, and performance across length scales remains a barrier to qualification.

To extract quantitative dose-dependent trends from the resulting damage, we employ a multimodal characterization workflow combining atomic force microscopy (AFM), scanning transmission electron microscopy (STEM-HAADF) with electron energy loss spectroscopy (EELS), and atom probe tomography (APT). Critically, we integrate AI/ML-assisted analysis at each scale: expert-guided feature analysis of surface morphology and modification, Z-contrast-aware segmentation and anomaly detection via the Z-CAT STEM toolkit, and compositional community analysis using k-means clustering of APT reconstructions. Results reveal dose-dependent surface modification including decomposition of the nitride and subsequent Ga droplet formation and near-complete removal of the heterostructure via sputtering at the highest dose. At a more local scale, progressive superlattice interface broadening is quantified as Al interdiffusion is observed into adjacent GaN layers.

This approach allows quantitative analysis of structural and chemical metrics, even from traditionally qualitative data, that are consistent across independent characterization techniques and demonstrates how controlled combined accelerator irradiation and advanced multi-scale analysis can establish systematic, reproducible pathways toward understanding radiation damage mechanisms in wide-bandgap semiconductors and beyond, ultimately accelerating device qualification and development.

Abstract 177 at 2:30 PM

Session CA-AR-05 Tuesday 1:30 PM - 332

Radiation effects on the structure and properties of glass and amorphous materials: insights from atomistic simulations

Jincheng Du

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Inorganic glass materials find applications for nuclear energy from fusion to fission, due to their outstanding thermal, mechanical and optical properties, as well as chemical stability. For example, phosphate glasses are used for high energy laser media, and borosilicate glasses are used for nuclear waste immobilization. Radiation induced structural changes impact their physical and chemical properties hence requires detailed understanding for designing these materials for the above-mentioned applications. However, due to the non-crystalline nature of these materials, understanding radiation induced structural modifications has been hampered by the lack of understanding of their atomic structures and limited experimental methods to directly probe their structures and changes. In this talk, I will introduce atomistic simulations-based approach in understanding short and medium range structure features of glass materials as well as its capability to gain insights of atomic level processes of radiation materials interactions. Example of radiation induced modifications in germania doped silica from first principles based calculations to large scale molecular dynamics simulations of collision cascade induced damage in rare earth containing silicate and borosilicate glasses will be presented.

Abstract 99 at 2:45 PM Session CA-AR-05 Tuesday 1:30 PM - 332

Phase Stability of a Zr-Ru BCC+B2 Eutectic Refractory Alloy during Annealing and Proton Irradiation

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Alloying refractory metals with Ru is a promising approach to obtain BCC+B2 microstructures. The current paper investigates a simple Zr-Ru binary alloy to gain fundamental insights into the effect of Ru on the phase stability. The alloy investigated, Zr80Ru20 (at.%), is a near-eutectic composition that consists of B2 rods in a BCC matrix. High-temperature annealing of the eutectic microstructure at 1150 °C coarsened the B2 rods into a blocky morphology, with a corresponding reduction in B2 number density. Aging at 600 °C transformed the BCC matrix into HCP and B2 phases via a divorced eutectoid reaction. During proton irradiation at 600 °C, the BCC phase underwent phase transformations depending on the initial microstructure. When the as-cast sample was irradiated at 600 °C, the BCC phase decomposed into HCP+B2, but when the high-temperature annealed microstructure was irradiated, the BCC decomposed into a mixture of HCP+FCC+B2. These results reveal pathways to alter phase stability and Ru concentration in the matrix, which can be applied to the design of promising alloys in the high-entropy space.

Abstract 34 at 1:30 PM Session CA-AS-08 Tuesday 1:30 PM - 314B/C

Advanced Porous Materials for Enhancing Target Functionality: An At-211 Case Study

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Astatine-211 is a powerful "Goldilocks" isotope for targeted alpha therapy, but its production at cyclotron facilities is limited by the relatively low melting point of metallic bismuth targets. In this work, we investigate porous bismuth materials as alternative phases for targetry. These advanced materials offer higher melting points and strategic surface area that may improve At-211 retention during production, target stability, and expedite post-processing recovery. Phases of interest include tunable Bi metal-organic frameworks and porous ceramics. New target candidate materials will be screened for their radiation stability with a 15 MeV alpha particle beam, below the Coulomb barrier for At-211 production. Irradiations will be performed at the Center for Accelerator Mass Spectrometry (CAMS). Targets will be characterized post-irradiation with X-ray diffraction, microscopy, and vibrational spectroscopy. These screening results will inform down selection for a future At-211 proof-of-principle production run. Through synthetic design of multi-functional materials for targetry, we aim to increase production capacity of valuable radionuclides.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and was supported by the LLNL-LDRD Program under Project No. 26-LW-013. The abstract was released under LLNL-ABS-2022473.

Abstract 74 at 1:55 PM Session CA-AS-08 Tuesday 1:30 PM - 314B/C

Dosimetric Characterization of a Preclinical Synchrocyclotron FLASH Platform

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Ultra-high-dose-rate (UHDR, FLASH, ≥40Gy/s) radiotherapy has shown promise for reducing normal tissue toxicity while maintaining effective tumor control (1)Growing interest in clinical FLASH delivery has driven the application of high-intensity, pulsed charged-particle beams; yet deploying these beams requires robust platform validation and reproducible dosimetric frameworks. In particular, high instantaneous flux radiation fields can affect conventional active detectors' response through space-charge effects, charge collection inefficiency, and signal pile-up.
To support preclinical FLASH investigations, we implemented a UHDR proton irradiation platform based on a 230 MeV synchrocyclotron delivering ~5-30 ms macro-pulses at 750 Hz, using passive modulation to produce volume-conformal spread-out Bragg peaks (SOBPs) (2)The platform was validated employing standard quality assurance devices, including gas ionization detectors, a CCD-coupled scintillation screen, and radiochromic film. The performance of these systems was evaluated for characterizing instantaneous dose rate, beam transverse profile, and range.
Furthermore, secondary neutrons produced in energetic protons interactions with beamline components and tissue complicate out-of-field dosimetry (3,4)Extended-range neutron rem counters are advantageous here as their energy response approximates the fluence-to-ambient-dose equivalent conversion coefficients and sensitivity spans up to a few GeV. Our work expands neutron dosimetry into short-pulsed UHDR proton fields to assess detector suitability and spatial anisotropy of the neutron yield per proton.
References
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Abstract 33 at 2:20 PM

Session CA-AS-08 Tuesday 1:30 PM - 314B/C

Physical Separation of ^{18}F via $^{19}F(\gamma,n)^{18}F$ and Kinematic Recoil with Electron Linear Accelerators

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Fluorine-18 (^{18}F) is an essential isotope used in Positron Emission Tomography (PET) scans for diagnostics in nuclear medicine. Typically, ^{18}F is produced via the $^{18}O(p,n)^{18}F$ reaction, which allows for chemical separation of the parent and daughter isotopes. However, due to the short half lives of many positron emitters, alternative production routes could be valuable to increase access to medical PET procedures. The photoneutron (γ, 1n) reaction dominates in photonuclear production as neutrons are typically emitted more easily than charged ions because they do not need to overcome a coulomb barrier. This study examines photonuclear production and a physical separation technique called "kinematic recoil," which takes advantage of the kinematics of the nuclear recoil due to high energy neutron emission to physically separate daughter products in (γ,n) reactions. In this method of separation, the emitted neutron carries momentum from the reaction and the daughter recoils from the reaction site and embeds into strategically placed catcher materials. This method allows for separation of chemically identical isotopes where chemical separation is effectively impossible.
This research is funded by the Department of Energy under the DOE RENEW DE-FOA-0002765 grant.

Abstract 68 at 2:40 PM

Session CA-AS-08 Tuesday 1:30 PM - 314B/C

Development and Geant4 Validation of a Gafchromic HD-V2 Film Dosimetry Method for Low-Energy Proton Cell Irradiation at ECU Accelerator Lab

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Introduction
Accurate dosimetry in low-energy proton radiobiology is challenging because the delivered dose is strongly affected by proton energy loss, beam scattering, exit-window interactions, and air-gap geometry. These effects are particularly important in cell irradiation experiments, where small changes in beam position and transport conditions can substantially alter the absorbed dose and lateral dose distribution. This study developed a proton-specific Gafchromic HD-V2 film calibration for the East Carolina University (ECU) accelerator and combined it with Geant4 Monte Carlo simulations to determine absorbed dose in the film active layer and reconstruct dose in the ECU cell irradiation beamline.
Materials and Methods
Gafchromic HD-V2 films were irradiated with monoenergetic 2-4 MeV proton beams in the ECU R-30 beamline under high-vacuum conditions. A proton-specific nonlinear calibration curve was established by relating red-channel mean gray values to absorbed dose determined from the measured beam current, irradiation time, irradiated area, and proton energy deposited in the film active layer.
The vacuum calibration curve was subsequently applied to HD-V2 films irradiated in the ECU L-15 cell beamline. In this geometry, protons exited through a 10-µm Havar window and traveled through air gaps of approximately 13, 17, and 24 mm before reaching the film. This approach enabled reconstruction of absolute absorbed dose and lateral dose profiles under realistic cell irradiation conditions.
Independent Geant4 models were developed for both the R-30 vacuum and L-15 in-air geometries. The simulations explicitly included the HD-V2 active layer and polyester substrate, the Havar exit window, and the corresponding air gaps. Energy deposition was scored directly within the film active layer and converted to absorbed dose. Simulated absolute doses and lateral dose profiles were then compared with the film-derived measurements.
Results
The proton-specific vacuum calibration produced a stable nonlinear relationship between film response and absorbed dose over the investigated energy range. Geant4 reproduced the energy deposited within the HD-V2 active layer and showed strong agreement with the film-derived doses. Mean relative differences for the vacuum calibration comparisons were approximately 3-7% across the investigated proton energies.
Application of the vacuum calibration to the L-15 films enabled absolute dose reconstruction at each air-gap distance. For most in-air comparisons, film and Geant4 dose values agreed within approximately 5-10%, while peak-dose differences generally remained below approximately 12%. Both measurements and simulations reproduced the progressive lateral broadening of the proton beam with increasing distance from the Havar window. For the representative 2.5 MeV irradiation, the film profile showed a central peak dose of approximately 161 Gy and a full width at half maximum of approximately 2.71 mm. Distance-dependent changes in peak dose and profile width reflected the combined effects of energy loss, multiple Coulomb scattering, and lateral fluence redistribution in air.
Conclusion
A proton-specific HD-V2 calibration established under vacuum conditions was successfully transferred to the ECU L-15 cell beamline for absolute dose and beam-profile reconstruction. Direct Geant4 scoring of energy deposition in the film active layer independently validated both the calibration methodology and the measured in-air dose distributions. The combined film and Monte Carlo approach provides a practical and reliable dosimetry framework for low-energy proton radiobiology experiments at the ECU accelerator.

Abstract 38 at 1:30 PM — Session WT-WT-01 Tuesday 1:30 PM - 382A

Microscope and Ion Accelerators for Materials Investigations (MIAMI-2) Facility

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The Microscope and Ion Accelerators for Materials Investigations (MIAMI-2) instrument is a United Kingdom Atomic Energy Authority (UKAEA) facility combining a transmission electron microscope (TEM) and two ion beam accelerators. A new laboratory is currently being designed and commissioned to provide MIAMI-2 with bespoke accommodation incorporating expanded co-located and complimentary capabilities including atom probe tomography (APT) and time-of-flight secondary ion mass spectrometry (TOF-SIMS) enabling targeted focus ion beam (FIB) milling TEM sample preparation. These will augment the ability of MIAMI-2 to perform TEM with in-situ ion irradiation to explore the dynamic effects of radiation on materials at the nanoscale.
The MIAMI-2 facility provides the ability to induce atomic displacement damage and gas/transmutant incorporation to (and beyond) end-of-life levels in materials at both in-service and accident scenario temperatures for nuclear fission and fusion environments. An overview and update on the MIAMI-2 facility and its capabilities will be overviewed along with case studies of recent irradiation campaigns by our user community.

For those of you interested in utilising these capabilities, the MIAMI-2 facility is part of the United Kingdom National Ion Beam Centre which is distributed between the Ion Beam Centre at the University of Surrey, the Dalton Cumbrian Facility operated by the University of Manchester and the UKAEA. An overview of the multiple facility-access routes available (including for international researchers) will be presented which offer dynamic, flexible and rapid experimental turnaround timescales to enable both academic and commercial users to perform cutting edge science.

Abstract 181 at 2:00 PM

Session WT-WT-01 Tuesday 1:30 PM - 382A

The in situ dual ion beam TEM at JANNuS-Orsay: recent updates and perspectives

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In situ Transmission Electron Microscopy (TEM) with ion implantation/irradiation is a key tool to investigate a wide field of topics, such as phase transition far from the equilibrium, solid-state nucleation/growth, and ageing of materials used in nuclear or space industries.
In the 1980's our laboratory was a pioneer in operating this kind of facility (M.-O. Ruault **et al**., J. Mater. Res. (2005))Thanks to this long experience, our **in situ** experimental facility was extended to multiple simultaneous scanned beams, by building an **in situ** dual ion beam TEM setup. Based on a 200 kV Tecnai G2 20 Twin FEI microscope coupled with two ion accelerators, it offers a large choice of ions and energies (from 10 keV to 6 MeV) and complementary analytical equipment (EDX, STEM and EELS) associated with different specimen holders (from LN_2 temperature up to 1000°C).Launched in 2009 as an open facility, JANNuS-Orsay allows each year several worldwide teams to process their **in situ** TEM experiments through the EMIR&A French accelerators federation (https://emira.in2p3.fr).
The JANNuS-Orsay experimental hall is part of the MOSAIC facility at IJCLab (https://mosaic.ijclab.in2p3.fr), an interdisciplinary research ion beam platform open to users and supporting many scientific fields ranging from materials science to astrophysics, including geology and nuclear physics. The JANNuS-Orsay experimental hall groups together the **in situ** dual ion beam TEM, the IRMA 190 kV ion implanter, and the ARAMIS 2 MV ion accelerator and associated beam lines (implantation/irradiation, ion beam analysis including **in situ** RBS-C, future **in situ** XRD). The coupling of the Transmission Electron Microscope with ARAMIS and IRMA is unique in the world due to the diversity of elements that can be accelerated inside the microscope in a wide range of energies, with a well-controlled dosimetry, making it possible to characterize **in situ** at the nanometric scale the evolution of structural and chemical modifications of materials subjected to one or two ion beams, at a given temperature.
Recent updates of the equipment will be given in this presentation, with a focus on the **in situ** Transmission Electron Microscope and its perspectives, illustrated by a selection of scientific results obtained throughout the past years with examples mostly based on different materials studied for energy applications [A. Gentils **et al**., Nucl. Instrum. Methods B (2019)].
The JANNuS-Orsay / MOSAIC accelerator staff (in particular C. Bachelet, J. Bourçois, S. Hervé, S. Picard) are gratefully acknowledged for their unfailing assistance during in situ experiments, along with Université Paris-Saclay and CNRS Nuclei and Particles for their strong support.

Abstract 45 at 2:30 PM

Session WT-WT-01 Tuesday 1:30 PM - 382A

IVEM-Tandem Facility: Overview and Capability Update

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The Intermediate Voltage Electron Microscopy (IVEM)-Tandem Facility at Argonne National Laboratory is a unique national user facility that enables **in situ** transmission electron microscopy (TEM) studies under concurrent ion irradiation. By integrating ion accelerators with a 300 KV TEM, the facility provides direct, real-time observation of irradiation-induced microstructural evolution under well-controlled experimental conditions. This capability allows researchers to investigate fundamental radiation damage mechanisms, validate computational models, and accelerate the development of structural materials for nuclear energy, fusion systems, space applications, and other radiation environments. The facility remains one of only a few worldwide capable of combining ion irradiation with simultaneous TEM characterization.

This presentation provides an overview of the IVEM-Tandem Facility, including its overall architecture and the integration of its major components. The configuration of the ion accelerators, beam transport system, and Hitachi H-9000NAR intermediate-voltage transmission electron microscope will be described, illustrating how these systems operate together to deliver synchronized **in situ** irradiation experiments. The discussion will also introduce the range of available ion species, beam energies, irradiation temperatures, dose rates, and experimental configurations that enable studies spanning displacement damage, ion implantation, and defect evolution under precisely controlled conditions.
In addition to the irradiation capabilities, the presentation will summarize the experimental operations available to users. This includes the range of specimen holders supporting heating, cooling, tilting, straining, together with the current imaging and data acquisition systems. A particular focus of the presentation will be recent enhancements that expand the experimental capabilities of the facility. New instrumentation now enables **in situ** nanomechanical testing during concurrent ion irradiation through the integration of a Bruker PI 95 PicoIndenter and a new Hummingbird MEMS-based holder. This capability provides a powerful platform for directly correlating irradiation-induced microstructural evolution with mechanical response in real time, enabling experiments such as compression, tension, and other small-scale mechanical tests while specimens are simultaneously exposed to ion beams. The combination of controlled mechanical loading, high-resolution TEM imaging, and concurrent irradiation opens new opportunities for investigating deformation mechanisms, irradiation-assisted plasticity, defect-dislocation interactions, and the evolution of mechanical properties under extreme environments.

Abstract 85 at 3:30 PM Session CA-AF-02 Tuesday 3:30 PM - 339

BeamNetUS: Accelerating Beam-Based Research

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BeamNetUS (beamnetus.org) is a network of accelerator test facilities united by a common mission: providing user access for advancing particle accelerator research, technology development, and breakthrough applications. Users gain access to a diverse set of experimental capabilities, specialized expertise, and distributed resources available across the 12 beam test facilities located at six U.S. Department of Energy national laboratories. Through an annual open call for proposals, BeamNetUS invites exploratory research aimed at seeding new collaborations and fostering innovation across the accelerator community and beyond. Since its launch in 2025, a broad range of experiments received beamtime, spanning accelerator and light source R&D, light-matter interaction and imaging, materials science, plasma physics, beam diagnostics and control - including studies leveraging artificial intelligence and machine learning - and biochemical irradiations. This contribution provides an overview of the BeamNetUS program and highlights recent progress, achievements, and future outlook.
Funding: BeamNetUS is funded by the U.S. Department of Energy, Accelerator R&D and Production Program under contract numbers DE-AC02-06CH11357, DE-SC0012704, DE-AC02-07CH11359, DE-AC05-06OR23177, DE-AC02-05CH11231, and DE-AC02-76SF00515.

Abstract 29 at 4:00 PM Session CA-AF-02 Tuesday 3:30 PM - 339

Advancing particle accelerator technology and control at High Voltage Engineering

Alessandra Palazzo

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Over the past decades, High Voltage Engineering has manufactured particle accelerators, developing cutting edge technologies and solutions for applications in research and industry. Accelerators in the 100 kV - 6 MV energy range have been manufactured for a wide range of applications, including Accelerator Mass Spectrometry, ion implantation, Ion Beam Analysis and electron beam processing. The different requirements imposed by different applications led to the development of different accelerator configurations and technologies, making the company continuously improve and increase the variety of its products.

At High Voltage Engineering, the production of particle accelerators has been accompanied by the development of a dedicated control system. A new software for the accelerators control, called Argus3 has recently been developed based on the open source EPICS control system. The new software aims to improve the user experience and minimize the manual effort needed to configure new systems or new additions to already existing accelerators using a modular approach. Continuous development of Argus3 is ongoing to keep improving the quality of the product and add new advanced features. Nevertheless, it has already been successfully installed both as an update of legacy systems and as the standard control system for new accelerators.

Abstract 98 at 4:20 PM Session CA-AF-02 Tuesday 3:30 PM - 339

Progress Report on the High-Current Electron-Beam Ion Source Charge Breeder for the ReAccelerator at the Facility for Rare Isotope Beams

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The ReAccelerator (ReA) at the Facility for Rare-Isotope Beams (FRIB) utilizes an Electron-Beam Ion Trap (EBIT) charge breeder to reaccelerate rare isotopes with a superconducting linear accelerator to several MeV/u for research in nuclear physics. The ReA EBIT produces an electron current of 300 - 600 mA with a current density of 170 - 340 A/cm^2 in the 0.6-m long ion trap region and has a trap capacity of ~10^{10} elementary charges. To accommodate rates of >10^{10} particles/s, anticipated for certain isotopes as FRIB's production capability ramps up, and to provide redundancy, a High Current Electron-Beam Ion Source (HCEBIS) is being commissioned. Operating with an electron current of 4 A, it will facilitate a trap capacity of ~10^{11}e.

The HCEBIS electron beam is launched from a 9.2-mm convex cathode, immersed in a 0.15-T axial magnetic field, and adiabatically compressed by the 4-T field of a superconducting solenoid surrounding a 0.7-long ion trap. The electron beam was produced with two different cathodes: lanthanum hexaboride and barium-impregnated tungsten dispenser. Both cathodes were 3D thermally imaged and their perveances evaluated to ascertain optimal operation. An electron-beam current of 2 A was run for an extended time with 50% duty cycle; initial tests reached 4-A beam at a duty cycle of 0.1%. The charge breeding of residual gas has been studied by periodic extraction of highly charged ion pulses. Measured time-of-flight spectra provided charge-state distributions to determine the electron-current density. This paper presents recent commissioning results of the HCEBIS, its status and plans for its integration into ReA for user operations.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics and used resources of the Facility for Rare Isotope Beams (FRIB) Operations, which is a DOE Office of Science User Facility under Award Number DE-SC0023633.

Abstract 100 at 4:40 PM Session CA-AF-02 Tuesday 3:30 PM - 339

Progress in in-situ Positron Beamline Development at Los Alamos National Laboratory

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A major effort within nuclear materials research is developing facilities capable of probing material behavior **in situ** across several spatial and temporal scales under ion-irradiation conditions. As a part of this broader initiative to enable real-time investigation of defect evolution, a ^{22}Na source-based **in-situ** slow positron annihilation spectroscopy (PAS) beamline has been installed at the Ion Beam Materials Laboratory (IBML) in Los Alamos National Laboratory (LANL). PAS is a unique

characterization technique that provides exceptional sensitivity to atomic-scale open-volume defects and has proven to be a powerful, nondestructive method for studying irradiation-induced damage. The positron end station is coupled with a 3 MV NEC tandem accelerator combining variable-energy PAS with simultaneous high-energy ion irradiation, allowing the formation, accumulation, and evolution of vacancy-type defects to be monitored under controlled ion beam irradiation conditions.
This presentation will provide an overview of the experimental platform's current status, including the beamline design and instrumentation, recent developments that have enhanced its capabilities, and upgrades currently underway. Finally, preliminary **in situ** results demonstrating the capabilities of the beamline will also be discussed.

Abstract 22 at 3:30 PM Session CA-AR-06 Tuesday 3:30 PM - 332

Multiscale Modeling of Radiation Damage and Tritium Transport in Lithium Aluminate Ceramics

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Gamma lithium aluminate (γ-$LiAlO_2$) is used in tritium production for the strategic stockpile and is being considered for fusion reactor blanket applications. Under continued irradiation, a secondary phase, $LiAl_5O_8$, forms in the $LiAlO_2$ matrix via precipitation. This talk presents a multiscale modeling framework, spanning single-crystal and bicrystals to understand radiation damage, role of grain boundaries (GB) effect, and tritium transport in these ceramics. Cascade damage was modeled in molecular dynamics (MD) by initiating primary knock-on atoms (40 keV) and quantifying Frenkel pair production for Li, Al, and O. Single-crystal simulations showed $LiAlO_2$ sustains 3-5 times more Li Frenkel pairs and ~2 times more Al and O Frenkel pairs than $LiAl_5O_8$, due to the higher Li displacement threshold energy in $LiAl_5O_8$, which suppresses amorphization. Bicrystal models with explicit GBs showed GBs act as efficient defect sinks via interstitial emission and lower Li Frenkel pair by defect annealing. Tritium and helium diffusion were calculated using free-energy cluster dynamics (Centipede code) with inputs obtained from density functional theory (DFT), showing tritium diffusion at least one order of magnitude higher, and helium diffusion 2-13 orders of magnitude higher, in $LiAlO_2$ than in $LiAl_5O_8$. MD predicted volumetric swelling (7.03% for $LiAl_5O_8$; 1.36-3.27% for γ-$LiAlO_2$) due to irradiation agreed well with complementary dual-beam ion irradiation experiments (AFM, STEM, PAS, ToF-SIMS), validating the framework as a predictive tool for ceramic breeder materials.

Abstract 145 at 4:00 PM Session CA-AR-06 Tuesday 3:30 PM - 332

Preferential Void Swelling Along Cellular Walls in Additively Manufactured 316L Stainless Steel Under Fe Self-Ion Irradiation

Alec Curtis Pfundheller[1], Yinyin Hong[1], Benjamin Mejia-Diaz[1], Michenna Allen[1], Zhihan Hu[1], Sisi Xiang[2], Dan Thoma[3], Lin Shao[1]

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Additively manufactured (AM) 316L stainless steel fabricated by laser powder bed fusion was irradiated with 5 MeV Fe self-ions to 50 peak displacements per atom at 600 °C to evaluate its swelling resistance in reactor-relevant environments. Cross-sectional transmission electron microscopy (TEM) revealed large voids with diameters up to 140 nm that were preferentially aligned rather than randomly distributed. The spacing between adjacent void strings was approximately 500 nm, matching the cellular wall structure present prior to irradiation. It is hypothesized that the high dislocation density associated with these walls acts as a strong yet biased sink for interstitials, promoting local vacancy accumulation and enhanced void formation. This facilitated nucleation also reduces the influence of injected interstitials, resulting in a wider safe analysis zone than typically observed during heavy-ion irradiation. Swelling measurements extracted from this region show an approximately linear dependence on local damage level, corresponding to a swelling rate of ~1% per dpa with little or no incubation period. The results indicate that the cellular structures play an important role in void swelling. The results demonstrate that the retained cellular structure plays a dominant role in void swelling evolution in AM 316L

stainless steel. Therefore, post-build stress-relief treatments should be carefully optimized to reduce cellular dislocation density and enhance the swelling resistance of AM 316L for nuclear reactor applications.

Abstract 25 at 4:30 PM

Session CA-AR-06 Tuesday 3:30 PM - 332

Influence of Initial Damage State and Electronic Energy Loss on Ionization-Induced Damage Recovery in Silicon Carbide

William Lenouvel, Yanwen Zhang

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Managing radiation-induced damage is a fundamental challenge in developing materials capable of operating in next-generation nuclear reactors and space exploration technologies. Exposure to radiation produces atomic-scale defects (vacancies, interstitials, etc.), primarily caused by nuclear energy loss, that degrade mechanical, thermal, and chemical performance. Silicon carbide (SiC) is a promising candidate material for applications in extreme conditions due to its high-temperature stability and resistance to irradiation-induced amorphization. Research has shown that SiC can undergo defect recovery under highly ionizing irradiation, where electronic energy loss dominates. Energy deposited in the electronic subsystem can be transferred to the atomic lattice through electron-phonon coupling, causing local heating that promotes defect recovery. This work analyzes Rutherford Backscattering Spectrometry in channeling mode (RBS/C) spectra of SiC samples pre-damaged with 900 keV Si ions to varying relative disorders and subsequently annealed using 21 MeV Ni ions over a range of fluences. The results show that defect recovery increases with initial damage level reaching a maximum near the damage peak, suggesting that an initial damage threshold is required for efficient defect annealing. In contrast, near-amorphous samples exhibited decreased recovery, attributed to the reduced ability of highly disordered defect structures to be annealed. Additionally, the comparison of experimental results with SRIM simulations highlights the importance of ionization energy on defect recovery. Because both electronic energy deposition and S_e/S_n vary with depth, changes in damage recovery observed at differing depths within a single sample cannot be interpreted as the evolution of annealing under constant irradiation conditions. Therefore, multiple irradiation fluences are required to analyze the progression of ionization-induced annealing.

Abstract 139 at 4:45 PM

Session CA-AR-06 Tuesday 3:30 PM - 332

Floating-Zone Growth of SiC Single Crystals and Prospects for Ion-Beam Modifications

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Silicon carbide (SiC) is a wide-band-gap semiconductor central to high-power electronics, extreme-environment devices, and emerging quantum-defect platforms. Despite its importance, bulk SiC crystal growth remains challenging due to high melting temperatures, polytypism, and the limitations of vapor-phase routes. We report the growth of centimeter-scale SiC single crystals using a traveling-solvent laser-diode floating-zone (LDFZ) method with Cr-based molten flux. Single-crystal boules 10-20 mm in length and ~4 mm in diameter were obtained, with polytype formation (3C vs. 6H) determined by chamber conditions and melt dynamics. Structural quality was confirmed by single-crystal X-ray diffraction, while Raman spectroscopy and photoluminescence provided insight into phase purity and electronic characteristics.
The availability of ion-beam modification and analysis capabilities at UNT provides a natural pathway for subsequent studies on these bulk SiC crystals, enabling controlled defect creation, irradiation-response measurements, and systematic exploration of defect-driven electronic and optical behavior. This combined growth and post-growth modification approach

will support future investigations of SiC defect physics relevant to radiation-hard electronics and solid-state quantum technologies.

Abstract 4 at 3:30 PM Session CA-AS-01 Tuesday 3:30 PM - 314B/C

Advanced Compact Linear Accelerator Concepts and New Developments at Varex Imaging Corporation

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Over the last 10 years with Varex Imaging Corporation, which I celebrated on 31 May 2026, we have substantially fulfilled the original objectives set for me by Varex management to establish design and production line of Accelerator Beam Centerlines (ABC) at Varex plant in Salt Lake City, spearhead ABC and linear accelerator (LINAC) development ensuring replacements of predecessor products. We now focus on continuous improvements and on broadening and enhancing Varex LINAC product line by introducing new ABCs and turn-key LINACs for a variety of applications, which currently include security screening, Non-Destructive Testing (NDT), and radiation therapy. We have been keeping the community informed regarding our key results. In this review, I am summarizing the work completed earlier, but focusing on recent advances, concepts, products under development, and patents pending. It is my sincere hope that the particle accelerator community and our customers will enjoy the review and aim to use our existing and new products. While working with my talented colleagues at Varex, our vendors and customers, we formed the High Energy Sources (HES) team of outstanding professionals, which I am honored to lead, thanks to Varex Senior Management for the leadership, support, and encouragement I receive.

Abstract 41 at 4:00 PM Session CA-AS-01 Tuesday 3:30 PM - 314B/C

Commissioning and Initial Demonstrations of the Tunable Inverse Compton Scattering X-Ray Source at RadiaBeam

Robert Berry[1], Alex Murokh[1], Amirari Diego[1], Maksim Kravchenko[1], Daniel Matteo[1], Ronald Agustsson[1], Loic Amoudry[1], Gerard Andonian[1], Nathan Burger[1], Dan Schneberk[1], Emilio Nanni[2], Sami Tantawi[2], James Rosenzweig[3], Jonathan Edelen[4]

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RadiaBeam has developed, commissioned, characterized, and began demonstrating applications of Inverse Compton scattering (ICS) X-ray source currently tunable in the range of 30-180 keV. The electron beam is generated by the hybrid photoinjector to achieve a sub-picosecond bunch compression within a compact footprint and then accelerated in a 2 meter C-band linac module capable of up to 100 MeV, before focusing into the ICS interaction chamber. After the first year of operations, we discuss facility capabilities and review the characterization process with e-beam measurements, ICS X-rays measured properties, and initial application specific studies.

Abstract 81 at 4:20 PM Session CA-AS-01 Tuesday 3:30 PM - 314B/C

Demonstration of Battery-Operated 3 MV Linac for Threat Detection

Amy Shiroma[1], Kirk Bertsche[1], Bryan Woo[1], Ben Coffer[1], Paul Probst[1], Sami Tantawi[1,2]

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(2)Department of Physics, Arizona State University, Tempe AZ, United States

Threat detection in the field demands x-ray sources that can penetrate dense cargo yet still be carried to the object of interest, set up by a small crew, and run without shore power. Each incumbent option carries a penalty: betatrons are limited in dose rate, subject to sourcing issues, and have strongly asymmetric focal spots, while Co-60 sources bring licensing, security, and disposal burdens that operators would rather not take on. Linac-based sources solve the physics but have historically been too large, heavy, and power-hungry to deploy.
We report the successful demonstration of a complete battery-operated 3 MV linac x-ray source. Previously, we reported this architecture as a design, with the accelerator not yet beam-tested. The system has now been operated end to end at beam energies above 3 MeV, producing radiographic images of representative objects on a flat-panel detector with a symmetric, sub-millimeter focal spot of 850µm, and was shown to U.S. government stakeholders in January 2025.
We set out to reach 5 Rad/min at 1 meter, sustained for 15 minutes. At 50 Hz the battery-powered system has delivered that dose rate for more than 30 minutes, twice the endurance we targeted. Dose rate and endurance trade against one another: pushed to 200 Hz, the system delivers better than 20 Rad/min for roughly 5 minutes of imaging. Neither mode requires external power, and a fast battery-swap mechanism now in development will extend high-dose-rate operation beyond a single pack.
That system's performance rests on two developments. The first is the accelerator, based on the distributed-coupling concept developed at the SLAC National Accelerator Laboratory. Feeding each cavity independently yields a structure far more efficient than conventional designs, and the reduced demand on the RF source collapses the size and weight of everything downstream. The accelerator operates at X-band, a frequency band already standard in medical and industrial practice. We have fabricated two structures in-house and brought the first to full operation: tuned to design frequency, held at high vacuum, and run at full RF power. Automated frequency control has been demonstrated using forward and reflected RF power measurements, keeping the source matched to the structure without operator intervention.
The second is the power system. RF comes from a compact 400 kW X-band magnetron, driven by a battery-powered 30 kV, 30 A modulator we designed and built in-house. The modulator is a distributed Marx capacitor bank: low-voltage modular units stack to reach the operating voltage, running at high efficiency from a removable battery pack. We proved it first into a ceramic resistive load; with over-voltage and over-current protections added, it has since driven the magnetron directly at 350 kW to produce the results above. Packaged, the modulator will weigh under 50 lbs. Further volume reduction comes from our compact isolator, built around a novel circular polarizer and half the size of comparable devices.
Variable-energy operation is a build option, specified when the system is ordered. The system has demonstrated electronic control of beam energy from roughly 1.5 MeV to 3 MeV with limited penalty in dose rate, verified against lead attenuation measurements that agree well with simulation. A system built instead for a single fixed energy packages lighter. The right configuration follows the field application: variable energy where inspection tasks span a range of thicknesses or require material discrimination, fixed energy where minimum weight governs.
Work continues over the coming year on a 7 MeV system built on the same architecture for greater penetration. A modulator variant is also under development that will run from either wall power or batteries, so one unit serves both fixed-site and field use.
These results show that a portable, battery-operated linac source is no longer a projection but a working system: an alternative to betatrons and to radioactive sources, with no licensed isotope to manage. The same efficiency gains carry directly into industrial radiography and non-destructive testing. We are already building radiotherapy systems on a similar linac architecture, with FLASH treatment in our sights as the architecture scales to larger power sources.

Abstract 20 at 4:40 PM

Session CA-AS-01 Tuesday 3:30 PM - 314B/C

High-Energy Tomographic Scanner for Inspection of Contraband in Air Cargo

Joseph Bendahan, Harry Martz

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Cargo is inspected for contraband, e.g., explosives, at private air cargo facilities. Often, items from multiple vendors and of varying content are consolidated onto single units called skids. Commonly, existing x-ray scanners either do not penetrate dense cargo placed on the skids or produce images that are too cluttered for contraband detection. This requires unpacking the skids, scanning more manageable individual packages as "break bulk" cargo, and then re-consolidating the cargo. This is labor intensive and time consuming. To get similar levels of detection as Explosives Detection Systems (EDS) for checked luggage, tomographic scanners were recently scaled up by manufacturers for air cargo skids. These systems operate up to a potential of 450kV. LLNL has developed a high-potential, 3 MV, tomographic scanner that allows further penetration for dense air cargo with similar spatial resolution as EDS at an operational of throughput of 20 skids/hour. The system can also detect general contraband for customs purposes. The basic system design will be described, and preliminary results will be presented.

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Abstract 142 at 3:30 PM

Session CA-PS-05 Tuesday 3:30 PM - 382B

A Tutorial on Rutherford Backscattering Spectrometry: Concurrent Depth Profiling and Radiation Evaluation of Perovskite Solar Cells

Mritunjaya Parashar

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Abstract:
Rutherford backscattering spectrometry (RBS) uses MeV-energy light ion (e.g. He^+ or H^+) to resolve the elemental depth distribution of a multilayer stack without sputtering, without reference standards, and with minimal sample preparation. This tutorial develops RBS as a practical, largely non-destructive characterization route for metal-halide perovskite solar cells (PSCs), where conventional keV sputter-based profiling can itself drive compositional intermixing, preferential sputtering, and structural damage that compromise quantitative accuracy. We first set out the physical basis of measurement: kinematic factors, scattering cross section, and stopping power, that translate these into the practical levers which govern mass separation, depth resolution, and detection limits in complex target stacks. We then describe spectrum simulation and fitting workflows for quantifying layer composition and interfacial diffusion, together with the principal pitfalls: signal overlap between heavy constituents, roughness- and straggling-limited resolution, and the low sensitivity to light elements. A distinguishing feature of the technique is that the analyzing beam is simultaneously an irradiation source, so a single measurement yields both an elemental depth profile and an assessment of radiation hardness at a known fluence. Case studies on n-i-p and p-i-n PSC architecture illustrate this approach. We close with guidance on experimental design, complementary techniques, and reporting practice, so that RBS can be applied reproducibly to screen perovskite devices for terrestrial and space photovoltaic deployment.

Brief Bio:
Mritunjaya Parashar is a senior Ph.D. candidate in Physics at the Ion Beam Laboratory, University of North Texas, where his dissertation applies MeV ion beam analysis to elemental depth profiling, interfacial diffusion, and radiation tolerance in metal-halide perovskite solar cells for terrestrial and space photovoltaics. He is experienced in perovskite device fabrication and in ion beam methods including RBS, ion channeling, and targeted ion implantation, and has helped develop in-situ radiation testing capabilities for measuring device performance during irradiation. In Summer 2026 he was a Module Development Engineer intern at Intel Foundry, Hillsboro, Oregon, in the Logic Technology Development and Manufacturing (LTD-M) division, where he worked on optimizing atomic layer deposition (ALD) process for metal deposition. He has authored more than 40 publications, including journal articles, book chapters, and conference proceedings, which have been cited approximately 1,700 times, and received an Outstanding Talk Award at the 2023 MRS Spring Meeting. His work appears in leading peer-reviewed journals such as APL Energy, ACS Applied Materials & Interfaces, ACS Energy Letters, ACS Applied Energy Materials and the Journal of Physics: Energy and is carried out in collaboration with National Laboratory of the Rockies, Oklahoma University, Arizona State University, University of Toledo, and University at Buffalo.[1-7]

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Abstract 154 at 4:15 PM

Session CA-PS-05 Tuesday 3:30 PM - 382B

A Tutorial on Particle-Induced X-ray Emission (PIXE) Spectroscopy: From Concentration Analysis to Elemental Mapping

Darshpreet Kaur Saini

Department of Physics, University of North Texas, Denton Texas, United States

For the past six decades, ion beam accelerators have been used to analyze a wide range of samples, from delicate specimens such as herbal leaves to robust materials like silicon. Their strength lies in the flexibility to tune both beam energy and ion species according to the type of analysis, the depth of interest, and the nuclear reactions involved. To exploit this versatility at the microscale, nuclear microprobes were developed to focus the beam down to sub-micron dimensions using magnetic lenses. Scanning such a focused beam across the sample then yields two-dimensional elemental maps with high spatial resolution.

When an energetic ion beam interacts with a target material, it triggers a variety of radiative and non-radiative processes, including the emission of X-rays. This radiation can be recorded using an appropriate detector and data acquisition system. Particle-Induced X-ray Emission (PIXE) is one of the most informative ion beam analysis (IBA) techniques, in which the emitted X-rays are used to map elemental distributions and to compare concentration ratios across different regions of interest. It can be performed in a microbeam configuration (micro-PIXE), when spatial maps of elemental distribution are required, or in a broad-beam configuration (broadbeam-PIXE), when only bulk elemental concentrations are needed. PIXE is further valued for its non-destructive nature and minimal sample preparation, providing elemental concentrations with minimum detection limits (MDLs) in the parts-per-million (ppm) range. Positioned among micro- and surface-analytical techniques by lateral spatial resolution and minimum detection limit [1,2], PIXE occupies a distinctive niche, offering ppm-level sensitivity, while remaining non-destructive, and it has been applied across biological, environmental, and engineered samples [3].

The PIXE workflow proceeds in three stages: accumulation, conversion, and extraction. During accumulation, the focused proton beam is raster-scanned across a region of interest divided into a fine pixel grid, and the data acquisition system records each detected X-ray in an event-by-event mode, tagging every photon with its energy and the beam's position until a fixed incident charge is reached. Because the target chamber can house PIXE, RBS, and STIM detectors together, elemental, compositional, and density information are collected in a single scan. In the conversion stage, the summed spectrum is fitted with standardless software such as GeoPIXE, which subtracts the bremsstrahlung continuum, corrects detector artifacts like silicon-escape and pile-up peaks, and transforms the fitted peak areas into a charge-normalized concentration vector, yielding quantitative values with detection limits at the ppm level. Finally, extraction rebuilds the spatial picture: integrating the per-pixel concentrations produces element-specific maps, which can be superimposed to reveal where species co-locate. From these, regions of interest are selected to obtain localized spectra, element-to-element concentration correlations, line profiles, and particle sizes, linking each feature's composition to its likely origin.

Taken together, these stages make PIXE more than an elemental accounting tool. The elemental maps reveal where each species sits and how it is spatially distributed across the scanned region, while the correlation maps link pairs of elements through their concentration ratios, isolating the specific phases in which they co-occur. By selecting regions of interest, one can extract localized spectra, concentration values with uncertainties and detection limits, line profiles across a feature, and particle sizes so that composition can be tied to individual structures rather than averaged over the whole area.

This tutorial talk will demonstrate the breadth of micro-PIXE through elemental and phase-correlation studies spanning biological samples (herbal leaves, pine needles), environmental samples (airborne dust), extraterrestrial samples (chondritic meteorites), and engineered materials (solar cells), showing how spatial mapping combined with concentration correlation traces the origin, function, or source of each element within a sample. In this way, micro-PIXE bridges quantitative elemental analysis and spatial context, offering a non-destructive route to understand not just what a sample contains, but where those elements reside and how they relate to one another.

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Abstract 43 at 3:30 PM

Session WT-WT-02 Tuesday 3:30 PM - 382A

Irradiation induced phase transformation in Fe2O3 and Cr2O3and its impact on irradiation induced-loop formation through the use of in-situ TEM and spatially resolved EELS spectroscopy

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(3)University of California Berkeley, Berkeley CA, United States

Oxide scales are typically formed on top of steels when exposed to extreme condition of irradiations and corrosion such as in a nuclear reactor environment. Understanding how irradiation affect the different oxide layers is critical to understand how they build in-reactor and how irradiation impacts the passivating nature of these oxides. In this work, we explore the irradiation effects in Fe/Cr_2O_3/Fe_2O_3/Al_2O_3 multilayer samples through in-situ ion irradiation in a TEM using 1 MeV Kr ions at room temperature and 300̊C followed by spatially resolved EELS spectrocopy. The formation of irradiation induced extended defects and their evolution and interaction with preexisting microstructure features is followed as a function of dose and temperature. Dislocation loops are observed to form in both Cr_2O_3 and Fe_2O_3 but their formation and growth followed different kinetics despite the similar initial crystal structure and thickness. Spatially resolved EELS spectroscopy was instrumental in elucidating the reasons for such drastic different behavior.

Abstract 184 at 4:00 PM Session WT-WT-02 Tuesday 3:30 PM - 382A

In-Situ Approaches for Structural and Chemical Analysis in Extreme Environments

Christopher M Smyth[1], Sadie Wicks[1,2], Anne H Davis[1], Nicholas Brechtel[1], Assel Aitkaliyeva[2], David Robinson[3], Rob Kolasinski[3], Mary Alice Cusentino[1]

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(2)Nuclear Engineering, University of Florida, Gainesville FL, United States
(3)Sandia National Laboratories, Livermore CA, United States

Understanding the mechanisms that govern changes in materials strength, defect population, and surface potential under extreme environments (high flux plasma, radiation, temperature extremes) is essential for designing resilient structural and functional materials for nuclear, fusion, space, semiconductor, and chemical-processing technologies. To capture the rapid, often metastable evolution of nanostructure, bonding environment, and local composition, of novel materials subjected to extreme environments, real-time interrogation is required. This can be achieved either by coupling extreme environments directly with characterization tools such as a transmission electron microscope (TEM), or by preserving the metastable state of a specimen between extreme environments exposure and measurement in separate experimental chambers. Both approaches are technically demanding, yet they provide unprecedented insight into materials response - information that is critical for materials design, selection, and qualification.
In this presentation, we will first give an overview of the unique in-situ capabilities of the Sandia Ion Beam Lab currently in use for in-situ materials characterization under extreme environments, focusing on the In-Situ Ion Irradiation Transmission Electron Microscope (I^3TEM) end station and the newly deployed Ion Beam Extreme Environment X-ray Photoelectron Spectrometer (IBE^2X) end station. We will then showcase recent experiments that illustrate how these platforms enable real-time coupling of nanostructure and composition for both structural and electronic materials. Using the I^3TEM, we have tracked dislocation slip plane orientation and density in model first wall (tungsten) and blanket (vanadium) metals for fusion reactors under simultaneous ion beam irradiation and heating. For example, dislocation loops with (110)<111> orientation accumulate in vanadium with increasing displacement damage, in agreement with molecular dynamics simulations. This coupled experiment-with-modeling approach directly inform predictions of component lifetime and hydrogen isotope retention of leading-candidate fusion reactor materials. In a separate study of palladium-an archetypal hydrogen-storage metal-combined heating and ion irradiation induced unexpected formation of nano-voids, revealing a previously unknown aging pathway that could limit performance in high-hydrogen-capacity metals. Finally, the IBE^2X end station has shown that ion beam irradiation suppresses the orthorhombic phase fraction in $HfZrO_2$ capacitors by counterintuitively reducing the oxygen vacancy density. This study reveals a previously unknown pathway to phase change and device performance degradation in non-volatile memory materials like $HfZrO_2$, key to engineering more radiation tolerant memories. Altogether, these recent in-situ experiments exemplify the unique structure-chemistry insights attainable through the synergy of the I^3TEM and IBE^2X end stations.
This work was supported in part by a Laboratory Directed Research & Development program at Sandia National Laboratories. Sandia National Laboratories is a multimission laboratory managed and operated by National Technology &

Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. DOE's National Nuclear Security Administration under contract DE-NA-0003525. The views expressed in the correspondence do not necessarily represent the views of the U.S. DOE or the United States Government. This work was performed, in part, at the Center for Integrated Nanotechnologies, a User Facility operated for the U.S. DOE Office of Science.

Abstract 178 at 4:30 PM — Session WT-WT-02 Tuesday 3:30 PM - 382A

Proton-Irradiation Response of Laser Powder Bed Fused W and W-5Re Alloy

Krishna Kamlesh Verma[1], Shashank Sharma[1], Mohin Sharma[2], KV Mani Krishna[3], Madhavan Radhakrishnan[1], Sameehan Joshi[1], Bibhudutta Rout[2], Narendra Dahotre[1]

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Tungsten is a leading candidate for plasma-facing components in fusion systems, but irradiation-induced surface damage, defect accumulation, and hardening remain important performance limitations. This study compares the microstructural and mechanical responses of laser powder bed fusion (LPBF)-fabricated pure W and W-5 wt.% Re following room-temperature irradiation with 1.0 MeV H^+ ions to a fluence of 1.0×10^{19} ions/cm^2. Multiscale characterization revealed markedly different irradiation responses in the two materials. Irradiated pure W developed extensive surface blistering, with a density of 22.5±1.0 blisters/mm^2 and blister diameters of 75-115 µm. In comparison, W-5Re exhibited a substantially lower blister density of 1.8±1.0 blisters/mm^2, with diameters limited to 0.22-0.26 µm. Scanning transmission electron microscopy showed that pure W contained a relatively high density of small dislocation loops, measuring 6-23 nm, with a reported density of $8.6 \pm 6.0 \times 10^{14}$ /m^2. W-5Re exhibited a lower dislocation density of $2.2 \pm 4.1 \times 10^{14}$ /m^2 and larger dislocation tangles measuring 32-94 nm. Atom probe tomography showed that W and Re remained uniformly distributed in W-5Re, without detectable clustering or segregation either before or after irradiation. Nanoindentation measurements indicated irradiation-induced hardness increases of approximately 58% in pure W and 38% in W-5Re. The combined reduction in blister formation, defect accumulation, cracking susceptibility, and irradiation hardening demonstrates that Re addition improves the microstructural stability and proton-irradiation tolerance of LPBF-fabricated W. These results support further consideration of LPBF W-5Re for components exposed to severe fusion-relevant irradiation environments.

Abstract 187 at 6:30 PM — Session CA-PS-06 Tuesday 6:30 PM - 314B/C

Vendor Roadshow

Bibhudutta Rout

Physics, University of North Texas, Denton TEXAS, United States

In this session, we would like to thank our exhibitors for supporting the conference. They will have the opportunity to present their company and discuss their products in a brief 5- to 10-minute presentation.

Abstract 130 at 9:00 AM — Session CA-PS-03 Wednesday 9:00 AM - 314B/C

Starting the Fusion Fuel Cycle Without a Fusion Reactor: A New Supply of Commercial Tritium

Terence J. Tarnowsky, Paul Lisowski, Richard Sheffield

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The United States lacks a dedicated domestic capability for commercial tritium production. The estimated value of commercial tritium is approximately $34 million per kilogram in 2026 dollars (1)A 1-GWth D-T fusion energy plant would require more than 55 kg of tritium per full power year. These plants are expected to breed tritium during operation,

requiring a tritium breeding ratio above 1.0 and ideally approximately 1.1-1.2. Even a 1% uncertainty in the system-level breeding ratio can correspond to more than ±500 g of tritium per full-power year for a 1-GWth plant (2)Starting a fusion plant without an external tritium inventory by using D-D reactions to breed the initial tritium is not economically viable under realistic technological assumptions [3,4].
Current commercial tritium supplies are recovered primarily from critical heavy-water reactors, including Canada Deuterium Uranium (CANDU) reactors, at rates on the order of 0.1 kg per reactor-year [5].
We propose to investigate the design, development, performance requirements, and cost of an accelerator-driven system using molten-salt technology to produce commercial tritium. Neutrons generated by the accelerator are multiplied through subcritical fission, providing a neutron population sufficient to produce tritium at rates relevant to D-T fusion-plant startup inventories. Energy generated by fission could offset part of the accelerator power demand and provide additional plant revenue through the sale of process heat. Operation in a subcritical configuration may also improve safety while reducing criticality constraints.
The proposed ADS-molten-salt fusion-fuel plant is well suited to a commercial tritium production mission and could transform the existing limited supply chain into a more conventional, demand-driven fuel supply system. An ADS-molten-salt facility could achieve tritium yields exceeding 20 tritons per incident proton using existing technology and could produce tens of kilograms of tritium annually at the gigawatt thermal scale. A dedicated fusion-fuel facility could reduce the construction cost and operational complexity associated with tritium breeding at individual fusion power plants, allowing D-T plant designers to focus on energy production while reducing fuel-cycle risk.
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Abstract 52 at 10:00 AM Session CA-AF-03 Wednesday 10:00 AM - 339

A Generalized Principle of Resonant Coupling

James M. Potter

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In 1956, researchers at Harwell considered resonant coupling of accelerator cavities, and a 1963 Rutherford analysis identified voltage breakdown in the coupling elements as a serious practical concern. The Los Alamos development began independently in 1964, prompted by the discovery of a narrow band of slot resonances in a 40-cell sheet-metal cloverleaf model. That discovery led to perturbation theory and a coupled-circuit model for biperiodic resonators, analysis of capacitively loaded coupling slots, and construction of the 22-cell side-coupled "Mickey Mouse" coupled-cavity linac (CCL) prototype. Within measurement accuracy, deliberate detuning of both accelerating and coupling cells produced no change in the accelerating-cell field distribution.
Subsequent Los Alamos developments included DTL post couplers, transient analysis and visualization of biperiodic coupled-cavity linacs, long TM010 bridge couplers stabilized by TE113, TE115, or higher TE11N modes, disk-and-washer structures, TEM-mode bridge couplers, an adjustable resonant RFQ-to-DTL power coupler, and the Klynac, a resonantly coupled klystron-electron accelerator.
These apparently different systems, whether composed of discrete resonators or transmission lines, share a common principle. At the confluence of two passbands, tuning errors excite the coupling mode required to satisfy the boundary conditions, thereby preserving the useful field amplitudes and phases to first order. This generalized view treats resonant stabilization as a modal property rather than as a special feature of a particular geometry.

Abstract 152 at 10:20 AM Session CA-AF-03 Wednesday 10:00 AM - 339

An Ion Track You Can Aim: A Quasi-Bessel Laser Platform for Depth-Controlled Single-Event Effects Testing

Rodolfo Antonio Rodriguez Davila, Hamza Selami, Robert Baumann, Ted Moise, Bruce Gnade, Manuel Quevedo Lopez

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Pulsed-laser single-event effect (SEE) testing by two-photon absorption (TPA) dates back to McMorrow and co-workers in 2002 and has since been applied to amplifiers, flip-chip SRAM, and thinned ASICs via the wafer backside. That work, including the dosimetry established by Khachatrian and co-workers in 2014, uses Gaussian focusing, which concentrates carrier generation near the focal plane, yielding an axial profile unlike that of an ion track. Hales and co-workers introduced the quasi-Bessel beam (QBB) focusing in 2019 and 2020 to extend deposition along the propagation axis, then applied it to latchup and transient prediction in circuits. Ildefonso and Hales have since added agreement metrics and a framework for laser-equivalent LET. The quasi-Bessel record remains small and, to our knowledge, confined to that group. Its diode studies are topside, on commercial parts whose depletion architecture the experimenter does not control. Ryder and co-workers, using Gaussian focusing, showed that ion- and laser-sensitive volumes agree only when the diode is fully depleted, making that architecture a controlling variable.

We describe a QBB-TPA platform built at the University of Texas at Dallas, the first such implementation we are aware of outside that group. An optical parametric amplifier provides tunable output from 320 to 1600 nm, feeding two paths: infrared for silicon and ultraviolet-to-visible for wide-bandgap materials such as GaN and SiC. An axicon converts the beam into a quasi-Bessel focus, with angles between 10 and 25 degrees, setting the axial extent over which charge is deposited. Imaging on both faces, infrared through the substrate and ultraviolet to visible from the top, allows a target to be revisited from either side. A precision three-axis stage carries the device, so a chosen site can be addressed, mapped in two or three dimensions, and revisited. A heavy-ion beam arrives at random positions and needs masking and repeated exposures to localize a response; the laser places each event where the experiment requires it.

Depth control was verified on a silicon PN diode of 2.1 cm² fabricated in-house, with its space-charge region extending 375 µm into a 500 µm substrate, and a back-surface aluminum window, so that front-side ions and backside photons interrogate the same volume. Axial charge-collection response extends to 950 µm at $1/e^2$ for 322.5 fs pulses at 1300 nm, and the collected charge scales as the square of the pulse energy from 10 to 40 nJ, as two-photon behavior requires. Charge is recovered with a transimpedance amplifier without a shaping stage, so the transient is slowed in time while its shape is preserved rather than being imposed by the electronics. It was calibrated against known injected charge over gain and response-time settings from 50 ns to 1 µs, returning charge to better than 0.05 pC.

Heavy-ion reference data were taken at the Texas A&M University Cyclotron Institute with ^{40}Ar, ^{63}Cu, ^{109}Ag, ^{129}Xe, and ^{165}Ho from the 15 MeV/u line. Conditions at the device were set by transport calculation rather than nominal beam values: aluminum degraders, a 25.4 µm polymer window, and a variable air gap were modeled in SRIM to place a chosen LET at a chosen depth in silicon, giving LET at the collection depth from 9 to 80 MeV·cm²/mg, extended to 0.9 by a laboratory 5.3 MeV alpha source. LET varies substantially over the collection depth for heavier species: for ^{165}Ho, the value at 10 µm exceeds the track average by more than 15 percent, so LET is quoted at defined depths with Bragg-peak depth and straggling. Backside QBB-TPA collected charge tracks equivalent LET across that range. The conversion from pulse energy to equivalent LET holds only for this optical geometry, is reported with its uncertainty, and is not universal.

The platform does not replace beam time. It changes what beam time has to accomplish. Where a device is sensitive, laterally and in depth, is mapped in the laboratory along with bias dependence and part selection, and the board, biasing, trigger, and acquisition chain is exercised before travel. Hence, a campaign opens with a working experiment and a list of locations worth exposing. Absolute cross-section qualification and any response driven by nuclear reaction products remain beam-only. Extension to GaN and SiC follows from the built-in ultraviolet-to-visible path.

Abstract 79 at 10:40 AM

Session CA-AF-03 Wednesday 10:00 AM - 339

Capabilities and Infrastructure Upgrades at the Michigan Ion Beam Laboratory (MIBL)

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As a charter National Scientific User Facility (NSUF), the Michigan Ion Beam Laboratory (MIBL) at the University of Michigan provides essential irradiation infrastructure for nuclear materials testing research. MIBL houses a 3 MV tandem, a 1.7 MV tandem, and a 400 kV single-ended accelerator, offering single-, dual-, and triple-beam irradiations. Dual and triple irradiations are specifically conducted in a dedicated multi-beam chamber. Existing capabilities also include dedicated target stations for irradiation, mechanical loading combined with strain mapping, and irradiation-assisted

corrosion studies. MIBL also has a specialized single- and dual-beam in situ Transmission Electron Microscopy (TEM) ion irradiation facility.
This presentation highlights recent technical upgrades designed to expand MIBL's research utility. The primary focus is the update of the TORVIS ion source on the 3 MV tandem accelerator, which enables helium beam production, followed by an upgrade to a dedicated beamline designed to investigate material properties under the combined effects of irradiation, mechanical load, and temperature. Additionally, the facility's ion beam analysis chamber has been enhanced with micro-beam capabilities, providing the high spatial resolution necessary to investigate small, specific areas of interest. Together, these advancements reinforce MIBL's capacity to characterize material performance under the extreme irradiation conditions required for nuclear materials testing.

Abstract 104 at 11:00 AM Session CA-AF-03 Wednesday 10:00 AM - 339

Overview of the University of North Texas Ion Beam Laboratory for Materials Modification and Microanalysis

Todd Byers, Jorden Matty, Darshpreet Kaur Saini, Mohin Sharma, Mritunjaya Parashar, Charles Bowen, Aaron Richardson, Luke Claycomb, Daniel Brown, Ariel Dumond, Tony Dobis, Taylor Mestis, Duncan Weathers, Gary A. Glass, Bibhudutta Rout

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Energetic ion beams are used for the modification, manipulation, synthesis, and analysis of materials in a wide range of fields involving astrophysics, biomaterials, environmental materials, metallurgy, nuclear energy materials, photovoltaics, and semiconductors. At the University of North Texas Ion Beam Laboratory (UNT-IBL), four separate accelerators (two NEC 3MV Pelletrons, a 2.5 MV Van de Graaff, and a 200 kV Cockroft-Walton) are utilized for educational, research and industrial purposes. One low and two high energy ion implantation beamlines are used to perform targeted irradiation within materials and electronic devices. Three multipurpose analysis beamlines are equipped to study the elemental composition and layer structure of samples and devices. A light ion microprobe with sub-micrometer spatial resolution can perform standardless elemental concentration mapping and compositional characterization on a variety of materials and device structures. The capabilities of each accelerator and beamline are discussed here along with some of the recent research utilizing them.

Abstract 160 at 10:00 AM Session CA-AN-04 Wednesday 10:00 AM - 382A

Machine Learning in Lattice QCD for EIC Physics

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Recent advances in machine learning have opened new pathways for accelerating discovery in lattice QCD, with a particular focus on parton distributions. As lattice calculations grow in scale and precision, machine learning offers tools not only to speed up computation, but to uncover structure in high-dimensional data that might otherwise remain hidden. This talk explores several rapidly evolving directions at this intersection, including approaches that respect the symmetries and gauge correlations inherent to lattice-QCD data, improving both efficiency and physical interpretability. We explore approaches that enable a flexible, data-driven reconstruction of parton distributions that retains correlations across operator insertions and kinematic regimes, offering a path toward a unified extraction of parton distributions. We also discuss multiple examples of how machine learning has been used to improve the signal-to-noise ratio in notoriously difficult lattice QCD calculations. Throughout, we highlight examples and open directions most relevant to EIC physics discovery, with an eye toward how these emerging tools may inform both theoretical predictions and future experimental analysis.

Abstract 151 at 10:30 AM

Session CA-AN-04 Wednesday 10:00 AM - 382A

Calorimeter-only collision-vertex reconstruction at sPHENIX with a Vision Transformer

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The position of the collision vertex along the beam axis is an important input to jet measurements at sPHENIX, and the Minimum Bias Detector (MBD) normally measures this position. However, an MBD vertex is unavailable for a substantial fraction of events selected by triggers that do not require an MBD coincidence. Some of these events contain a high-energy calorimeter signal but have too little activity within the MBD acceptance for vertex reconstruction. We present a machine-learning method that estimates the vertex using only calorimeter information.

The model uses energy and timing measurements from the electromagnetic calorimeter and the two hadronic calorimeters. These measurements are arranged as images in pseudorapidity and azimuth. A Vision Transformer processes the images and predicts the longitudinal vertex position. The model uses the same patch embedding for each calorimeter. Learned layer-dependent transformations identify the calorimeter associated with each token. The model also includes event-level quantities such as the energy difference between the two sides of each calorimeter. Tower timing is used to adjust the weight of different regions in the energy images. The treatment of image boundaries follows the detector geometry, including the periodic boundary in azimuth. Training also includes uncertainty in the common event-time reference.

The model is trained and tested with simulated jet events from several leading-jet energy ranges. Its resolution improves with increasing jet energy. These results show that the calorimeter energy and timing patterns contain useful information about the collision vertex. Further validation with collision data will be done to verify the performance of the model. And more applications of this model is under developing.

Abstract 136 at 11:00 AM

Session CA-AN-04 Wednesday 10:00 AM - 382A

SIDERIUS: Resource-Aware AI Agents for Particle and Nuclear Physics

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Rare event searches is an important method to make new discoveries in particle and nuclear physics inaccessible with other means by leveraging specialized radiation detectors. Machine learning has become an increasingly important tool for extracting the maximum scientific information from these detectors, while recent advances in Large Language Models (LLMs) introduce the possibility of automating substantial portions of the workflow. As LLM agents evolve from solving short, inexpensive tasks to performing real scientific machine learning workflows, computational cost becomes a fundamental constraint. Model training, evaluation, simulation, and high-fidelity validation can differ substantially in resource requirements, making exhaustive exploration impractical. SIDERIUS is a resource-aware multi-agent system for automated machine learning. It coordinates agents across scientific reasoning, model proposal, implementation, validation, tuning, and interpretation, while explicitly accounting for limited computational resources. We present lessons learned from applying SIDERIUS to a real rare-event search datasets, highlighting practical challenges that emerge in long-horizon scientific workflows. These observations motivate SciTra (Cost-Aware Science Trajectory), an ongoing framework for evaluating and optimizing the computational efficiency of long-running scientific AI agents.

Abstract 108 at 10:00 AM

Session CA-AR-07 Wednesday 10:00 AM - 332

Advancing Reliable Ion Irradiation Studies Through Refined DPA Calculations and Artifact Control

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Accurate vacancy production estimation is essential for calculating displacements per atom (dpa) and for using ion irradiation to study neutron-irradiation effects. We evaluated vacancy production for >150 ion-target combinations using the full-cascade (FC) and quick-calculation (QC) options of SRIM-2013, applying both vacancy-file and damage-energy methods. The FC vacancy-file method overpredicts vacancy production by factors of 1.1-4 relative to the FC damage-energy and QC methods. Comparisons among SRIM, Iradina, and MARLOWE showed that unphysically low threshold energies used in replacement calculations produce excessive vacancies and too few replacements; corresponding source-code corrections were subsequently proposed and implemented. The corrected SRIM FC approach should provide the most reliable binary-collision-approximation estimate by accounting for the stopping powers of incident and recoil ions. However, SRIM-2013 overpredicted the peak depth of 8 MeV Ni in Fe by ~700 nm, suggesting that the SRIM stopping-power data for some ion-target systems still require revision. This talk also discusses key limitations of ion-neutron comparisons, including depth-dependent damage profiles, dose-rate and beam-pulsing effects, the absence of transmutation gases, contamination, stress, near-surface effects, implanted-ion effects, and swift-heavy-ion phenomena. Cavity-swelling and diffusion measurements show that temperature-dependent surface effects and implanted-ion broadening can further narrow the artifact-free analysis region at elevated temperatures. Ion energies of ~8-15 MeV are therefore recommended to provide a sufficiently broad midrange region for reliable microstructural characterization.

Abstract 162 at 10:30 AM

Session CA-AR-07 Wednesday 10:00 AM - 332

Mitigating Heavy-Ion Irradiation Artifacts through Neutron and Proton Preconditioning

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Accelerator-based ion irradiation is widely used as a surrogate for reactor neutron irradiation in accelerated radiation damage studies because it produces a much higher damage rate. However, ion irradiation introduces well-known artifacts, particularly surface effects and injected interstitials, which can significantly reduce the fidelity of swelling experiments. Various approaches have been proposed to mitigate these artifacts. One strategy is neutron preconditioning, in which reactor neutron irradiation first introduces radiation damage, followed by heavy-ion irradiation to promote void growth. Because voids nucleate under reactor-relevant damage rates, this approach minimizes accelerator-induced artifacts and improves the fidelity of swelling measurements. A second strategy is proton preconditioning, in which proton irradiation is first used to initiate void nucleation at a damage rate much lower than that of heavy-ion irradiation. This proton-preconditioned state has a controlled microstructure with some similarities to neutron irradiation microstructure. Subsequent heavy-ion irradiation then accelerates microstructural evolution while reducing the incubation artifacts associated with heavy-ion irradiation alone. Here, we summarize our recent progress on both approaches, demonstrating that neutron and proton preconditioning both significantly enhance void swelling compared with heavy-ion irradiation alone. Compared with neutron preconditioning, proton preconditioning is substantially lower in cost, more accessible, and readily implemented at accelerator facilities, making it a broadly applicable strategy for improving the fidelity of accelerator-based swelling testing across a wide range of structural metals.

Abstract 62 at 11:00 AM

Session CA-AR-07 Wednesday 10:00 AM - 332

A new tool to unlock the capabilities of SRIM: Investigating the ability of ion beams to emulate neutron irradiation

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Understanding the behaviour of materials under nuclear reactor irradiation is vital to the development and safe operation of nuclear energy systems. Ion beams are widely used to reproduce selected aspects of neutron irradiation present in these environments, but the primary damage states induced in materials by such charged particles can be very different. Weighted primary recoil spectra (WPRS) describe the distribution of recoil energies weighted by their contributions to displacement production. These spectra can differ significantly between ions and neutrons, leading to differences in defect production,

cluster formation, and the spatial and size distributions of the resulting defects and defect clusters. WPRS are thus a crucial metric for comparing irradiations by different energetic particles. Projectiles producing similar WPRS in a given material are expected to produce more comparable primary displacement-cascade distributions and resulting defects, although other differences between ion and neutron irradiation must also be considered.
The Stopping and Range of Ions in Matter (SRIM) code is commonly used to predict ion stopping powers, energy deposition, ion range, and damage dose. However, the collision data required to construct WPRS is not readily accessible through the standard SRIM interface and requires substantial extraction and post-processing. Thus, WPRS are not commonly assessed despite their importance. A new open-source Python code, SRIMpro, has been developed to extract and process detailed SRIM output data, making these SRIM capabilities more readily accessible. SRIMpro generates WPRS and provides many other tools for plotting depth-dependent displacement damage, ionization energy deposition, and other commonly analyzed SRIM outputs.
The capabilities of SRIMpro are demonstrated by comparing the SRIM-predicted WPRS generated by selected ions and energies with those calculated for representative fission and fusion neutron spectra in SiC, Ni, and Zr-2.5Nb. The results show that protons and other light ions produce significantly different WPRS from those produced by fast neutrons, while heavier ions with higher energies produce WPRS more similar to those of fast neutrons. Nonetheless, all the ion conditions investigated produced WPRS noticeably different from those associated with the higher-energy neutron spectra considered. In contrast, heavy ions more closely reproduced the WPRS associated with the lower-energy neutrons of a thermal reactor. These results demonstrate that ion species and energy should be selected using recoil-spectrum similarity rather than penetration depth or displacement dose alone. SRIMpro makes such comparisons more accessible and provides a practical tool for designing ion-irradiation experiments intended to reproduce selected aspects of neutron-induced primary damage.

Abstract 114 at 10:00 AM Session CA-AS-04 Wednesday 10:00 AM - 314B/C

Replacing Americium-Beryllium-based Well Logging Tools

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Efforts to reduce or eliminate americium-beryllium (Am-Be) neutron sources in well-logging applications have long been motivated by concerns related to security, safety, environmental impact, and regulatory burden. Under the Advanced Logging Techniques to Eliminate Radiological Risk (ALTERR) project, the National Nuclear Security Administration (NNSA) Office of Radiological Security (ORS) and Oak Ridge National Laboratory have identified significant opportunities to transition away from legacy Am-Be-based logging tools toward advanced alternative technologies. ALTERR's methodology integrates a market landscape assessment, technology readiness evaluation, and preliminary modeling and simulation to examine both the technical and non-technical factors influencing the adoption of alternatives. The project surveyed a diverse set of "source-less" or reduced-source technologies, including deuterium-tritium (D-T) and deuterium-deuterium (D-D) neutron generator-based tools, as well as non-nuclear approaches such as vibration-while-drilling analysis, electrical resistivity measurements, sonic methods, and nuclear magnetic resonance (NMR). These technologies span a wide range of Technology Readiness Levels (TRLs).
This presentation will provide an overview of ALTERR's findings, including the landscape of emerging alternatives to Am-Be tools and the primary barriers to their widespread deployment. Particular attention will be given to the most viable near-term option—D-T neutron generators—and the critical need to expand and diversify generator supply chains to ensure more accessible, cost-effective, and robust systems. By lowering supply-chain barriers and increasing market availability of D-T and D-D generators, the well-logging industry can accelerate the transition away from outdated Am-Be sources toward safer, more secure technologies.

Abstract 132 at 10:30 AM Session CA-AS-04 Wednesday 10:00 AM - 314B/C

Energy Transition- A Potential Role for Accelerators?

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D-T generator- based tools, ubiquitous in subsurface monitoring to locate remaining hydrocarbon volumes, have been proposed for geological probing necessary in certain low-carbon energy generation options. Applications that have shown promise are: (i) locating suitable minerals, (ii) near-bore monitoring of leakage of buried radioactive waste from storage drums, (iii) temporal monitoring of plume of CO_2 injected into the geology for carbon capture and sequestration (CCS), and (iv) potentially identifying source rocks that can be used to generate geologic hydrogen. However, in some cases, these techniques may have to augmented, while in others such augmentation may not suffice and consideration of novel radiation sources may be necessary. Both cases will be examined, including use of Muons for deep and millennial-scale monitoring that would be required of radioactive waste repositories and sequestered CO_2, or identifying resources very deep in the geology.
A successful use of machine-based devices in subsurface probing in low-carbon energy generation would provide a strong additional incentive, besides **security**, for replacing risky radioactive source-based tools currently used for subsurface probing to initially characterize geological formations. Such replacement has been of much interest and both DT-generator and X-ray based tools have been tested to determine bulk petrophysical parameters, but the results have been mixed.

Abstract 26 at 11:00 AM — Session CA-AS-04 Wednesday 10:00 AM - 314B/C

Experimental Characterization and Particle-in-Cell Modeling of a Penning Ion Source for Compact D-T Neutron Generators

Valentin Chalancon[1,2], Adrien Cheminet[1], Olivier Galland[1], Darius Mofakhami[3], Adrien Revel[2], Tiberiu Minea[2]

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Sealed deuterium-tritium (D-T) neutron generators are compact electrostatic accelerators widely used in industrial applications, non-destructive testing, homeland security, and scientific instrumentation. Their performance and operational lifetime strongly depend on the stability of the low-pressure Penning ion source, which produces and extracts deuterium ions toward the tritium target. Accurate prediction of plasma behavior and ion beam formation is therefore essential for improving ion optics design, beam transport efficiency, and high-voltage reliability.
This work presents an experimental and numerical investigation of a Penning ion source developed in the framework of a PhD research project conducted jointly by Sodern and the Laboratoire de Physique des Gaz et des Plasmas (LPGP, France). The numerical approach relies on SAPIC (Saclay Simple AMR Particle-In-Cell), a Particle-in-Cell code developed at LPGP and originally designed for magnetron plasma simulations. The model has been adapted to describe the discharge physics of a Penning ion source operating under crossed electric and magnetic fields. A realistic magnetic field map, computed using CST Studio Suite®, is incorporated into the simulations to reproduce the experimental magnetic confinement.
The first stage of the study focuses on rare gases (helium and argon), providing simplified reference cases for validating the plasma model and the implemented electron-impact ionization processes before extending the model to molecular hydrogen. Parametric studies investigate the influence of operating pressure, anode voltage, extraction voltage, and source geometry on plasma characteristics, ion production, and beam extraction.
To validate the numerical model, a dedicated experimental campaign is performed on the Epsilon test bench using two Penning source geometries and different operating gases. Measurements include extracted ion current using a Faraday cup and ion energy and velocity distribution functions obtained with a Hiden EQP mass-energy analyzer. These diagnostics provide a comprehensive database for quantitative comparison with SAPIC simulations and assessment of the predictive capability of the model.
The combined experimental and numerical approach establishes a validated framework for the simulation of Penning ion sources dedicated to compact neutron generators. Beyond improving the physical understanding of plasma generation and ion extraction, this work contributes to the optimization of accelerator operation, reduction of beam losses, enhancement of ion optics design, and improvement of the reliability and lifetime of next-generation compact neutron generators.

Abstract 157 at 1:30 PM — Session CA-AN-05 Wednesday 1:30 PM - 382A

Edge AI for feature streaming of radiation detectors

Maxx Lowy[1], Soumyajit Mandal[2], Alessandro Tricoli[3], Chiara La Tessa[4], Mst Shamim Ara Shawkat[1]

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There has been a migration towards streaming readouts for front-end radiation detectors. These streaming readout ASICs produce data continuously without a trigger, and data filtering, reconstruction, and algorithms are done through software. Data streaming ASICs allow more in-depth analysis and filtering of incoming data, but have constraints on the data reduction and maximum data bandwidth that can be streamed out of the ASIC. The integration of Machine Learning (ML) directly on the front-end ASIC of particle detectors can greatly increase the quality of the data reduction of the streaming ASICs and allow for classification and regression tasks to allow for feature streaming superior to traditional methods. We have been using a multifunctional streaming readout ASIC with an integrated Neural Network developed at Brookhaven National Laboratory (BNL) to interface with a Silicon Strip Detector (SSD) and an AC Low Gain Avalanche Detector (ACLGAD). This is to test how digital filtering and Neural Networks perform in real-life environments, for example, measuring a proton beam used for radiation microdosimetry.

Abstract 82 at 2:00 PM — Session CA-AN-05 Wednesday 1:30 PM - 382A

Photonuclear Production Yields for Radioisotopes of Terbium

Aidan Villa[1], Douglas P Wells[1], Van Romero[1], Robert Bentley[1], Geno Santistevan[1], Mariana Baca[1], Willie Hughes[1], Clarissa Zeiger[1], Jacob C Sandusky[1], Jack Nation[1], Cody Gustafson[1], Ryan Zander[1], Brandon Tso[1], Daniel Hojnowski[1], Daniel S Dale[2], Tony Forest[2], Kean Martinic[2], Robert Staub[2], Brian Rasmussen[2], Edna Cárdenas[3], Michael Reichenberger[3]

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Several radioisotopes of terbium are of particular interest in nuclear medicine, especially Tb-155 and Tb-161. Photonuclear reaction channels from isotopes of dysprosium can, in principle, be leveraged to produce these isotopes using an electron linear accelerator, offering a potential alternative to current reactor and cyclotron production methods. In order to properly characterize the efficacy of photo-production, it is necessary to have thorough experimental data on the relevant reaction cross sections and excitation functions. This study measured production yields from the bremsstrahlung gamma irradiation of a natural dysprosium oxide target. Prior to performing the experiment, theoretical yields were calculated using evaluated cross sections from TENDL and photon flux data from Monte-Carlo simulations performed in FLUKA. Irradiations were performed at Idaho State University's Idaho Accelerator Center at beam energies of 20 to 23 MeV in 1 MeV steps. An electron beam from an electron linear accelerator impinged on a tungsten radiator to generate a beam of bremsstrahlung photons for target irradiation. Post-irradiation, a High-Purity Germanium (HPGe) detector was used to record gamma spectra of each sample. Spectra were then analyzed to determine the induced activity levels for each produced species in the sample. Activity yields for Tb-155, Tb-160, Tb-161, Tb-162, Tb-163, Dy-155, and Dy-157 at beam energies from 20-23 MeV will be presented. In future experiments, we plan to extend these measurements across a larger energy range and produce full excitation functions, and extract photonuclear cross sections from these excitation data.
Acknowledgements: This work was supported by the U.S. Department of Energy under grant number DE-SC0023665.

Abstract 6 at 2:15 PM — Session CA-AN-05 Wednesday 1:30 PM - 382A

Measurement of photonuclear cross-section and production yields of ^{100}Mo(g,x)^{99}Mo, ^{100}Mo(g,np)^{98m}Nb, and ^{59}Co(g,xn; x=1-4) $^{58\text{-}55}$Co reactions with 50-70 MeV bremsstrahlung

Md Shakilur Rahman[1,2], Guinyun Kim[1], AKM Moinul Haque Meaze[3]

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The average cross-sections of $^{100}Mo(g,\mathbf{x})^{99}Mo$, $^{100}Mo(g,pn)^{98m}Nb$, and $^{59}Co(g,\mathbf{x}n;\ \mathbf{x}=1\text{-}4)\ ^{58\text{-}55}Co$ reactions was measured with bremsstrahlung end-point energies of 55-, 60- and 65-MeV via photo-activation technique at Pohang Accelerator Laboratory (PAL), Korea. Bremsstrahlung beam is generated from high energy electron beam by hitting a thin tungsten target. High-purity metallic foils of ^{nat}Mo and ^{59}Co with monitor foil Au were irradiated with bremsstrahlung beam and the activation product was then measured by off-line g-spectrometric system. Flux correction factors from monitor foil reaction to observed reaction were calculated from bremsstrahlung spectrum via GEANT4 simulation code. The measured experimental values together with other literature data are compared with theoretical nuclear reaction code Talys 1.6 and Empire 3.2.2 Malta that shows in general agreement with theoretical prediction. The specific activities of medically important isotopes ^{99}Mo, ^{58}Co and ^{57}Co were found (1.114±0.082), (9.337±0.554), and (1.718±0.108) MBq/mA.h.gm at bremsstrahlung end point energy 65 MeV which shows an excellent possible production route via electron accelerator. From the experimental cross-section data, it is observed that the average cross-sections increase with bremsstrahlung energy up to Gaint Dipole Resonance (GDR) and thereafter shows a small change at higher energies. The decrease of the average cross-sections at intermediate bremsstrahlung energy indicates the effect of QD (Quasi Deuteron) beside GDR.

Abstract 87 at 2:30 PM

Session CA-AN-05 Wednesday 1:30 PM - 382A

Precise cross-section measurement of the 11B(p,α)$\alpha\alpha$ resonance using the inverse kinematics technique

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The $^{11}B(p,\alpha)\alpha\alpha$ reaction has been studied extensively for its role in proton-boron capture therapy (PBCT) and in aneutronic fusion, where its first resonance near a center-of-mass energy of ~149 keV is a primary driver of the reactivity at temperatures of fusion interest and of the alpha yield in compact accelerator-driven experiments. Despite this long history, the available cross-section data in the resonance region remain sparse: measurements are tabulated at coarse energy steps, the underlying datasets are inconsistently cited across evaluations, and the resonance centroid, width, and peak magnitude are not constrained to the precision now demanded by fusion yield calculations. We performed a high-resolution measurement of this resonance using the inverse kinematics technique, in which a ^{11}B ion beam is incident on a hydrogen-bearing target. The kinematic transformation factor between the laboratory and center-of-mass frames is reduced from 11/12 in the direct geometry to 1/12 in the inverse geometry, compressing both beam-energy spread and energy drift by an order of magnitude when expressed in the frame relevant to the reaction. Combined with a demonstrated laboratory-frame beam-energy stability of ~1 keV, this yields a center-of-mass energy resolution of approximately 83 eV, sufficient to constrain the resonance centroid far more tightly than existing data allow. In this talk, we describe the ^{11}B beam production, the hydrogen target, the experimental setups, and current results

Abstract 94 at 2:45 PM

Session CA-AN-05 Wednesday 1:30 PM - 382A

Research and Education using Photonuclear Reactions for Isotope Production

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A three-institution collaboration of New Mexico Institute of Mining and Technology (NMT), Idaho National Laboratory (INL), and Idaho State University (ISU) is conducting an education program and systematic study of photo-nuclear reaction yields and excitation functions, cross sections and novel isotope separation techniques for a variety of targets of interest to the isotope production community. The research is focused on promising photonuclear reactions for many radioisotopes listed in the 2015 DOE/NIH National Nuclear Science Advisory Committee (NSAC) Isotope Subcommittee report "**Meeting Isotope Needs and Capturing Opportunities for the Future: The 2015 Long Range Plan for the DOE-NP Isotope Program**". This research, in turn, has been leveraged to educate a cadre of new isotope scientists in the largely untapped area of photo-nuclear production. We are measuring bremsstrahlung-weighted excitation functions, and inferring

the photonuclear cross sections to fill in some of the many gaps in the world's photonuclear data. Photonuclear excitation function measurements include (γ, α), (γ, p), (γ, n), (γ, 2n) (γ, np) and (γ, d). This program provides support and education each year for roughly 15 students and will provide critical talent in support of domestic efforts in isotope science. Experiments were conducted using a variable-energy electron linac at the Idaho Accelerator Center. Bremsstrahlung photons were produce with end-point energies ranging from 8 - 23 MeV, in increments of 1 MeV. Bremsstrahlung photons were then used to irradiate natural targets from Z=7 to Z=82, and activated via photonuclear reactions. The targets were metal foils, pellets, or oxide powders encased in aluminum foil. By a series of irradiations excitation functions (normalized yield curves) were measured, and cross sections extracted. Spectra from activated targets were measured with high purity germanium detectors. Particular care was taken to measure variations in the beam intensity throughout the irradiations, as well as the energy distribution of the electron beam. The nickel foils were used to measure relative photon flux in stacked target foils, while the gold foils were used for overall normalization, due to the well-known gold (γ,n) cross section. We will describe the current state of progress in this experimental program, the plans for future measurements, and address comparison of these results with the literature. We will also discuss the progress of this education program and the ongoing student successes.
Acknowledgements: This work is supported by the U.S. Department of Energy under grant number DE-SC0023665.

Abstract 35 at 1:30 PM

Session CA-AR-08 Wednesday 1:30 PM - 332

Laser Impulse Dependence on Scale, Laser Intensity and Tamper Materials

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Radiation-driven thermomechanical shocks (TMS) pose a significant threat to exo-atmospheric objects exposed to high-flux X-ray radiation. Specifically, critical surface electronics such as silicon-based photovoltaic cells are vulnerable to intense irradiation and TMS during extreme events. In this study, high-power lasers were employed as surrogates for X-ray fluxes to investigate surface plasma ablation. To enhance ablation pressure, a transparent medium was used to confine the plasma. We report on comprehensive experimental campaigns conducted across small-scale (LIGHT Laser), mid-scale (Jupiter Laser Facility), and large-scale (NIF-DLI) facilities. The experimental matrix spanned intensities of POWER(10, 9)POWER(-10, 11) W/POWER(cm, 2), pulse durations from 350 ps to 10 ns, mm to cm laser beam size, and both infrared and green wavelengths. Ablator materials included aluminum (Al) and titanium (Ti), while sapphire, fused silica, and LiF were utilized as tamper materials. A suite of diagnostics was employed, including line Velocity Interferometer System for Any Reflector (VISAR) for pressure and density measurements, SOP/ultrafast interferometry for ablation plume thermal emission and density, and photodoppler velocimetry (PDV) for surface velocity. For NIF-DLI experiments, we utilized post-mortem techniques such as optical and line profilometry and scanning electron microscopy (SEM) to study damage due to laser impulse. This work elucidated the mechanisms driving pressure enhancement in tamped ablation and defined the limitations of this enhancement as a function of intensity, pulse duration, and wavelength. Our results demonstrate tamping's influence over the entire laser-material interaction, resulting in at least a tenfold increase in surface velocity for tamped targets, indicating a significant enhancement in energy coupling and laser impulse. The experimental data correlate well with modeling predictions for aluminum and titanium ablators, confirming the achievement of higher pressures using tampers.
The project or effort depicted was or is sponsored by the Department of War, Defense Threat Reduction Agency under the MSEE URA, HDTRA1-20-2-0001. This work was supported by the U.S. DOE Office of Science, Fusion Energy Sciences under Field Work Proposal No. SCW1836-1: LaserNetUS: Discovery Science and Inertial Fusion Energy research at the Jupiter Laser Facility, and Lawrence Livermore National Laboratory, under Contract No. DE-AC52-07NA27344.

Abstract 147 at 2:00 PM

Session CA-AR-08 Wednesday 1:30 PM - 332

Impact of Ion Implantation of Bolometric Properties of VOx Films.

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Vanadium Oxide (VO_X) films are commonly used as sensing membrane material in uncooled microbolometers. This is because of their high sensitivity to temperature and low 1/f noise signal. This work reports the changes to the VO_X film electrical properties following ion implantation. The ion of choice, fluence, and accelerating voltage were varied to assess their impact on the VO_X films temperature coefficient of resistivity (TCR) and 1/f noise. The films were implanted with carbon, boron, or tungsten, at either 1% or 10% fluence. The accelerating voltages were selected to ensure the ions penetrated into the bulk of the film, determined by simulations in SRIM. At a fluence of 10%, for all ions, the damage to the films structure from the aggressive nature of implantation largely increased the films 1/f noise signal, negatively impacting its bolometric properties. Implantations of boron and carbon at 1% provided no significant change to any of the film's properties. The 1% tungsten implantation yielded favorable results, showing an increase in TCR and a reduction in 1/f noise. The increase in TCR with lowered film resistivity and reduced noise is possibly due to modification of the relative concentrations of mixed vanadium oxide phases.

Abstract 97 at 2:15 PM — Session CA-AR-08 Wednesday 1:30 PM - 332

Dynamic, Temperature Dependent Radiation Induced Conductivity Analysis of Dielectric Materials

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In harsh space or artificial environments, insulating materials can accumulate charge gradually, often reaching a high enough internal electric field to induce arcing. Subjected to incident radiation, the conductivity of the disordered insulating materials can increase multiple orders of magnitude as energy is transferred through inelastic collisions to the electrons within the trapped states and valence bands, exciting some of the charge carriers into the conduction band. The equilibrium value from this process of radiation induced conductivity (RIC) is proportional to the incident dose rate via the Rose/Fowler/Vissenberg power law equation, $\boldsymbol{\sigma_{RIC}(D,T)=k_{RIC}(T)D^{\Delta(T)}}$, where $\boldsymbol{\sigma_{RIC}}$ is the additional conductivity from radiation $(\Omega\text{-cm})^{-1}$, **D** is the dose rate (rad/s), **T** is the temperature (K), while $\boldsymbol{k_{RIC}}$ (s/rad-Ω-cm) and **Δ** (unitless) are material dependent parameters that can vary with temperature and dose rate. RIC results are often listed exclusively in terms of the equilibrium values (in the form of $\boldsymbol{k_{RIC}}$ and **Δ)**; however, RIC does not reach equilibrium instantaneously, often taking an hour or longer to stay static. Once the dose rate is ceased, the residual RIC is non-negligible for hours to days, known as delayed RIC (DRIC). Dynamic RIC data presented in this study were acquired at the Idaho Accelerator Center's using a 2 MeV to 25 MeV High-Repetition Rate Linear Accelerator (LINAC) operating at 4 MeV as the radiation source for all the analyzed materials. The samples were exposed to successive constant dose rate pulses over ~30 min minutes and then allowed to relax over similar time periods before the next higher dose rate pulse was applied. The five insulating polymeric materials studied are polytetrafluoroethylene (PTFE or Teflon™), ethylene-tetrafluoroethylene (ETFE or Tefzel™), Low Density Polyethylene (LDPE), and two polyimide samples (PI or Kapton HN™ and Kapton E™). Data were acquired over a temperature range of 103 K to 333 K (±3K), held constant for each run. Samples were placed between two electrodes in a parallel plate geometry with a constant voltage applied. Presented will be two models for fitting the finite processes of RIC and DRIC, both of which estimate RIC with an exponential rise and DRIC with a hyperbolic decay. The dynamic RIC results were analyzed separately for every single dose cycle, yielding fitting parameters for different dose rates. The most complex dual defect model incorporates seven fitting parameters for each dose cycle: $\boldsymbol{\sigma_{RIC}}$ at asymptotic equilibrium; two time constants and $\boldsymbol{F_{rise}}$ for rising RIC; and two time constants and $\boldsymbol{F_{DRIC}}$ for DRIC. This model uses two independent fast and slow rise and decay time constants. The fast time constants can be attributed to "shallow traps" with trap energy distributions near the conduction band edge which retain trap charge carriers for shorter times. Likewise, longer time constants can be attributed to "deep traps" with trap energy distributions further below the conduction band edge which retain trap charge carriers for longer times. $\boldsymbol{F_{Rise}}$ and $\boldsymbol{F_{DRIC}}$ are the relative fractions of fast traps for rising and decaying RIC, respectively. The simplified model assumes the rise and decay models each have only one time constant. The first model uses two time constants for a more accurate fit, while the second model uses one time constant for an approximate time scale of RIC/DRIC for the material at that temperature and dose rate. The results for the five materials will be compared. The discussion will include the effects of radiation dose rate, temperature, and material on the time constant and defect occupation fitting parameters through the fit to the experimental data. These will be related to our interpretation of the fitting parameters in terms of the spatial and energy densities of defect states and their time-dependent occupation.

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Instrumentation for Radiation Induced (RIC) and Constant Voltage (CVC) Conductivity Measurements

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In extreme environments such as those found in accelerators, fusion/fission reactors, and space, radiation induced conductivity (RIC) and dark current conductivity are important charge dissipation mechanisms for insulating materials. As such materials are exposed to ionizing radiation, inelastic scattering transfers energy to trapped electrons without charge deposition. This can excite electrons into the conduction band which can result in conductivities that are several orders of magnitude greater than the baseline dark conductivity of the insulating material. Equilibrium RIC is reached after prolonged exposure to an incident dose rate and follows a standard theoretical model proposed by Rose/Fowler/Vissenberg in which equilibrium RIC follows a power law model and contains material parameters that are dependent on both temperature and dose rate. RIC displays a time-dependent rise (an exponential increase) and decay (an inverse hyperbolic decrease, termed delayed RIC or DRIC) in conductivity before and after equilibrium in response to the onset and cessation of radiation, respectively. The Materials Physics Group at Utah State University has developed an ultrahigh vacuum chamber designed to specifically study these dose rate-, temperature-, and time-dependencies of RIC and dark conductivity. The set up uses an electron beam from an 80 keV electron gun to generate continuous (not pulsed) penetrating electron radiation capable of dose rates ranging between 0.1 mGy/s - 1 Gy/s. Samples of ~ 3 cm^2 are in-line with this well-characterized radiation beam, mounted on custom test fixture structured in a parallel-plate configuration. The fixture allows for **in situ** dose rate calibration and real-time monitoring by measuring the axial current transmitted through the sample and electrodes. The samples are thin films (≤ 50 μm) onto which guarded conducting electrodes are vapor deposited (≤ 200 nm). The voltage across the sample is provided by a very stable current DC battery power supply (~ 450 V). The noise threshold for current measurements is <1 fA. This sets lower limits of measurable dark conductivity and RIC of $\leq 10^{-20}$ $(\Omega\text{-cm})^{-1}$. RIC data from this set-up is comparable to data previously acquired by the Materials Physics Group at the Idaho Acceleration Center (IAC) user facility using a 4 Mev pulsed LINAC beam. The new RIC/CVC system provides several advantages when compared to previous IAC efforts. These included: (i) unrestricted data acquisition time and greatly reduced operating costs, (ii) reduced current and conductivity measurement thresholds, (iii) greatly reduced ambient current noise over the accelerator hall environment with resulting higher precision and accuracy conductivity measurements, (iv) decreased data acquisition intervals and increased temporal resolution for dynamic CVC and RIC measurements, (v) extended and refined temperature control, and (vi) reduced sample areal size. The higher IAC electron source did allow experiments to be conducted on >10X thicker samples. The initiation of RIC experiments requires that the sample has reached equilibrium conductivity under the applied voltage. The establishment of the baseline equilibrium required for RIC is the same set up for a constant voltage conductivity (CVC) experiment—traditionally used to determine equilibrium dark current conductivity values needed to calculate and model internal charge storage and transport. Hence, in addition to RIC, this instrumentation also provides CVC data. Temperature control is implemented by mounting the test fixture on a closed-cycle He cryostat which allows for experiments to be conducted within the temperature range of <130 K to >300 K. Both dynamic CVC and RIC data can be acquired in two complimentary modes measuring current under fixed applied voltage: (i) at a fixed temperature over time as dose rate is zero (CVC) or varied (RIC) and (ii) at a fixed dose rate (incident beam current) as the temperature is decreased or increased. This chamber will allow for the acquisition of a robust database of dose rate-, temperature-, and time-dependent RIC and constant voltage conductivity data for diverse highly insulating materials. This addresses a current critical need as such data is scarce in the literature.

The work of Jenny R. Whiteley was supported in part by the Utah NASA Space Grant Graduate Fellowship and the work of Tyler Heggenes was supported by funding from a NASA Space Technology Research Fellowship.

Abstract 155 at 2:45 PM Session CA-AR-08 Wednesday 1:30 PM - 332

Engineering Amorphous Vanadium Oxide Thin Films for Infrared Radiation Detection through Control of Growth Conditions

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Amorphous vanadium oxide (VO_x) thin films were deposited on Si/SiO_2 substrates by direct current magnetron sputtering. In this work, we demonstrate strong correlations among film resistivity, temperature coefficient of resistance (TCR), electrical 1/f noise, and the oxygen concentration in the working gas. Structural, morphological, and compositional characterization was performed to elucidate the evolution of film properties as a function of deposition conditions. The results reveal strong correlations between processing parameters and electrical performance, with optimized VO_x films exhibiting enhanced TCR and reduced electrical noise. VO_x films grown with an SiO_x cap layer are thermally more stable as validated by reproducible electrical behavior.

Abstract 171 at 1:30 PM

Session CA-AS-02 Wednesday 1:30 PM - 314B/C

A Laser-Plasma-Accelerator-Driven Pump-Probe Platform for Time-Resolved Studies of Transient Defects in Scintillators

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Scintillation mechanisms in inorganic scintillators are understood to proceed through a cascade of transient defect states, self-trapped holes, self-trapped excitons, and free electron-hole plasma that form and interact on femtosecond-to-picosecond timescales. The kinetics of these defects are believed to underlie key limitations on scintillator performance, including high-density quenching, nonproportionality of light yield with deposited energy, and the resulting ceiling on achievable energy resolution. Directly resolving how these transient species are created and how their dynamics differ across host materials would help identify which microscopic processes actually govern macroscopic scintillator function, information that is largely inaccessible with existing measurement approaches.

We are developing a pump-probe experiment designed to access this regime directly, using a laser-plasma accelerator (LPA) to generate Inverse Compton Scattering gamma-ray pulses that excite scintillator samples, followed by a femtosecond white-light-continuum probe to track the resulting transient absorption dynamics. The central advantage of this approach is timing: because the gamma pump and optical probe are derived from the same laser system, they are synchronized to roughly 30 fs, a precision that is effectively unreachable with stochastic radioisotope sources and, to our knowledge, has not been demonstrated with conventional accelerator-based gamma sources. This gives access to the earliest stages of defect formation, before recombination and trapping processes obscure the initial dynamics. Beyond the scintillator physics, we see this measurement as a demonstration of the growing maturity of LPA technology as a compact, table-top alternative to conventional accelerator facilities for radiation-matter interaction studies.

We report on the current status of this experimental campaign. A prototype version of the pump-probe setup has been built and validated using a non-scintillating reference sample under conventional 400 nm photoexcitation: we reproduced literature transient absorption spectra, kinetic traces, and decay times, confirming that our probe chain and analysis pipeline correctly capture known ultrafast dynamics. This validation step established the baseline sensitivity and time resolution of the detection system ahead of integrating the LPA-driven gamma pump at BELLA Center.

We will discuss the design and validation of this platform, the challenges specific to coupling an LPA gamma source to an ultrafast optical probe, including shot-to-shot pointing and energy stability, gamma-probe temporal overlap, and extracting weak transient signals against source-driven background, and present preliminary results from the measurement campaign.

Abstract 75 at 2:00 PM

Session CA-AS-02 Wednesday 1:30 PM - 314B/C

Characterization of Proton and Ion Quenching in GAGG:Ce Crystals

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Charged particles within the earth's magnetosphere can have significant effects on equipment and infrastructure. The charged particle flux in orbit can be measured with scintillation detectors; however, quenching effects significantly reduce light output, so precise measurements of detector response are required to accurately reconstruct incident spectra for space weather models. Cerium-doped Gadolinium Aluminum Gallium Garnet (GAGG:Ce) is a recently developed scintillator that is well-suited for high rate measurements in the space environment. In this talk, we will present results from recent experiments at Texas A&M University and Los Alamos National Laboratory utilizing elastic scattering and nucleon transfer reactions to measure proton response across a broad range of energies, which can be used to predict on-orbit performance. The proton response data will be compared to that of other ions in GAGG:Ce in the framework of different quenching models.

Abstract 106 at 2:20 PM Session CA-AS-02 Wednesday 1:30 PM - 314B/C

Compact neutron source and high throughput detector for portable active interrogation missions

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LLNL is developing a new portable, short-pulse neutron source and compact, high-throughput detector that together enable new active interrogation systems for deployment in the field. The source is a compact dense plasma focus, a pulsed-power driven fusion device capable of generating bursts of neutrons 10^6 to 10^9 only 100 ns long depending on system size. This is much shorter than typical handheld accelerators which and several orders of magnitude higher instantaneous flux. A new, high throughput detector is being developed in concert with the source featuring a segmented scintillator and silicon photomultiplier SiPM board that when tiled, can process hundreds of millions of events per second. The bright, short, neutron pulse and high throughput detector can be paired for a variety of new activation capabilities. Neutron interrogation setups and missions enabled by this new pairing will be presented.
Prepared by LLNL under Contract DE-AC52-07NA27344. Supported by the Laboratory Directed Research and Development program 24-FS-039 and 25-ERD-031

Abstract 42 at 2:40 PM Session CA-AS-02 Wednesday 1:30 PM - 314B/C

A Portable SSA-Driven Linac for Radiography

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Portable radiography is a critical capability for defense and national security, enabling nondestructive inspection of suspicious packages, vehicles, and cargo in constrained environments. Conventional radiography sources are often limited by size, cost, and logistical burden. DC x-ray tubes require increasingly large high-voltage supplies and insulation systems to achieve higher endpoint energies, while betatrons rely on large magnet assemblies and complex pulsed power supplies. In contrast, a solid-state-driven RF linac offers a more compact, modular form factor and power architecture. We report progress on a compact, solid-state-driven RF electron linac intended as a scalable, portable source for radiography applications.
The prototype is designed to accelerate electrons to 50 keV using a four-cell standing-wave X-band structure, with each cell independently powered by a 100 W solid-state RF amplifier, eliminating the need for a single high-power RF source. We will present the beamline and RF design, an overview of the solid-state source architecture, beam dynamics simulation results, and initial cavity measurements. Future iterations will leverage this modular design to scale toward a compact accelerator capable of producing electron energies up to 1 MeV over a 1-meter structure, enabling higher-penetration radiographic imaging relevant to defense and security.

Abstract 56 at 1:30 PM   Session WT-WT-03 Wednesday 1:30 PM - 339

Tracing Ionization-Driven Aion Void Lattice Self-Organization in CaF_2 by In Situ Electron Irradiation

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Energetic-particle irradiation drives materials far from thermodynamic equilibrium through the continuous production, migration, interaction, and annihilation of defects. Although defect accumulation and degradation of crystallinity are common outcomes, irradiation-induced defects can also self-organize into ordered nanoscale structures. Void superlattices (VSLs), gas-bubble superlattices, ordered defect clusters, and compositional patterns have been reported under neutron, ion, and electron irradiation across different crystal structures and bonding types. Their broad occurrence suggests that defect ordering is a recurring response of irradiated solids, yet no single formation mechanism has achieved consensus. A complete description must account for both a characteristic length scale and crystallographic symmetry. Instability-based models describe wavelength selection, whereas kinetic-anisotropy models propose that direction-dependent self-interstitial atom (SIA) transport contributes to symmetry selection through anisotropic recombination and defect-cluster survival. Electron irradiation of ionic materials provides an underexplored test of this framework. Unlike the cascade-dominated damage commonly considered for neutron- and ion-irradiated metals, electronic excitation and ionization can produce atomic rearrangement in ionic crystals. Calcium fluoride (CaF_2) is a model system because electron irradiation preferentially modifies the fluorine sublattice, producing a matrix-commensurate simple-cubic array of anion-deficient clusters. However, whether these sites are empty cavities or calcium-containing anion-deficient regions, and how displaced fluorine contributes to ordering, remain unresolved.

Here, we traced the formation of ionization-driven anion VSLs formation in CaF_2 using spatially confined in situ electron irradiation combined with diffraction-correlated TEM and STEM imaging, energy-dispersive X-ray spectroscopy (EDS), and low-dose electron energy-loss spectroscopy (EELS). CaF_2 lamellae were irradiated near room temperature at 60, 200, and 300 kV. Confining the beam to a defined region enabled examination of the irradiated core, boundary, and adjacent unirradiated matrix. Across all accelerating voltages, the anion-defect population evolved from random nucleation to a simple-cubic ordered state and, at high fluence, to degradation of the ordered structure. At comparable electron fluence, microstructural evolution was more advanced at lower accelerating voltage. Together with calculated ionization cross sections and electronic stopping powers, this inverse-voltage dependence supports ionization-driven radiolysis as the predominant defect-production pathway under the investigated conditions, although a ballistic contribution cannot be excluded.

Multimodal elemental analysis showed fluorine depletion at ordered sites while the calcium distribution remained comparatively uniform, supporting their identification as calcium-containing, anion-deficient regions rather than empty cavities. Outside the irradiated region, {111} and in-plane {110} dislocation loops exhibited fluorine enrichment by low-dose EELS, consistent with outward migration and aggregation of displaced fluorine. Time-resolved in situ TEM further captured mobile defect clusters moving away from the irradiation boundary along projected trajectories consistent with ⟨110⟩ directions. Although a single projection cannot uniquely resolve the three-dimensional migration vector, the combined chemical, spatial, and dynamic evidence supports anisotropic fluorine-interstitial transport.

The combined structural, chemical, spatial, and dynamic observations support a model in which preferentially displaced fluorine interstitials migrate anisotropically and modify the local vacancy-interstitial recombination field, while electrons may become trapped at anion-vacancy sites. These results provide experimental support for anisotropic SIA diffusion as a potential symmetry-selection mechanism during anion void superlattice formation in electron-irradiated CaF_2. More broadly, this work extends the investigation of irradiation-induced defect self-organization from predominantly ballistic metallic systems to an ionization-dominated ionic material.

Abstract 55 at 1:45 PM   Session WT-WT-03 Wednesday 1:30 PM - 339

Intermittent 3D Reconstruction in In-Situ Irradiation TEM experiments: Toward Unified Spatial-Temporal Characterization of Defect Evolution

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In situ TEM provides a powerful window into irradiation-induced defect dynamics, revealing nucleation, migration, and interaction processes in real time. Yet, conventional manual analysis has long struggled to handle the full volume and complexity of these data-rich experiments. Recent advances in machine learning (ML) now enable automated, real-time detection and tracking of defects, significantly reducing human effort while pushing the temporal resolution higher. These developments also enable the recovery of depth information at high temporal rates (<1 s) when combined with high-speed imaging. By leveraging these advances, we establish a unified framework that connects dynamic imaging with depth recovery - transforming two-dimensional projections into time-resolved volumetric insight.
Building on this foundation, we introduce the Small-Tilt Automated Reconstruction (STAR) workflow. STAR integrates state-of-the-art YOLO-based detection and tracking models for real-time defect identification and trajectory analysis, coupling continuous 2D imaging with brief, small-tilt stereo acquisitions to add a depth dimension to dynamic observation. While real-time 3D reconstruction is the ultimate goal, our current implementation inserts rapid "3D checkpoints" to recover depth, examine defect habit planes, and resolve interactions while preserving continuous 2D imaging. The reconstruction capability continues to advance: a built-in stereoscopy model already supports real-time operation, and ongoing tests with smaller multi-view reconstruction further enhance depth accuracy and flexibility. This intermittent mode does not yet fully capture transient 3D events but provides robust, fast depth insight that strengthens the interpretation of dynamic 2D data and lays the foundation for true real-time stereo operation.
The workflow is demonstrated for Ni, Ni-5Cr, and Ni-15Cr alloys under identical ion irradiation conditions. Continuous 2D imaging provides quantitative defect statistics and dynamics, while brief tilt excursions less than 5° generate stereo pairs that reconstruct their spatial distribution, relative depth, geometric relationships, and free-surface effects. These 3D checkpoints complement the 2D data by validating observed trends and revealing depth-related features previously hidden in projection, connecting past 2D findings to a more complete three-dimensional understanding.
This study establishes STAR as a practical workflow for multidimensional in situ microscopy, bridging the time-resolved 2D view and an emerging 3D capability that unifies temporal and spatial perspectives into a single framework. The intermittent-tilt design demonstrates a scalable path toward real-time, spatially resolved observation and future adaptive operation, advancing STAR toward fully automated 4D characterization of radiation damage.

Abstract 165 at 2:00 PM Session WT-WT-03 Wednesday 1:30 PM - 339

Installation of an in situ Ion Gun on a JEOL JEM-2100 Plus for Dual-Beam Transmission Electron Microscopy at the Tennessee Ion Beam Materials Laboratory

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Materials for fusion reactors, advanced fission systems, and hypersonic vehicles must perform under some of the most extreme environments such as particle bombardment, high temperature, mechanical stress, and reactive environments. A material's deformation under such extremes must be studied to predict its response and lifetime behavior; post-irradiation examination captures the end state of that degradation but not the path to it. Cascade formation, defect clustering, and loop growth happen in fractions of a second, and they set component lifetime. In situ ion irradiation transmission electron microscopy (TEM) records these processes at the atomic scale as they occur. This work presents the design, installation, and commissioning of an ion gun on the TEM at the Tennessee Ion Beam Materials Laboratory (TIBML) at the University of Tennessee, Knoxville, converting the instrument into a dual-beam platform for simultaneous ion irradiation and real-time imaging.
The base instrument is a modified JEOL JEM-2100 Plus operating between 80 and 200 kV with a point resolution of 0.25 nm and a lattice resolution of 0.14 nm. A high-tilt configuration permits ±81 degrees for tomographic techniques. An added C0 condenser lens pushes extra illumination through thick samples. A Gatan ClearView camera records up to 200 frames per second at 4k resolution, fast enough to catch rapid defect processes, and automated crystal orientation mapping (ACOM) resolves phase and orientation in irradiated regions. A set of in situ holders extends the accessible conditions: a Bruker/Hysitron PI-95 picoindenter performs nanoindentation, pillar compression, tensile, fatigue, and creep testing with micronewton force resolution; a Protochips Poseidon AX liquid cell supports electrochemistry and corrosion; a Waviks gas injection system supplies reactive atmospheres including oxygen, steam, and hydrogen; and a 20 W, 1064 nm laser provides ultra-high heating rates at the sample.
For in situ coupled irradiation experiments, the ion beam enters through customized ports machined into the microscope column. A dedicated 20 kV ion gun was installed and coupled to the TEM in July 2025. The compact beamline delivers low-energy ions directly to the sample position for in situ irradiation and implantation, with a mixing magnet steering the beam into the column. A beam profile monitor and Faraday cup handle beam characterization and dosimetry. An

electrically isolated section with bellows decouples the line mechanically and permits current measurement, and dedicated turbomolecular pumping protects the column vacuum. This work walks through the practical engineering and capabilities available by mating an ion gun to a commercial TEM: port geometry, beam alignment to the sample position at high tilt, vacuum management, and dose quantification, along with first commissioning results.
The dual-beam system keeps the full holder suite available during irradiation, which enables researchers to combine ion damage with laser heating, quantitative mechanical loading, or a controlled gas or liquid environment in a single experiment. This brings experimental conditions close to what a plasma-facing component or material used in hypersonic flight sees in service.

Abstract 53 at 2:15 PM Session WT-WT-03 Wednesday 1:30 PM - 339

Towards a Deployable Automated In Situ TEM Drift Correction and 3D Reconstruction System

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In situ TEM ion irradiations enable the study of defect formation, migration, phase transformations, and grain-boundary evolution in real time, but generate immense amounts of data, posing unique challenges for high-temporal-fidelity analysis. In addition to large amounts of data, artifacts from the experiment, such as mechanical or thermal stage drift, must be considered and corrected. Machine learning (ML) has proven useful for accelerated and automated image and video analysis, but to date has only been used sparingly for robust off- and on-microscope drift correction. By using ML tracking with Ultralytics' YOLO model and the Trackpy algorithm to calculate visual drift, experimental drift can be corrected in complex visual experiments. Unlike keypoint-based stabilization methods that require a stable, unchanging reference feature, the ML-based approach can estimate drift from rapidly evolving features within the experimental field of view. The efficacy of ML-enabled drift correction is exemplified in two cases with different conditions: (i) a low-feature case on precipitates in CNA9 steel and (ii) a high-feature case of dislocation loops in titanium. These test cases represent the state of the art for in situ TEM ion irradiation and post-irradiation annealing experiments, respectively. In the CNA9 dataset, which primarily contains immobile MX-TiC nanoprecipitates, after correction the average standard deviation for each unique feature was reduced from 4.5 nm to 1.1 nm in the X-direction and 5.2 nm to 0.9 nm in the Y-direction, single-frame corrections were successfully corrected by up to 22.9 nm in either direction. Successfully stabilizing the videos from these experiments allows precipitate evolution and loop dislocation motion to be studied in closer detail, without the drift visual noise and the subsequent manual effort to correct it. In addition, since the pipeline performs per-feature identification and tracking over the full temporal range, per-frame feature analysis is also generated, enabling high-fidelity spatiotemporal data to be extracted and studied. To bring ML-enabled drift correction and other useful techniques, such as real-time 3D reconstruction for in situ TEM; a workflow is being developed for closed-loop TEM automation, analysis, and feedback control. The feedback loop will leverage Gatan's capabilities for TEM control via Python scripting and combine them with ML inference to enable the microscope to receive real-time commands based on experimental conditions. Additionally, by incorporating ML into the workflow, the experiment's analysis can be displayed in real time, allowing users to observe emerging trends during acquisition rather than waiting for post-experiment processing. This presentation will showcase the results of ML-based drift correction and discuss the current progress towards an automated TEM workflow for closed-loop acquisition, analysis, and reconstruction.

Abstract 54 at 2:30 PM Session WT-WT-03 Wednesday 1:30 PM - 339

Precipitate dissolution in advanced RAFM steel recorded during in situ TEM dark-field heavy-ion irradiation

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High-temperature creep is predicted to be the life-limiting factor for structural steel in a commercial fusion reactor. Castable Nanostructured Alloys (CNAs) are advanced reduced-activation ferritic martensitic steels processed to achieve a high density (>10^{22} m^{-3}) of small (<15 nm) and dispersed MX-type TiC precipitates, which have been shown to improve long-term high-temperature strength at fusion-relevant temperatures. Although MX-TiC precipitates are crucial in limiting thermal creep, the mechanisms for their stability under irradiation are not well understood. Conventional ex situ ion irradiations show near-complete dissolution of these precipitates between 15 and 50 displacements per atom (dpa), but experiments at these discrete damage levels cannot capture the dynamic evolution of precipitates. Continuous monitoring of precipitate dissolution under irradiation to the same final dose of 50 dpa, assessed via ex situ irradiation, is possible using in situ transmission electron microscopy (TEM) with heavy-ion irradiation.
We show precipitate dissolution under in situ irradiation conducted at 100°C increments between 100 and 500°C using dark-field imaging conditions. The MX-type precipitates, where M is a metallic element such as titanium and X is carbon or nitrogen, obey an orientation relationship with the matrix, such that they can be observed during irradiation under strong darkfield imaging conditions near the [100] zone axis with g = 002. The use of a custom heating double-tilt goniometer during in situ irradiation enables characterization of the temperature-dependent evolution of precipitates. Irradiation at 100, 200, and 300°C continued until significant dissolution was observed by darkfield (DF) TEM, yielding final doses of 33, 20, and 50 dpa, respectively. Additionally, we conducted three irradiations to final doses of 15 dpa at temperatures of 300, 400, and 500°C.
Irradiation at 100°C showed the most dynamic response, with more subtle changes during irradiation at 200 °C and above 300°C. In situ TEM recordings show precipitates undergoing any combination of gradual dissolution, "fracturing" (e.g., rapid contrast splitting), and/or reprecipitation, as evidenced by contrast appearance. Precipitate dissolution is cross-referenced with conventional ex situ ion beam irradiation using scanning transmission electron microscopy (STEM) with energy dispersive X-ray spectroscopy (EDS) chemical analysis. Post-irradiation precipitates are still visible under darkfield TEM and STEM-EDS across all in situ irradiation conditions. For 15 dpa irradiations at 300, 400, and 500°C, the post-irradiation precipitate size distribution of in situ samples measured using STEM-EDS is compared with ex situ irradiated specimen at the same dose and temperatures. The difference in precipitate density between the two irradiation techniques increased from 300°C up to 500°C, with the in situ samples having a lower precipitate density for all temperatures at 15 dpa. The highest density of MX-TiC between in situ and ex situ conditions was at 500°C, with 14.2 ± 1.0 and $17.3 \pm 2.7 \times 10^{20}$ m^{-3} for in situ and ex situ irradiated samples, respectively.
Precipitate stability up to 50 dpa during in situ irradiation at 300°C exceeds that seen with ex situ techniques. Moreover, fracturing and abrupt dissolution of small precipitates are not well described by existing theory, which predicts gradual changes to the average population, underscoring the potential for in situ TEM to refine existing theories on precipitate stability under displacement damage. Rapid changes in size revealed by DF-TEM suggest that collision cascades directly incident on MX-TiC precipitates may play a significant role in controlling precipitate dissolution, especially for small-sized (<10 nm) precipitates. Differences in precipitate stability among experimental techniques will be discussed, considering the different heavy-ion species used for irradiation and the enhanced surface-defect sink effects observed when irradiating a thin-film specimen.

Abstract 168 at 2:45 PM Session WT-WT-03 Wednesday 1:30 PM - 339

Design and Development of the Tennessee Ion In Situ Scanning Electron Microscope

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The Tennessee Ion Beam Materials Laboratory (TIBML) at the University of Tennessee, Knoxville is developing an in situ ion irradiation scanning electron microscope to observe microstructural evolution as it occurs rather than infer it afterward. The initial goals are irradiation-induced blistering, grain growth, crystallization, and radiation-induced segregation. Each is dynamic and path-dependent: blisters nucleate, grow, and rupture over a dose history no post-irradiation image can recover; grain growth and crystallization depend on incubation dose and local temperature; segregation evolves continuously with dose and dose rate. Real-time imaging gives direct access to the kinetics and to the transient states that govern them.
The microscope, a JEOL JSM-IT710HR field emission SEM, was delivered in July 2026 and installed on the -45° beamline of our 300 kV ion implanter. We kept the beamline short to reduce cost and to make efficient use of the available floor space. Several components were repurposed from a tandem beamline being reconfigured for another use. The beam is shaped and diagnosed with a set of four-jaw slits, which define a rectangular beam of adjustable size. Reading the current through each jaw with a picoammeter serves as the primary alignment tool. A beam profile monitor, Faraday cup, and raster scanner, with gate valves and bellows at both ends of the line, complete the beamline. If space allows, a small intermediate

chamber built from a DN100CF six-way cross will be added midway along the line, carrying its own turbomolecular pump, Faraday cup, and sample holder for high-dose irradiations that do not require imaging.
Integration with the microscope requires several custom solutions. The beam enters through the WDS port, which sits at 45° to both the sample and the ground plane, so a custom adapter is being designed to bring the implanter beam onto the sample at the correct angle. The port height also required raising the microscope to the beamline elevation. To minimize cost and time, a wooden stand was built to both raise the SEM and damp vibrations.
The short beamline is a deliberate trade, and it places the microscope close to the implanter high voltage deck. Room-level vibration is already visible at high magnification, and starting the deck generators produces noise, vibration, and possible electromagnetic interference with a qualitatively noticeable effect on image quality. Characterization of these effects is underway. If they prove significant, the microscope can be moved to the -15° beamline, at the cost of a substantially longer beamline requiring a neutral beam deflector, quadrupole, and more floor space.
The WDS adapter is also being designed to admit a second beam. A 5 kV Nonsequitur Technology ion gun is already in hand and a 20 kV model is on order; either would enter parallel to the WDS axis while the implanter beam enters parallel to the ground plane, bringing two ion beams and the electron beam to a common focal point for dual-ion irradiation under continuous observation.
We present the beamline and mechanical design, the integration challenges specific to coupling an ion beamline to a commercial SEM, and the results of the vibration and interference characterization.

Abstract 186 at 3:00 PM Session WT-WT-03 Wednesday 1:30 PM - 339

Discussion of the Future of TEM and Coupled Ion Accelerators

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This will be an open discussion of the future direction of the TEM focused work and couple it with ion accelerators. It will be started with a presentation by Lewys Jones discussing some recent advancements in TEM capabilities and will be followed by an open discussion on how these might impact the development of TEMs with in-situ irradiation capabilities.

Abstract 111 at 3:30 PM Session CA-AN-06 Wednesday 3:30 PM - 382A

TexNAAM: Texas NaI(Tl) Array for Astrophysical Measurements

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The Texas NaI(Tl) Array for Astrophysical Measurements (TexNAAM) is a new experimental setup at Texas A&M. TexNAAM is designed to study α-transfer reactions at sub-Coulomb energies in inverse kinematics using the rare-isotope beams produced at the Cyclotron Institute. These reactions provide a powerful tool to determine the Asymptotic Normalization Coefficients (ANCs) of sub-threshold states in nuclei important for astrophysics. TexNAAM is made of 16 NaI(Tl) detectors of dimensions 4"x2"x16" coupled to photo-multiplier tubes. In a typical TexNAAM experiment, a rare-isotope beam impinges on a light-isotope target, thick enough to stop the beam. A Si detector or a Si-detector telescope placed after the target detects the light particles ejected, whereas the NaI(Tl) detectors detect the γ rays.
We characterized the response of the TexNAAM array using the γ-sources ^{137}Cs, ^{22}Na, and ^{60}Co. We also performed a benchmark experiment measuring the beta decay of an ^{11}Be beam implanted in the Silicon detector. The results of the source tests and the measurement of the ^{11}Be beta-decay will be presented and compared with Geant4 simulations.
The goal of our first experimental campaign is to constrain the capture cross section for the ^{15}O(α,γ)^{19}Ne reaction. This reaction is significant for understanding the behavior of type 1 X-ray bursts (XRBs). Constraints on the ^{15}O alpha-capture reaction can be obtained indirectly via alpha-transfer reactions such as ^{15}O(^{6}Li, d)^{19}Ne to determine the alpha-Asymptotic Normalization Coefficients (α-ANCs) of the states in ^{19}Ne that contribute to the α-capture reaction rate in ^{15}O.

In our first experiment, we measured the alpha-transfer reaction $^{15}N(^{6}Li,d)^{19}F$; preliminary results will be presented. We plan to determine the α-ANCs of the mirror states in ^{19}F corresponding to the states in ^{19}Ne that contribute to the α-capture reaction.

Abstract 70 at 3:45 PM

Session CA-AN-06 Wednesday 3:30 PM - 382A

Design and Testing of Magnetic Analyzers for X-Pinch Accelerated Electron and Ion Beams

Aspen Wagner[1], Logan Friedrichsen[2], Richard Kraus[1], Eric Dutra[2], Alexey Astonovitsky[1], Benny Bach[1], Piotr Wiewior[2], Aaron Covington[1], Jeremy Iratcabal[1]

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Energetic electron and ion beams drive various phenomena of interest in pulsed power experiments. Measurements of short pulse, high dose MeV photons show the viability of X-pinch accelerated electron beams to produce intense bremsstrahlung bursts. Similarly, neutron energy anisotropy in deuterium gas puff experiments suggests that beam-target interactions drive a significant portion of overall D-D fusion neutron yield. To investigate both processes, as well as to gain further understanding of X-pinch plasmas, a robust measurement of the energy spectra of both beams is required. Therefore, two magnetic analyzers have been designed and tested to simultaneously measure the energy spectra of electron and ion beams generated at the Zebra pulsed power accelerator at the University of Nevada, Reno. The 180 degree electron spectrometer faces a substantial X-ray background. To mitigate this, a modified method of image plate scanning, staged beam collimation, and a novel process for obtaining image plate energy response have been implemented. Due to engineering constraints, the ion spectrometer was built into the pulsed power driver cathode and utilizes thin films to filter different ion species. Preliminary experimental results will be presented in support of research efforts into fundamental Z-pinch plasma physics and high-intensity radiographic source development.

Abstract 17 at 4:00 PM

Session CA-AN-06 Wednesday 3:30 PM - 382A

Characterization of Forward-directed Neutrons from the Inverse-Kinematics $^{1}H(^{7}Li,n)^{7}Be$ Reaction for the development of a Lithium-Beam-Driven Neutron Source

Toshiro Sakabe[1], Madhawa Horana Gamage[1], Shunsuke Ikeda[1], Takeshi Kanesue[1], Antonino Cannavo[1], kazumasa Takahashi[2], Masahiro Okamura[1]

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Accelerator-based neutron sources are increasingly important for detector calibration, nuclear-data measurements, materials irradiation, isotope production, fusion research, and medical applications such as boron neutron capture therapy. Many conventional proton- or deuteron-driven sources emit neutrons over relatively broad angular ranges; consequently, only a limited fraction of the produced neutrons contributes to the usable flux at an irradiation position, and substantial collimation and shielding may be required. In inverse kinematics, a heavy-ion beam impinges on a light target. For the $^{1}H(^{7}Li,n)^{7}Be$ reaction, the forward motion of the center-of-mass system kinematically enhances neutron emission in the beam direction, while the neutron energy can be tailored through the lithium-beam energy, target thickness, and observation angle. Building on our previous studies of lithium-beam acceleration and Monte Carlo modeling of this reaction, we are experimentally characterizing the neutron field produced by the inverse-kinematics reaction.
The present study conducted experiments at the Brookhaven National Laboratory Tandem Van de Graaff facility using $^{7}Li^{3+}$ beams with energies of 16.5, 20.0, 30.0, and 39.0 MeV incident on a 12-µm-thick polypropylene target. An EJ-301 liquid scintillator, a chemical-vapor deposition diamond detector, and a moderated BF_3 counter were used for complementary measurements of the angular dependence, neutron-energy characteristics, and relative neutron and gamma-ray contributions. Pulse-shape discrimination (PSD) in the liquid scintillator was used to separate neutron- and gamma-ray-induced events. Since the lithium beam passed through the thin target, aluminum and tantalum beam dumps were also compared to assess secondary radiation generated by interactions of the transmitted beam.
The measurements showed enhanced neutron emission in the forward direction, and the spectral features observed with the liquid scintillator and diamond detector were consistent with reaction-kinematics calculations. Under the tested beam and

geometrical conditions, the tantalum beam dump produced lower measured secondary-radiation levels than the aluminum dump, indicating that beam-dump material selection is an important consideration in radiation-field optimization. These results support the feasibility of the inverse-kinematics $^{1}H(^{7}Li,n)^{7}Be$ reaction as the basis of a tunable, forward-directed neutron source. Detailed PSD results, neutron angular distribution, neutron-energy estimation, and their implications for future experimental and radiation-field optimization will be presented at the conference.

Abstract 50 at 4:15 PM

Session CA-AN-06 Wednesday 3:30 PM - 382A

Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Intense Charge-Neutralized Ion Beam Development

Kelly Wood, Carlos Ordonez, Duncan Weathers

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The Cool Fusion Research Facility is being developed to detect low-energy unconventional nuclear fusion reactions by directing an intense ion beam onto a cooled target. The reaction signal grows with the ion current delivered to the target, but conventional beams are limited by their own space charge. This limit can be overcome through charge neutralization. The beam space charge can be compensated by a confined electron plasma, so the attainable ion density is limited by electrical breakdown at the surrounding wall rather than by the space-charge limit. We model the transverse equilibrium of such a beam as a two-species, edge-confined non-neutral plasma in cylindrical geometry. The electrons produce an electric field that confines a drifting ion population, which travels along a neutralized core. Because the field falls off across the vacuum gap between the plasma and the wall, the system size and the plasma-to-wall gap are design variables that determine the wall field for a given beam density. We examine how large an ion density is attainable as a function of the wall-field breakdown ceiling, subject also to electron confinement. This identifies the beam and geometry parameters that give the largest ion density that the electrical breakdown limit of the surrounding wall allows.

Abstract 89 at 4:30 PM

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Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Charged Particle Diagnostics and Coincidence Measurements

Luke P Claycomb, Daniel K Brown, Duncan L Weathers, Carlos A Ordonez

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The cool fusion research facility is currently under development at UNT for the purpose of studying unconventional nuclear fusion reactions at low energies. An experiment has already been performed in which a deuterium beam with energies up to 50 keV was directed toward a deuterium implanted palladium target. Conventional deuterium-deuterium (D-D) reaction channels have been detected using a silicon charged particle detector and a helium-3 neutron detector. A new experimental setup is intended to allow for the detection of unconventional D-D reaction channels. The new setup includes a silicon transmission detector placed in front of a BGO scintillation detector. Coincidence measurements will be performed for the detection of high energy electrons which may be associated with D-D fusion reactions. With the addition of a coincidence detection system, rates for unconventional reaction channels can be compared to conventional reaction channels, and a branching ratio for D-D nuclear reactions can be obtained.

Abstract 64 at 4:45 PM

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Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Neutron Diagnostics and Target-Temperature Control

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In UNT's Ion Beam Laboratory (IBL) a new accelerator end-station has been commissioned for the observation of unconventional nuclear fusion reaction channels. These reactions occur at relatively low energy, with deuterium-deuterium (D-D) channels currently being studied. A target of deuterium-implanted palladium foil with a copper backing was used with a deuteron beam with energies less than 50 KeV. Preliminary experiments suggest that a temperature-controlled target is necessary to carry out experiments at higher beam currents. Experiments even at lower beam energies will see a benefit, as the deuterium is more readily trapped in a lower temperature foil. A temperature control and monitoring subsystem has been added. In this new subsystem, the target is cooled via water cooling, the target temperature is monitored with an infrared detector, and the target mount temperature is monitored with a thermocouple. We will describe the utility of our diagnostics, such as a neutron detector to explore unconventional channels of D-D reactions. The addition of these subsystems allow the construction of a more comprehensive picture of the behavior of nuclear fusion reaction channels, and the temperature control and monitoring subsystem will allow for additional control of relevant experimental parameters.

Abstract 180 at 3:30 PM — Session CA-AR-09 Wednesday 3:30 PM - 332

The Silicon Color Center Zoo and its Applications to Quantum Information Processing

Cody Fan[1], Murat Can Sarihan[1], Jiahui Huang[1], Avik Pamarthi[1], Jin Ho Kang[1], Alex Giovannone[2,6], Juan Gaitan[2,6], Wei-Hsu Lin[2,6], Pathorn Teptarakulkarn[3,4], Kai-chi Chang[1], Kemal Enes Aykuz[1], Khalifa Azizur-Rahman[1,7], Wei Liu[1], Andrew Lin[1], Baolai Liang[1], Jaya Nolt[5], Nikolay Agladze[2,6], Hannah Shafaat[3,4], Mark Sherwin[2,6], Chee Wei Wong[1]

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Many protocols in quantum communication and computation require high fidelity quantum memory for repeater nodes that extend the distance of entanglement distribution through entanglement swapping (1)In addition, for distributed and modular quantum computing, quantum transduction becomes a key protocol to allow for the coupling of quantum systems of different modalities and frequencies (2)For these tasks, silicon color centers have emerged as a promising platform due to their optical transitions in the near infrared telecom bands and spin degrees of freedom that allow for them to couple to microwave photons under a Zeeman splitting (3)This talk will be discussing mainly the X-center, L-center, and Cu* center in silicon, which have emission wavelengths of 1192 nm,1235 nm, and 1312 nm respectively and different properties of these color centers relevant for their application in quantum information processing [4, 5, 6, 7].

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Abstract 96 at 4:00 PM Session CA-AR-09 Wednesday 3:30 PM - 332

Mechanical Properties of Low-Energy Electron-Irradiated Graphene: Modeling the Two-Stage Response Using a Local Defect Activation Model

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Graphene is routinely exposed to low-energy electron beams during imaging, characterization, and nanofabrication, yet their effects on its mechanical properties remain poorly understood. Here, we investigate suspended monolayer graphene under 1.5 keV electron irradiation using atomic force microscopy (AFM) nanoindentation and Raman spectroscopy. Graphene drums suspended over ~4 µm circular cavities were irradiated under ultrahigh vacuum at fluences from 1×10^{16} to 6×10^{16} electrons/cm². The two-dimensional Young's modulus, pretension, and fracture properties were obtained from force-deflection measurements using a nonlinear membrane model. The Young's modulus exhibited a two-stage response, increasing by approximately 40% at low fluence before decreasing at higher fluence. This trend closely followed the Raman $\mathbf{I_D/I_G}$ ratio, which increased, reached a maximum, and then decreased with decreasing mean defect spacing. To explain this behavior, a local defect activation-type model was developed in which defects generate localized regions with distinct elastic moduli. The effective modulus was calculated using the inverse rule of mixtures and showed excellent agreement with the experimental data. In contrast, the fracture force decreased monotonically in both irradiation stages, indicating that defective regions act as mechanically weak sites. Post-fracture AFM images showed tears extending to the drum boundaries along preferred crystallographic directions, suggesting that the underlying $\mathbf{sp^2}$ lattice remained largely intact. Annealing at 250 °C substantially reduced the Raman defect signal and partially restored the mechanical properties. These results demonstrate that low-energy electron irradiation provides a controllable route for tuning graphene's mechanical response. This work was supported by NSF Grant No. DMR-2312436.

Abstract 49 at 4:15 PM Session CA-AR-09 Wednesday 3:30 PM - 332

Scanning Tunneling Microscopy of Hydrogenated Highly Oriented Pyrolytic Graphite After Electron Irradiation in Ultra High Vacuum

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Hydrogen is an appealing source of green energy. The largest obstacle to the adoption of hydrogen as a source of energy is the difficulty of storing large quantities under normal conditions. The ability to hydrogenate HOPG and graphene provides an appealing avenue for hydrogen storage under normal atmospheric conditions. There is significant indirect evidence for the ability to hydrogenate HOPG and graphene via electron irradiation. In particular electron irradiated graphene has shown to be well modeled by the Local Defect Activation model and shows healing after annealing. This study will use scanning tunneling microscopy to show the presence of hydrogen on HOPG after electron irradiation and healing after annealing. HOPG was exposed to water vapor at approximately 25 Torr for 8-12 hours. The HOPG was then irradiated in UHV with doses ranging from $1\text{x}10^{16}$ e/cm^2 to $1\text{x}10^{17}$ e/cm^2 using a 1.5keV electron beam. STM was then used to image the HOPG. Point defects were observed with diameter of approximately 2nm. The density of states was also measured showing an increase in occupied states above the Fermi level. The HOPG was then annealed at 250C in a dry Nitrogen atmosphere for 15 minutes. Imaging after annealing shows significant healing of the HOPG. The presence of point defects and ability to heal those defects through annealing provide strong direct evidence of hydrogenation. The ability to hydrogenate HOPG in this manner provides confidence that graphene is also hydrogenated through electron irradiation. This work is supported by National Science Foundation grant number DMR-2312436.

Abstract 91 at 4:30 PM Session CA-AR-09 Wednesday 3:30 PM - 332

Ambient-Air Electron Irradiation as a Simple Route for Defect Engineering and Surface Functionalization of Graphene for Functional Device Applications

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There have been many studies on graphene due to its superior electrical conductance, high charge carrier mobility, mechanical strength, and high specific surface area. However, the non-existence of the band gap and the chemical inertness of the pristine form of graphene have made the use of this material in the fabrication of semiconductor devices, chemical sensors, and functionalized nanomaterials difficult. Defect engineering has become an efficient approach for the tailoring of the structure and properties of graphene. Electron irradiation has become one of the most popular approaches since it is not only precise but also chemical-free and maskless. Though there are many studies on electron irradiation in vacuum about graphene modification, not much is known about electron irradiation in air, despite the fact that oxygen and water vapor are important for the process.

This study involved irradiating graphene in the presence of air with 20 keV electron beam at a fluence of 5.4×10^{16} e^-/cm^{-2}. The presence of structural disorders and chemical evolution due to electron irradiation was studied with the help of Raman and X-ray photoelectron spectroscopies (XPS) including C 1s and C KLL Auger electron spectroscopic analyses. Raman spectroscopy indicates that defect density has significantly increased as a result of electron irradiation. The irradiated graphene shows an I_D/I_G ratio of 1.15, indicating substantial disruption of the graphitic lattice and activation of defect-induced scattering. An $I_D/I_{D'}$ ratio of 8.03 confirms that defects are sp^3 type, which supports the conclusion about the chemical functionalization.

The transformations of graphene surface during electron irradiation are confirmed by chemical changes observed through XPS. High-resolution C 1s spectra shows a decrease in sp^2 carbon in return for an increase in sp^3-hybridized carbon and oxygen-containing functional groups. Peak fitting shows that approximately 77% of the carbon atoms are in sp^3-hybridized state following irradiation, possibly due to the hydrogenation of graphene. The emergence of additional components corresponding to C-O and C=O suggests that oxidation occurred simultaneously with defects creation during electron irradiation in ambient air. The generation of sp^3(C-H) and oxygen-rich groups is due to interaction of defects created by irradiation with reactive oxygen species coming from atmospheric water vapor and molecular oxygen.

The change of hybridization in carbon is corroborated by C KLL Auger analysis. The measured D parameter value drops to 15.1 eV indicating a considerable decrease of sp^2 character of graphene and proof of significant rehybridization to the sp^3-dominated carbon network. The consistency of results obtained from Raman, C 1s XPS and C KLL Auger spectroscopies demonstrates the fact that electron irradiation in atmospheric conditions introduces structural disorder and profound chemical transformations such as hydrogenation and Oxidation.

These findings show that electron irradiation under atmospheric conditions can be an efficient technique to manipulate the structure and chemistry of graphene via defect creation and surface functionalization simultaneously. The combination of Raman and XPS studies have provided clear proof for the transformation of sp^2 carbon in graphite to sp^3(C-H) carbon in a functionalized network. This technique may lead to a straightforward approach for designing graphene for application in chemical/biological sensors, nanoelectronics, catalytic support, energy storage materials, and surface-functionalized carbon based devices. This research work is supported by the national science fundation (NSF) - (DMR-2312436)

Abstract 46 at 4:45 PM

Session CA-AR-09 Wednesday 3:30 PM - 332

Low-Energy Electron Irradiation Effects in Polycrystalline Chemical Vapor Deposition Graphene Under Ultra-High Vacuum

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Electron irradiation effects on graphene have been extensively studied, with most investigations focusing on monocrystalline exfoliated graphene irradiated in scanning electron microscopes (SEMs). However, practical applications, including electronic device fabrication, predominantly rely on polycrystalline chemical vapor deposition (CVD) graphene. The grain boundaries and crystallographic misorientation inherent to CVD graphene may alter its response to electron irradiation, making direct comparisons with exfoliated graphene uncertain. Furthermore, many previous SEM studies have reported the formation of electron-beam-induced surface contamination films that obscure the intrinsic effects of irradiation. To eliminate this complication, we perform electron irradiation under ultra-high vacuum (UHV) conditions with a base pressure of approximately $5\text{x}10^{-10}$ torr, enabling the investigation of irradiation-induced modifications in the absence of significant surface contamination. This approach also provides insight into the behavior of graphene in vacuum environments relevant to space applications.

In this work, CVD graphene is irradiated with low-energy electrons, approximately 1.5 keV, at fluences ranging from $2x10^{16}$ to $1x10^{17}$ electrons/cm². Raman spectroscopy is used to evaluate irradiation-induced structural changes and to determine whether the two-stage defect model, originally developed for exfoliated graphene, is applicable to polycrystalline CVD graphene. We find that the model accurately describes CVD graphene, with the I_D/I_G ratio exhibiting the characteristic two-stage evolution as defect density increases with electron fluence. Surface chemical and structural modifications are characterized using x-ray photoelectron spectroscopy (XPS), x-ray excited Auger electron spectroscopy (XAES), and Arrhenius analysis. Unlike previous SEM-based studies, UHV irradiation results in a narrowing of the XPS C 1s peak rather than broadening, indicating the absence of detectable surface contamination. XAES measurements show that the D-parameter decreases with increasing fluence to approximately 15.7, corresponding to an increase in the sp^3 fraction to about 66%. Arrhenius analysis yields an activation energy of approximately 0.2 eV, consistent with defect formation through hydrogenation. These results demonstrate that UHV electron irradiation enables the intrinsic evolution of defects in CVD graphene to be studied without contamination artifacts, providing a fundamental foundation for sample modification and controlled defect engineering for graphene-based technologies intended for space environments.

Abstract 18 at 3:30 PM   Session CA-AS-05 Wednesday 3:30 PM - 314B/C

Steri-Tek - Who We Are, What We Do, and How We can Help

Hannah Busard, Bradley Ross, Sandra Ramirez, Afeefa Haji, Johnathan Henkel, Brian Potts, Gustavo H.C Varca

Radiation Services, Steri-Tek, Lewisville Texas, United States

Steri-Tek is a contract-service provider that operates two world class linear electron beam accelerators from Mevex. Offering both variable power - 30, 50, and 80 kW - and energies - 5.8, 7.5 and 10 MeV - and operating in dual beam mode, we are able to offer a plethora of services for the industry. In addition, we can provide X-ray irradiation at scale using a tantalum target and bremsstrahlung effects, while operating at 7.5 MeV and 80 kW of electron beam power. Our LINAC system can reach not only ultra-low doses with our lowest dose hitting 0.8 kGy, but a near limitless upper range as well. Amongst diverse market segments, we service the medical device industry by sterilizing bandages, catheters, IV bags, to complex surgical tools in the clinical research and trial phase, tissue allografts, and ultra-dense "hard to clean" products. We work closely with 503A and 503B compounding pharmacies for both bio-reduction and terminal sterilization. We also offer bio-reduction services, crosslinking, chain scission, and gemstone enrichment among other features. Steri-Tek is the only irradiation provider cleared to handle and store DEA Schedule II to Schedule V medications. Using an under-beam conveyor and a proprietary tote system, we are equipped to handle any volume, from a single product to multiple pallets. We offer a range of processing conditions; ultra-freezer (-80°C to -40°C), freezer (-26°C to 16°C), refrigeration (2°C to 8°C), and ambient (20°C to 25°C). This allows for Steri-Tek to work with more sensitive and fragile products, vaccine development, and food products. This presentation aims to show real-life scenarios of the radiation processing industry.

Abstract 117 at 3:52 PM   Session CA-AS-05 Wednesday 3:30 PM - 314B/C

Accelerator-Based Irradiation as a Response to Rising Foodborne Illness: Engineering Advancements That Safely Support Pathogen Control

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The past year has underscored the persistent vulnerability of the U.S. food supply to pathogen contamination. A 2026 Cyclospora outbreak linked to fresh produce has affected nearly every state, alongside separate Salmonella outbreaks tied to dietary supplements and poultry. Both are reminders that foodborne illness remains a significant and recurring public health burden, particularly for young children and immunocompromised individuals. Electron accelerator-based irradiation is an FDA-approved, non-chemical technology capable of inactivating Cyclospora, Salmonella, and other pathogens without the drawbacks of chemical fumigants or thermal processing, yet broader adoption has lagged behind its demonstrated safety and efficacy.

Electron accelerators neutralize pathogens by delivering a controlled dose of ionizing radiation that damages microbial DNA beyond the point of repair, reducing pathogen levels exponentially without altering the treated product itself.

Advancements in the ability to design and deploy systems across a range of energies (roughly 1-10 MeV) and power levels (1-25+ kW) is what makes this technology adaptable to such a broad set of applications: lower-energy systems suit thinner or surface-level treatment, while higher energies provide the penetration depth needed for denser or bulk-packaged goods. Higher power levels, in turn, increase throughput for high-volume commercial processing. This flexibility allows accelerator platforms to be tailored to the specific density, geometry, and throughput demands of a given product line, rather than forcing a one-size-fits-all treatment approach.
Recent engineering advances aimed at expanding the practical footprint of accelerator-based processing for food safety support turnkey and mobile processing configurations, while a maturing regulatory certification pathway enables faster deployment of new systems across new markets.
As outbreaks continue to expose gaps in current pathogen-control practices, this talk argues that accelerator technology — paired with a clearer regulatory and engineering pathway to deployment — represents an available, underutilized tool for strengthening food safety and security going forward.

Abstract 48 at 4:14 PM Session CA-AS-05 Wednesday 3:30 PM - 314B/C

An Integrated Database and AI Expert for Radiation Compatibility of Medical Device Polymers

Yelin Ni, Md Kamrul Hasan, Ian P Finley, Leonard S Fifield

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The availability, safety, and throughput constraints associated with cobalt-60 gamma irradiation are of increasing interest in electron-beam (e-beam) and X-ray technologies for sterilization of polymer-containing medical devices. Direct comparisons and mechanistic studies have been performed on radiation-induced changes in polymer properties affected by material formulation, radiation modality, absorbed dose, dose rate, atmosphere, temperature, and test method. However, relevant evidence is dispersed across scientific publications, project reports, and experimental files, often in heterogeneous formats that are difficult to search, compare, and reuse. This fragmentation limits efficient interpretation of polymer compatibility and complicates assessment of alternative radiation technologies.
This work presents the development an AI-enabled polymer effects expert to organize and provide traceable access to evidence concerning the effects of ionizing radiation on polymers. The current work integrates two complementary capabilities. First, experimental data from the ongoing Team Nablo projects are being assembled in a structured SQLite database. The database captures materials, sample geometries, sample sources, irradiation conditions, experimental methods, and measured material properties. Current data ingestion includes studies of medical-device materials in the format of extruded samples (such as dogbones) or disassembled product components (such as tubing), as well as investigations on various radiation conditions including dose, dose rate, temperature and oxygen concentration. A local Dash-based visualization application enables users to select available polymer datasets, examine relationships between irradiation conditions and material properties, and download plotted raw data as CSV files.
Second, a conversational polymer expert prototype is being developed with a Chainlit interface, LangChain and LangGraph workflows, and a retrieval-augmented generation (RAG) pipeline using a vectorized document of considerations for transitioning between sterilization methods. The prototype retrieves relevant source text and returns references for questions concerning polymer and sterilization-method compatibility. The agent architecture is being extended to query the Nablo experimental-data database through a read-only Model Context Protocol (MCP) service with tools supporting data filtering, generation of scatter plots, CSV export, and provenance-rich results. Query interpretation will convert natural-language requests into proposed filters that require user confirmation before data retrieval and plotting.
This integrated approach is intended to make heterogeneous polymer-radiation evidence more accessible to non-expert users while preserving links to underlying text, measurements, and experimental conditions. Ongoing work will expand data ingestion, add guardrails to retrieval, and build tools for statistical comparisons between radiation sources, regression analysis of material properties with respect to radiation conditions, radiation-physics-based modeling, and evaluation of AI-generated answers by quantitative accuracy, completeness, and retrieval-groundedness metrics. The resulting framework is expected to make polymer-radiation data more available and accessible, and to support evidence-based assessment of polymer performance under gamma, e-beam, and X-ray irradiation.

Abstract 60 at 4:36 PM Session CA-AS-05 Wednesday 3:30 PM - 314B/C

Material Compatibility and Functional Performance of Greiner Bio-One Blood Collection Tubes Following Gamma, Electron Beam, and X-ray Sterilization

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Consideration of alternatives to radioisotope-based cobalt-60 gamma sterilization, including electron beam (e-beam) and X-ray irradiation accelerator-based technologies, requires comparative data to ensure the material compatibility and functional performance of medical devices. This study evaluated the effects of gamma, e-beam, and X-ray irradiation (25, 50, and 75 kGy) on Greiner Bio-One blood collection tubes by assessing their material compatibility and functional performance. Material characterization included color stability (ASTM E313 and ASTM D2244), hardness (ASTM D2240), and thermal properties (ASTM D3418), while functional performance was evaluated according to ISO 6710 through draw-volume, leak resistance, and centrifuge integrity testing. Radiation-induced color changes were component-dependent, with the paper label exhibiting the greatest yellowing, followed by the gel/polyethylene terephthalate (PET) region and PET tube, whereas the polyethylene cap showed minimal color change. Gamma irradiation generally produced greater yellowing than e-beam or X-ray for the paper label and gel/PET region, with statistically significant differences observed for selected color metrics. In contrast, the thermal and mechanical properties of the polymeric components exhibited minimal changes following irradiation. Functional testing demonstrated that draw volumes for all irradiated tubes maintained were within ISO 6710 acceptance limits, with no leakage, cracking, breakage, or centrifuge-related failures. Although statistically significant differences were observed for selected color metrics and draw volumes, all irradiated products satisfied ISO 6710 performance requirements, indicating that the observed differences were not functionally significant. Overall, gamma, e-beam, and X-ray radiation processing preserved the material integrity and functional performance of Greiner Bio-One blood collection tubes. These findings provide comparative data supporting the adoption of accelerator-based sterilization as a practical alternative to conventional gamma processing for blood collection devices.

Abstract 32 Poster Poster Sessions

Compositional Depth Analysis of Gallium Oxide Films Grown by Chemical Vapor Deposition on Gallium Arsenide Substrates Using Ion Beam Techniques

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Ultrawide bandgap semiconductors, particularly β-gallium oxide (β-Ga_2O_3) with a bandgap of 4.7-4.9 eV and a stable monoclinic phase, are promising candidates for next-generation power devices and gate dielectrics in III-V heterostructures. They offer superior breakdown voltage, temperature tolerance, and switching performance compared to traditional silicon, gallium nitride (GaN), and silicon carbide (SiC). This study combines chemical vapor deposition with Rutherford Backscattering Spectrometry (RBS) and Particle-Induced X-ray Emission (PIXE) for compositional depth profiling, along with X-ray Diffraction (XRD) and profilometry to enhance sensitivity. RBS confirmed film thicknesses of 100 to 122 nm with low oxygen flow achieving desired stoichiometry. PIXE indicated high purity, non-uniform growth, and gold diffusion. XRD confirmed β-Ga_2O_3 and GaAs phases, showcasing ion beam analysis effectiveness for evaluating heterostructure interfaces and emphasizing β-Ga_2O_3 thin films' promise for high-performance electronics.

Abstract 66 Poster Poster Sessions

Simulation-Based Dynamic Surface Evolution and Degrader-Derived Contamination During Ion Implantation Through Thin Energy-Degrading Foils

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Thin foil energy degraders are commonly used to tailor ion implantation depth profiles when direct control of beam energy is limited. Existing simulation frameworks accurately describe ion energy loss and scattering through degrader foils but typically treat the target as a static medium. In this work, an established degrader-foil implantation model is extended to include dynamic surface evolution and contamination originating from atoms sputtered from the degrader foil. The enhanced simulation is validated by reproducing published implantation depth profiles while maintaining agreement with corresponding EBS measurements. The model is then applied to silicon implanted with oxygen and platinum ions transmitted through aluminum and carbon degrader foils. Results show that light-ion implantation produces minimal surface modification, whereas heavy-ion implantation causes substantial surface evolution driven by sputtering, redeposition, and degrader-derived contamination. The improved framework provides a complete description of degrader-assisted ion implantation and identifies implantation regimes where surface evolution cannot be neglected.

Abstract 11 Poster Poster Sessions

Test Facility of Compact Nuclear Microprobe. Numerical Experiment.

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The concept of a compact nuclear microprobe based on an immersion probe-forming system (1,2) is considered. In this concept, an electrostatic accelerator tube is incorporated into the probe formation process, and mass analysis is performed downstream of the ion source at low beam energy. This concept allows to significant decrease in the size of the microprobe to a few meters, to reduce the energy consumption and to improve the resolution. A 100 kV test facility is proposed to develop then a full-scale compact nuclear microprobe with MeV energy. A low-power RF ion source with a micrometer extractor (3,4) is considered as an ion source of the compact microprobe for producing a proton beam. The source has high current stability (<1%), an energy spread of <10 eV, and an extractor aperture diameter of 50 μm, which allows for obtaining a proton current about 10 nA and has a brightness 240 $Am^{-2}sr^{-1}V^{-1}$. The ion injector of the microprobe consists of a low-power RF ion source, a compact Wien filter with permanent magnets, and an Einzel lens with an electrostatic quadrupole stigmator to correct the position of beam x-y crossovers in one plane. The beam crossover formed by the injector is used as a virtual object to form a microbeam on the target. The numerical experiment based on the measured characteristics of ion source was carried out to get all parameters of physical existing systems and resolution of microprobe test facility. A numerical simulation of beam optics was performed to obtain the ion-optical characteristics of the probe-forming system (demagnifications and all aberrations up to the third order). The simulation was performed using the PROBFORM (5) numerical code, based on the matrizant method developed by A. Dymnikov. The implementation of the proposed compact nuclear microprobe concept is expected to take the form of a test facility to verify the results of numerical experiment. The test facility is consisted of an ion injector, an accelerator structure in the form of a triplet of standard sections of the NEC accelerator tube, the developed electrostatic scanner, an integrated doublet of magnetic quadrupole lenses (6) and a target chamber. The results of the numerical experiment: the demagnifications of the immersion probe-forming system is $D_x \times D_y = (-47) \times (-6)$, the resolution is $0.5 \times 1.8\ \mu m^2$ with the proton current is 140 pA and the working distance is 5 cm. The length of the compact nuclear microprobe test facility is 2.3 m with the distance measured from the ion source to the target.

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Abstract 57 Poster [Poster Sessions]

Research of Gas Insulation of Electrostatic Accelerator

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The report discusses methods for monitoring the gas insulation of high- and ultra-high-voltage installations, using a 2 MV electrostatic accelerator (ESA) as an example. Dependencies of operating voltage on gas pressure, gas mass spectra, and voltage-current characteristics (VAC) of the gas-insulated measuring gap were obtained for the "Sokol" ESA at the IAP NASU. The proposed VAC method was verified.
Employing the suggested techniques enables:
 measuring the dielectric strength of gas insulation with sufficient accuracy due to direct measurements that eliminate the influence of extraneous factors.
 ensuring low cost and ease of operation by performing measurements with the accelerator turned off.
 ensuring equipment safety (during possible breakdowns of the measuring gap, negligible energy is released).

Abstract 69 Poster [Poster Sessions]

LCW Flow Induced Vibration on ALS-U 4th Generation Synchrotron Storage Ring Magnets and Beam Position Monitors

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The Advanced Light Source Upgrade Project (ALS-U) will deliver a coherent beam that is 100x brighter than the existing ALS. Critical to the success of this project is the vibrational stability of the Storage Ring Magnets and Beamline Position Monitors (BPMs). Studies of the vibration of test articles due to seismic disturbance demonstrate that SR Magnets meet the <200 nm requirements along the beamline direction and <35 nm requirements in both transverse directions under seismic conditions (1)Additional disturbances and mitigations of flow induced vibration from the low conductivity water (LCW) system which internally cools the magnet coils and BPMs are presented in this paper. This work focuses on the effect various supports mounting and dissipative schemes of the LCW system to the SR Raft has on the overall performance of the magnets and BPMs.
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Abstract 105 Poster [Poster Sessions]

Update on the Performance of an Accelerator-Based BNCT Cancer Treatment Facility

Mark Harrison, Alex Dunaevsky, Vlad Vekselman, Kirill Martianov, Anatoly Muchnikov, Alex Makarov, Ken Franzen

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A Neutron Beam System (NBS) has been installed at the Xiamen Humanity Hospital in Xiamen, China. It is an accelerator-based implementation of the Boron-Neutron Capture Therapy (BNCT) that has been used to treat more than 50 cancer patients since its installation in October 2023. It has cleared Phase I and is beginning Phase II clinical trials. The accelerator uses an electrostatic accelerator with a charge exchange target (CXT) for simplicity and robustness when delivering the 2.35 MeV 10-mA beam to the lithium target. The beam uptime during the Phase I and Phase II trials has been better than

96%. The beam parameters have been consistent throughout the trials and other experiments to better than 2%. Initial information regarding the construction of a second BNCT facility at CNAO in Italy will also be presented.

Abstract 116 Poster

Poster Sessions

LONG-TERM STABILITY MAGNET FOR ELECTROSTATIC ACCELERATOR X-RAY SUPPRESSION SYSTEM

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Currently, to reduce X-ray radiation from the accelerating tube of the "Sokol" electrostatic accelerator at the Institute of Applied Physics of the National Academy of Sciences of Ukraine, a magnetic system consisting of permanent magnets [1-2] has been used for 18 years.
Measurements of the magnetic field of a permanent magnet made using the rare earth alloy Nd-Fe-B were compared at an interval of 18 years. The 2025 data indicate that the magnet's metrological characteristics remained within the limits determined in the 2007 studies. Diffusion of Fe-Al-Nb with grain formation on the magnet surface was identified. The surface segregation time was 18 years. The grain composition was determined.

Abstract 158 Poster

Poster Sessions

Development of High and Low Temperature Dual-Beam Irradiation Capabilities at the Tennessee Ion Beam Materials Laboratory

Connor Cambria, Garrett Miller, Elijah M. Davis, Enzo Adorno, Micah Jones, Chun Yin (Tommy) Wong, Alexis Devitre, Khalid Hattar

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The Tennessee Ion Beam Materials Laboratory (TIBML) is in the process of developing dual-beam irradiation capabilities over a wide range of extreme temperatures to investigate irradiation damage in extreme environments from fusion energy to the vacuum of space. Following the installation of a 300 kV ion implanter, two of the existing 3 MV tandem accelerator beam lines and one future beamline are being coupled with the implanter to enable simultaneous irradiation with both heavy and light ions over a range of experimental conditions. The first of these that is incorporated is a liquid helium cryostat that has previously been shown to operate at temperatures as low as 30 K. This low temperature end station utilizes a six-axis sample manipulator coupled to an Advanced Research Systems 4 K cryostat, providing precise sample positioning and cryogenic temperature control for investigations of defect formation, migration, and damage accumulation under concurrent irradiation.

Complementing this capability, a high-temperature dual-beam end station is being developed to investigate irradiation effects under elevated-temperature conditions. The system incorporates laser-based heating using an IPG Photonics 400 W, 1070 nm laser with a 5 mm spot size, which is expected to heat materials that strongly absorb 1070 nm radiation to temperatures greater than 1000 °C. These end station developments will enable studies relevant to materials exposed to combined radiation and thermal extremes. Together, these complementary end stations expand the experimental capabilities of TIBML by enabling dual-beam irradiation across both cryogenic and high-temperature regimes. The development of these systems will provide a set of flexible platforms for investigating coupled temperature, implantation, and displacement-damage effects in materials relevant to nuclear energy, fusion, and other extreme-environment applications.

Abstract 28 Poster Poster Sessions

L X-ray production cross sections of Rh and Pd induced by $^{12}C^{3+}$ and $^{13}C^{3+}$ ions

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The L X-ray production cross sections of Rh and Pd induced by the impact of 1.6 MeV to 3.6 MeV $^{12}C^{3+}$ and $^{13}C^{3+}$ ions were determined. Thick targets of Rh and Pd were covered with Au thin films to integrate the total ion charge via ion backscattering and were irradiated with ion beams produced by the 1 MV Tandetron® accelerator at the Accelerator Mass Spectrometry Laboratory, Instituto de Física. The influence of different projectile masses on the productions of X-rays could be observed. When both isotopes have the same energy, cross sections are lower for ^{13}C ions than ^{12}C ions, because they penetrate the target atom inner shells less, thereby decreasing the ionization probability. However, when the data are plotted as a function of the reduced variable , which includes more details of collision such as the electron binding energy of the target atom and the projectile velocity, all cross sections seem to follow a single curve, consistent with previously published behaviors (1)The data were compared with the predictions of the Binary Encounter Approximation (BEA) [2], Semi-Classical Approximation (SCA) [3], Plane Wave Born Approximation (PWBA) [4], ECPSSR [5], and ECPSSR-United Atom [6] theoretical models. Better agreement was found with ECPSSR. Moreover, different databases of atomic parameters (fluorescence yields and Coster-Kronig transition probabilities) are compared and show no significant differences.

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Abstract 78 Poster Poster Sessions

Cool Fusion Research Facility for Accelerator Studies of Low Energy Unconventional Nuclear Fusion Reactions - Overview of Reactions To Be Studied

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A new experimental effort aims to study unconventional nuclear fusion reactions that have been reported for the first time relatively recently. Some examples include the following: A deuterium beam with an ion energy between 5 keV and 20 keV and that is incident on a deuterium-implanted zirconium target has been found experimentally to cause deuteron-deuteron fusion reactions that yield electron-positron pairs.[1] A deuterium beam with an ion energy as low as 500 eV and that is incident on a deuterated palladium target has been found experimentally to cause deuteron-deuteron fusion reactions that occur at rates much higher than expected.[2] A proton beam with an ion energy of 260 keV and that is incident on a deuterium-implanted graphite target has been found experimentally to cause a fusion reaction to occur between a proton and a deuteron that yields a He-3 nucleus and an energetic electron.[3] Many of the reactions that we will attempt to observe involve electron participation, and a categorization of such reactions will be presented.

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Abstract 84 Poster

Poster Sessions

Systematic studies to improve the experimental determination of helium 2P fine structure.

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Precision spectroscopy of the helium atom, particularly in the fine structure of the helium 2P triplet state, provides one of the most sensitive tests of the quantum electrodynamic description of the electron-electron interaction. Recent experimental efforts [1-3] help establish various precision experimental techniques and provide a benchmark for continuing advances in theoretical and computational atomic theory (4)Our approach uses laser excitation of 2S to 2P transitions in a room temperature metastable atomic helium beam. To obtain a reliable result with uncertainty comparable to the most accurate experiments (2 ppb or 60 Hz), a number of experimental tests and systematic studies are required. The most important of which involve magnetic field corrections, laser intensity control, laser and atomic beam alignment control, detection effects, and counting statistics. The accuracy of the magnetic field corrections has been studied and verified. Laser intensity control at the line splitting level of 1 part in 10,000 has been implemented and verified with several checks. Laser and atomic beam alignment sensitivity is studied with probe laser beams from both left and right sides of the atomic beam and studying the fine structure splitting as a function of alignment. The effects of transient changes in the detector efficiency with counts has been minimized and checked at the 1 part in 10,000 level. The data collection and status of these and other systematic studies will be described.

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Abstract 113 Poster

Poster Sessions

Using the AMOS Gateway for Low-Energy Electron-Helium Scattering

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For low-energy electron-helium scattering we employed the B-Spline Atomic R-Matrix (BSR) suite of codes on the Atomic, Molecular, and Optical Science Gateway (AMOS Gateway) [1] to compute the K-matrices for the first four partial waves and the summed elastic integrated cross section (2)We have studied the convergence of the K-matrices with respect to the number of states. We plan to compare the phase shifts from the computed K-matrices with those available in Refs. [3-5], and for the P-, D-, and F-wave with those from using the O'Malley **et al.** effective range theory expansion (6)Furthermore, we plan to show the elastic differential, elastic integrated, momentum transfer and viscosity cross sections that we compute. In addition, we plan to compare the elastic integrated cross section that we compute with the variational [3] and the R-matrix [7] results as well as comparing the momentum transfer cross section with the variational results [3].
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Tuning Superconductivity in FeTe Thin Films through Sulfur Ion Implantation

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Iron telluride (FeTe) is an iron chalcogenide material that is intrinsically non-superconducting but can exhibit superconductivity through chemical doping or structural modifications. However, the role of defects and disorder in controlling superconductivity in FeTe remains unclear. Ion implantation provides a controlled approach to introduce defects and modify the structural and electronic properties of thin films. In this work, sulfur ion implantation was performed on epitaxially grown FeTe thin films using the tandem Van de Graaff accelerator equipped with a Source of Negative Ions by Cesium Sputtering (SNICS) ion source at Western Michigan University. The pristine FeTe sample exhibits an antiferromagnetic (AFM) transition near 70 K with no evidence of superconductivity. Following sulfur implantation, the AFM transition remains but becomes broader, while low-temperature resistivity measurements indicate enhanced scattering associated with implantation-induced defects, consistent with X-ray diffraction measurements showing increased structural disorder. Although the as-implanted samples do not exhibit superconductivity, vacuum annealing at 100 °C for 2 hours induces superconductivity, suggesting that defect modification during annealing plays an important role in controlling the superconducting behavior of FeTe. These results demonstrate that accelerator-based ion implantation combined with controlled post-implantation annealing provides an effective approach for tuning superconducting properties in FeTe thin films.

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Microwave Properties of 3D Printed h-BN Foams for Satellite Communications using c-BN as a Pressureless Sintering Aid

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Boron nitride (BN) is an exceptional material for space applications due to its high resistance to radiation and ability to withstand radiation from gamma rays, electrons, and neutrons. Likewise, additive manufacturing technology has shown great promise for highly efficient materials use, rapid prototyping, and reduced product development times which, in turn, are expected to significantly lower manufacturing costs. However, hexagonal boron nitride has been a notoriously difficult to sinter material throughout its history due to its low self-diffusion and chemical inertness. In this study, the feasibility of producing a BN antenna operating in the 12–18 GHz Ku band for satellite communication using direct-write 3D printing was evaluated. Cubic boron nitride (c-BN) nanoparticles were shown to be an effective sintering aid for the pressureless sintering of additively manufactured hexagonal boron nitride (h-BN) foams printed using direct ink writing (DIW). This sintering process leverages the volume change caused by the phase transformation of c-BN to h-BN which reduces the unoccupied volume, enhances interparticle contact, and promotes necking between the nanoparticles utilized for the slurry design. The sintered foams exhibited **Q×f** values as high as 134,300 GHz, dielectric constants (**ε_r**) up to 3.50, and loss tangents (**tanδ**) as low as 4.63×10^{-4} at 15 GHz, demonstrating their suitability for high-performance microwave RF applications such as satellite communications operating in the 12–18 GHz Ku band. Excellent chemical stoichiometries with low carbon and oxygen residuals were achieved for samples sintered between 1700–2100°C. For samples sintered at 2100°C, bulk density increased to a maximum of 1.52 g/cm^3 while the open porosity reached a minimum of 31.4%. The thermal conductivities, densities, and hardness of the foams correlated well with the c-BN loading. By adjusting the ratio of h-BN to c-BN in the slurry, the RF properties and thermal conductivity can be tuned for device-specific needs. Using the printed BN foam, a proof-of-concept patch and lens antenna prototype was fabricated. The antenna prototype had a bandwidth of 9.1% (14.5–16.0 GHz), a peak gain of 12.4 dBi with the addition of the lens component, and a radiation efficiency of 95% between 15.0–16.5 GHz. These findings are promising for the development of 3D-printed boron nitride foams as a versatile next-generation RF material.

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Impact of thermomechanical processing on nanomechanical behavior in irradiated tungsten

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Tungsten is a leading candidate for plasma-facing components in fusion reactors due to its high melting point and temperature resistant properties. However, irradiation-induced hardening and embrittlement can significantly degrade its mechanical performance and limit its long-term application in fusion environments. Thermomechanical processing offers a potential approach to improving tungsten's mechanical properties and irradiation tolerance by modifying its grain structure and defect population. In this study, the nanomechanical behavior of unprocessed and hot-rolled tungsten was investigated before and after ion irradiation to evaluate the effects of processing and irradiation on mechanical performance. The materials tested were exposed to 5 MeV Ni^+ at 500 °C to a peak dose of 50 dpa, representing high-dose conditions relevant to the expected end-of-life exposure of plasma-facing components. Nanoindentation was used to characterize irradiation-induced hardening, while micro-cantilever bending was employed to evaluate fracture toughness at the microscale. These complementary techniques provide insight into both localized plastic deformation and resistance to fracture following irradiation. Comparisons between the unprocessed and hot-rolled conditions were used to assess the influence of thermomechanical processing on the mechanical response of tungsten and its susceptibility to irradiation-induced degradation. The results presented bring understanding to how thermomechanical processing can be used to improve the mechanical performance and irradiation tolerance of tungsten for future fusion energy applications.

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Modeling and Experimental Study of Irradiation of Prefabricated Silicon Nano-Tips and Analysis of Elemental distribution Using Atom Probe Tomography

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The study of the range and distribution of low-energy heavy ions implanted into curved-surface nanostructures, such as nanowires, is crucial for fabricating three-dimensional devices directly on these structures while minimizing processing steps. In this research, we report the distribution of 50 keV cobalt (Co) and iron (Fe) ions in silicon (Si) nanowires using a Monte Carlo-based ion-solid interaction simulation code called "Ion Range and Damage in Nanostructures" (Iradina). The three-dimensional target structure is incorporated at the beginning of the simulation.
We compared the simulation results with experimental data obtained through high-resolution atom probe tomography depth profiling of pre-fabricated conical Si nano-tips that mimic nanowires of various diameters. As predicted by the Iradina code, the distribution of the implanted ions in these nano-tips was not uniform and exhibited curved depth profiles. This study provides valuable information for optimizing ion irradiation experimental parameters, such as energy and fluence, to synthesize desired alloy structures in three-dimensional nanostructures.

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Charge-Referenced Analysis of Heavy-Ion Response in GaN MIS-HEMTs

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Gate-dielectric selection is a dominant lever for radiation hardness in GaN MIS-HEMTs, and radiation-induced threshold-voltage shift is the metric most commonly used to compare candidate films. That shift is trapped charge divided by oxide capacitance, $\Delta V_T = -QOT/C_{OX}$, so a comparison at fixed ΔV_T is not a comparison at fixed damage when the candidate films differ in permittivity. The dielectric field, set by the polarization-induced sheet charge, likewise scales inversely with permittivity.
We report an experimental comparison of PECVD SiN_X, ALD Al_2O_3, and ALD HfO_2 on identical GaN-on-Si epitaxy, irradiated with 1069 MeV ^{109}Ag at the Texas A&M K500 cyclotron under hard off-state bias with continuous in-situ terminal-current monitoring. Stress-only control devices were driven through the identical bias sequence outside the beam, separating radiation-induced from bias-stress degradation. Co-fabricated MIM capacitors provide C_{OX} independently of the transistor, and ellipsometry on co-deposited pilots provides film thickness, allowing ΔV_T to be converted to an areal trapped-charge density.
Referencing damage to charge changes the ordering of the three dielectrics and collapses transconductance degradation onto a single relation across all three films (pooled R^2 improving from 0.49 to 0.82). We further find that radiation-induced charge partially compensates bias-stress degradation of on-current, so on-state metrics alone can overstate radiation tolerance.

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Tuning the Carbon Bonding Configuration and Defect Density of Reduced Graphene Oxide Through Electron Irradiation and Thermal Annealing

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Reduced graphene oxide (rGO) is a versatile carbon-based material for energy storage, sensing, catalysis, and other advanced technologies, where its properties are strongly governed by its defect density and carbon bonding configuration. In this work, we investigate the controlled modification and thermal recovery of **sp**^{3}-related defects in rGO using electron irradiation followed by thermal annealing. Pristine rGO exhibited an initial **sp**^{3} carbon content of approximately 39%, as determined by X-ray photoelectron spectroscopy (XPS). Subsequent exposure to scanning electron microscope (SEM) irradiation at a fluence of 1×10^{17} e^-/cm^2 increased the **sp**^{3} content to 44%, indicating enhanced structural disorder. This evolution was corroborated by Raman spectroscopy, where the $\mathbf{I_D/I_G}$ ratio increased from 1.07 to 1.23. To evaluate the reversibility of these modifications, the irradiated samples were thermally annealed at 400 ^{0}C. Following annealing, the **sp**^{3} carbon content decreased to 41%, and the $\mathbf{I_D/I_G}$ ratio returned to 1.06, demonstrating substantial structural recovery. These findings demonstrate that electron irradiation paired with thermal treatment provides a controllable, two-step pathway for tuning the defect structure and bonding configuration of rGO, enabling tailored characteristics for electronic and catalytic applications. This research is funded by the National Science Foundation (NSF) under grant number DMR-2312436.

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Effects of Platinum Ion Implantation on the Structural, Optical, Morphological, and Interfacial Electrical Properties of TiO2 Compact Layers on FTO

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Titanium dioxide (TiO_2) compact layers are widely employed in dye-sensitized solar cells (DSSCs) to suppress charge recombination while facilitating electron transport between the photoanode and fluorine-doped tin oxide (FTO) substrate.

However, electrical resistance at the TiO_2/FTO interface can limit carrier extraction and reduce device performance. This work investigates platinum ion implantation as a potential method for modifying the electrical properties of TiO_2 compact layers deposited on FTO. Undoped TiO_2 films were fabricated by a sol-gel spin-coating process and characterized using profilometry, scanning electron microscopy, atomic force microscopy, X-ray diffraction, Raman spectroscopy, UV-Vis spectroscopy, and electrical measurements to establish baseline material properties. Platinum implantation was investigated computationally using SDTrimSP to predict implantation depth profiles, sputtering, and surface evolution for multiple implantation fluences. The simulated platinum distributions were incorporated into COMSOL Multiphysics to evaluate their influence on electrical conductivity and charge transport across the TiO_2/FTO interface. Simulation results predict controllable platinum incorporation within the compact layer and indicate that increasing platinum concentration may substantially reduce interfacial resistance through enhanced local conductivity. These findings provide a computational framework for selecting implantation conditions and establish a foundation for future experimental validation of Pt-implanted TiO_2 compact layers.

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Thank you for attending CAARI-SNEAP-WOTWISI 2026.

We are looking forward to seeing you again in 2028.