The Center for BRIGHTBEAMS

A NATIONAL SCIENCE FOUNDATION SCIENCE & TECHNOLOGY CENTER

NEWSLETTER 2024

The Beam Team Gathered at Cornell University for the 2024 Annual Meeting

Dear Friends of CBB,

Particle accelerators are a growth area. Today's electron beams probe material properties, produce x-rays and medical isotopes, probe elementary particles, and may be the future for waste treatment or semiconductor manufacturing. To deliver on this promise, the US needs more experts in accelerator science and technology.

At CBB, we are building the pipeline by engaging undergraduates in research and training more PhDs than any other U.S. program.

The field needs your help, too. Do you know a student considering their future? Tell them about accelerator science.

Ritchie

J. Ritchie Patterson
Director of the Center for Bright Beams

In This Issue

Editorial Team: J. Ritchie Patterson, Joan Curtiss, Lyanna (Xiangyu) Zhang

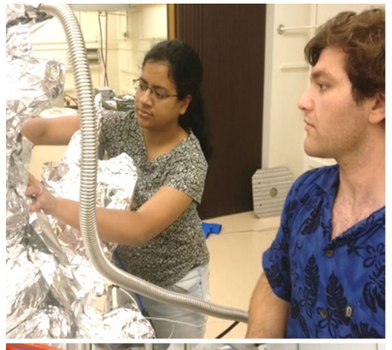
In the Press

Accelerator training at the Center for Bright Beams and the surprising benefits of Team Science

By: Ritchie Patterson & Joan Curtiss – Adapted from the APS Division of Physics for Beams 2024 Newsletter

Since its inception in 2016, the Center for Bright Beams (CBB) has been advancing accelerator capabilities and training the next generation of accelerator scientists. Supported by the National Science Foundation as a Science and Technology Center, CBB joins an interdisciplinary team of scientists from Arizona State University, Brigham Young University, University of Chicago, Cornell University (lead), UCLA, University of Florida, University of New Mexico, Northern Illinois University, and the national laboratories SLAC, Fermilab, and Berkeley Lab.

"CBB is cultivating the next generation of accelerator scientists, addressing critical workforce shortages through comprehensive training and mentorship."



CBB graduate student and post-doc education addresses a pressing shortage of accelerator scientists. There is a growing demand for experts who can design and build accelerators for a wide range of applications from large particle colliders and advanced x-ray light sources to beamlines for electron imaging, medical treatments and semiconductor manufacturing, yet only a few universities offer graduate education in this field. To date, CBB has successfully trained 61 doctoral students and postdocs in accelerator science and related disciplines, and 30 more are in the pipeline. In addition, 113 undergraduates have contributed to CBB research, and many of these students are choosing careers in accelerator science.

Cohort Building

To foster cohesion, CBB welcomes new members by introducing them to its goals and culture of interdisciplinary collaboration. Students learn how to access information and resources and are introduced to our Handbook, which has been featured in the NIH Team Science Toolkit. At onboarding, students also meet center management and connect with their incoming cohort. Building a sense of belonging has proved particularly important for students at universities with small accelerator science programs.

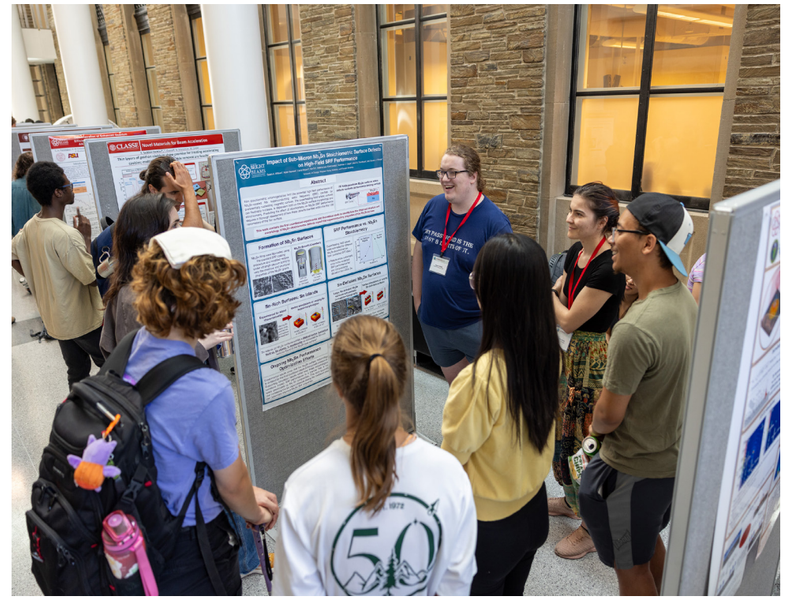
To provide a shared knowledge base, CBB created a comprehensive library of pedagogical videos, available on YouTube, addressing topics in accelerator physics and related materials science. Students further build their knowledge at grad-to-grad meetings where they can learn from one another, practice presentations, and ask questions. Regular research meetings provide opportunities to present work, share insights, and engage with peers. Presentations at these meetings always begin with a clear introduction to ensure that all participants, regardless of their field, can contribute meaningfully to discussions.

"Uniting nine universities and three national labs, CBB advances groundbreaking innovations in accelerator science for transformative applications."

Professional Development and Communication

Comprehensive training prepares students for diverse careers in accelerator science and beyond. Each student completes a professional development plan with their faculty advisor, in which they identify their career aspirations and map out a personalized path to achieve those goals. To support these plans, CBB hosts workshops in areas such as research ethics, resume building, and imposter syndrome. Many of the workshops build communication skills, such as George Gopen's workshop on The Science of Scientific Writing, programs by the Alan Alda Center, and workshops on grant writing, designing scientific graphics, and interpersonal dialogue. Students develop elevator pitches for their research and frequently present at international scientific conferences and workshops. CBB students get hands-on training at university accelerator facilities and five have conducted thesis research at DOE laboratories thanks to Department of Energy's Office of Science Graduate Student Research (SCGSR) awards.

"CBB fosters collaboration and teamwork, creating an inclusive environment where 28% of alumni are women or from minoritized groups."



Poster Session at CBB Annual Meeting

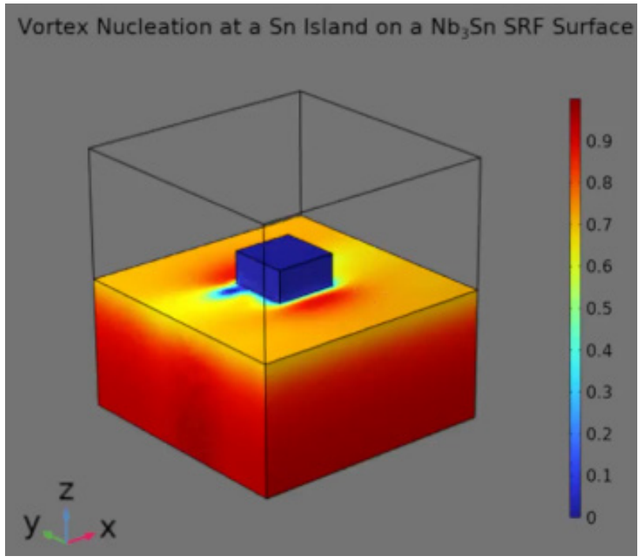
The outcome of these efforts is that students report high satisfaction with their research experience (4.8 on a scale of 5) and professional development (4.4), and rate CBB well for diversity and equality (4.3). An unanticipated outcome is that the team has become remarkably diverse. Roughly 28% of our alumni are women or members of minoritized groups. While not yet representative of the population, this figure exceeds the diversity seen in physics as a whole and highlights the inclusive environment fostered by a collaborative approach.

The Research Highlights on page 4 illustrate some of CBB's recent achievements and the teams who led them.

In the Press

Unveiling the Impact of Surface Defects: Optimizing Nb_3Sn Coatings for Superior SRF Cavity Performance

By: Sarah Willson and Rick Ryan



Coating the interior of superconducting radiofrequency (SRF) cavities with a Nb_3Sn film can drastically enhance the efficiency and performance of particle accelerator infrastructure. However, imperfections in the deposited Nb_3Sn coating, especially near the surface, limit its implementation as a next-generation SRF material.

This study represents a col laborative effort involving researchers from condensed matter physics, surface chemistry, and accelerator physics disciplines. Together, they explored how imperfections, specifically areas with too much or too little tin, form during the coating process and how they can affect SRF performance. Using both experiments and computer simulations, the team studied how tiny defects on the nanoscale, like tin-rich islands or periodic corrugations in tin-deficient areas, can cause issues during operation by creating points where magnetic vortices form and degrade the cavity's performance.

The findings show that just knowing the amount of tin in a surface is not enough to predict how well Nb_3Sn will work in an SRF cavity. The shape and size of surface defects also play a critical role. By combining theoretical predictions with experimental observations, this collaborative work provides a model for predicting how to improve the quality of Nb_3Sn films, helping to develop better materials for next-generation particle accelerators.

Reference: S. A. Willson, A. V. Harbick, L. Shpani, V. Do, H. Lew-Kiedrowska, M. U. Liepe, M. K. Transtrum, and S. J. Sibener, "Impact of submicron Nb_3Sn stoichiometric surface defects on high-field superconducting radiofrequency cavity performance," Phys. Rev. Res., vol. 6, no. 4, p. 043133, Nov. 2024,
doi: 10.1103/PhysRevResearch.6.043133. Available: https://link.aps.org/doi/10.1103/PhysRevResearch.6.043133

CBB Featured Articles

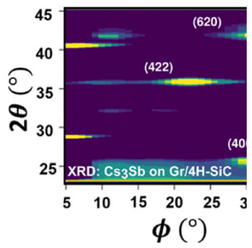
CBB Research Themes

- **Beam Production: Producing exceptionally bright electron beams using the process of photoemission.**
- **Beam Acceleration: Accelerating particle beams using new green technology.**
- **Beam Dynamics and Control: Addressing the transit of the beam from production through acceleration and onward to its target.**

Research Highlights

Understanding the growth of atomically ordered alkali-antimonide photocathode films

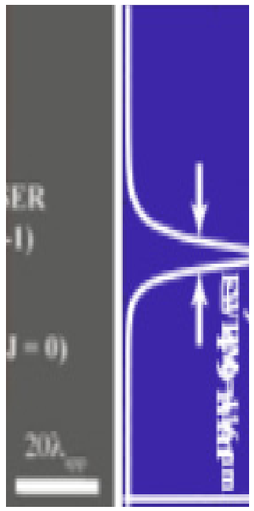
C. Pennington, M. Gaowei, E. M. Echeverria, K. Evans-Lutterodt, A. Galdi, T. Juffmann, S. Karkare, J. Maxson, S. J. van der Molen, P. Saha, J. Smedley, W. G. Stam, and R. M. Tromp



Ordered alkali antimonide photocathodes are emerging as a promising platform for producing high-brightness electron beams. Building on previous demonstrations of single crystal Cs_3Sb growth on 3C-SiC (001) using molecular beam epitaxy (MBE), we further explore this study by growing highly ordered Cs_3Sb films on graphene-coated 4H-SiC (0001) and 3C-SiC (001) substrates at the National Synchrotron Light Source II (NSLS-II) at Brookhaven National Laboratory using an innovative pulsed laser deposition (PLD) method. Operando diagnostics, including **Read More>>**

Revolutionizing Electron Sources with Plasmonic Interference

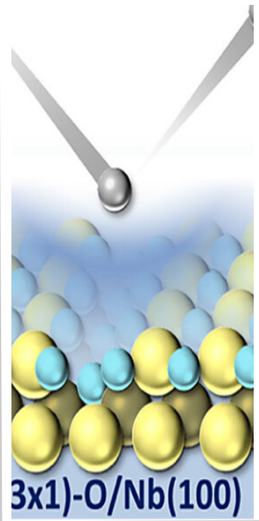
A. Kachwala, M. M. Rizi, C. M. Pierce, D. Filippetto, J. Maxson, and S. Karkare



In a groundbreaking advance, plasmonic interference has been harnessed to achieve a record low emittance of under 40 pm-rad rms from a geometrically flat metal photocathode. This innovation, utilizing plasmonic focusing to reduce the electron emission area to below 50 nm, marks a major leap forward for ultrafast electron diffraction and microscopy (UED/M) and other electron beam-based instruments. consisting of crystallites, with Laue oscillations around Bragg peaks further highlighting their ordered structure (see Figure). Additionally, tensile strain **Read More>>**

Relating Atomic-Scale Composition and Structure with Superconducting Properties via Helium Atom Scattering

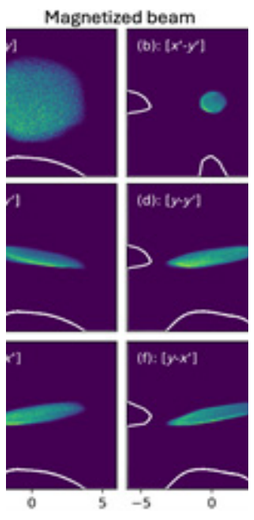
C. J. Thompson, M. Van Duinen, C. Mendez, S. A. Willson, V. Do, T. A. Arias, and S. J. Sibener



Superconducting radio frequency (SRF) niobium cavities comprise the accelerating components of today's linear particle accelerators. The goal for next-generation accelerators is to build higher performance SRF cavities using more highly perfected, doped, or alloyed materials to push the limits of operating temperatures and gradient fields. Several next-generation materials do not achieve their potential due to compositional inhomogeneities and structural defects. To overcome these challenges, it is crucial to correlate and understand how atomic-scale **Read More>>**

Four-dimensional phase space reconstruction of flat and magnetized beams

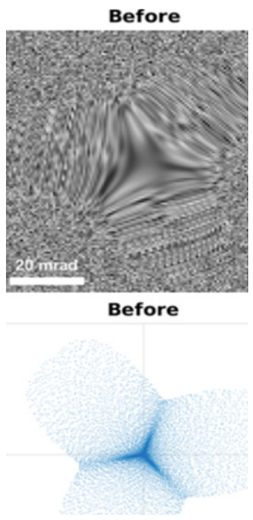
S. Kim, J. P. Gonzalez-Aguilera, P. Piot, G. Chen, S. Doran, Y.-K. Kim, W. Liu, C. Whiteford, E. Wisniewski, A. Edelen, R. Roussel, and J. Power



Flat and magnetized beams have become increasingly important in particle accelerators. For instance, flat beams can be used to increase luminosity for future colliders. On the other hand, magnetized electron beams can improve electron cooling performance in hadron beams. Characterizing these kinds of beams requires the full 4D transverse phase space distribution (TPS), which is usually time consuming and/or requires specialized diagnostics. In this work, our generative phase space reconstruction method (GPSR) consisting of crystallites , with Laue oscillations around **Read More>>**

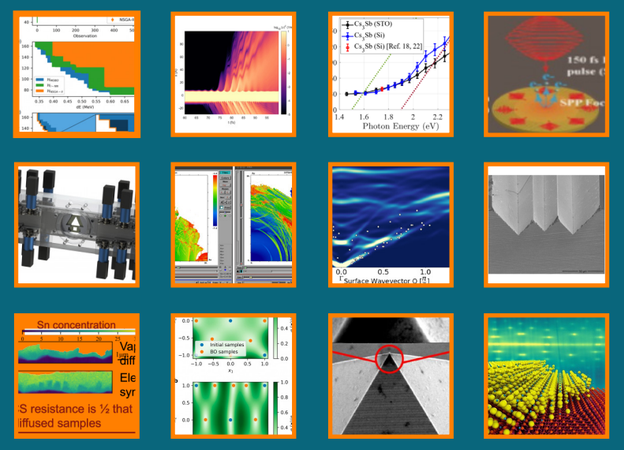
Physics-informed Bayesian Optimization of an Electron Microscope

D. Ma, C. Zhang, Y. Shao, Z. Baraissov, C. Duncan, A. Hanuka, A. Edelen, J. Maxon, and D. Muller,



Achieving sub-Angstrom resolution by aberration correction in an electron microscope requires the precise control of a large set of multipole electron-optical elements very similar to those used in synchrotron ring, with similar challenges in their multidimensional optimization. We approach this challenge by recognizing the equivalence between aberration correction in electron microscopy and phase space beam emittance minimization in accelerator physics. We show that emittance (the volume of phase space occupied by the beam) as an alternate metric of **Read More>>**

More Research Highlights



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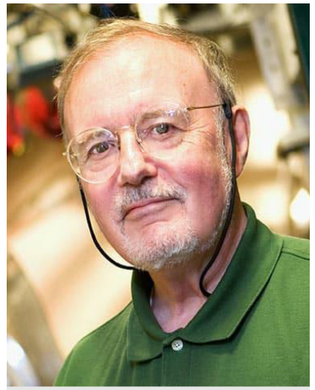
Tigner Traineeship in Accelerator Science Awarded by the Department of Energy

The Department of Energy (DOE) has awarded a new collaborative Accelerator Traineeship in partnership with the Center for Bright Beams (CBB). Named in honor of Maury Tigner, this traineeship will help address the need for accelerator scientists—a role CBB has largely fulfilled since 2017 and that will conclude in 2026.



Maury Tigner, Hans A. Bethe Professor Emeritus, Cornell University.

The Tigner Traineeships in Accelerator Science will offer two-year fellowships to graduate students interested in pursuing research in Superconducting RF cavities and the physics of large accelerators and systems engineering—two areas of expertise among participating universities. Fellowships will be available both to incoming students and to those who discover a passion for accelerator science after matriculating and will provide full tuition and stipend support. Fellows will also benefit from the research and professional development opportunities offered by the Center for Bright Beams and internships at DOE National Laboratories. By the time of graduation, Fellows will be well equipped to contribute as researchers in accelerator science, with strong connections and hands-on experience in national labs.

The program is committed to supporting students from marginalized groups, aiming to increase the representation of underrepresented minorities in accelerator science.

U.S. DEPARTMENT OF ENERGY

REMINDER: Join or Renew Your APS/Division of Physics of Beams (DPB) Membership Today!

APS's Division of Physics of Beams (DPB) membership benefits include discounts on conference registrations, access to mentoring programs, and opportunities to present research at conferences. In addition, your membership to DPB will ensure you receive the latest updates on accelerator research along with the annual DPB newsletter. If you are interests in meeting others in the field, DPB enables collaboration and offers opportunities to run for offices in the division.

Your membership is important to help keep the division strong, to maintain the number of fellowships and other privileges. Please consider becoming a member or renewing if your membership has expired.

APS Division of Physics of Beams DPB

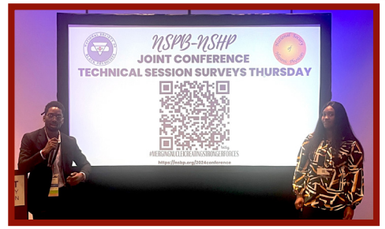
Creating a Cultural Shift in Physics - CBB Joins The American Physical Society's Inclusion, Diversity, & Equity Alliance (APS-IDEA)

CBB joined the APS's Inclusion, Diversity, and Equity Alliance (APS-IDEA). The APS-IDIA program empowers teams to create an inclusive environment, with the broader goal of driving impactful change across the field of physics.

Through network meetings and team sessions, participants explore organiza-tional change, and develop goals that address issues such as bias, power dynamics, inequity, and promote a culture of inclusion.

Accelerator Physics Section at 2024 National Society of Black Physicists (NSBP)

The first-ever sessions of the National Society of Black Physicists (NSBP) Accelerator Physics Section (ACCEL) held during the 2024 joint annual conference with the National Society of Hispanic Physicists (NSHP). The ACCEL section had a fantastic kickoff, featuring engaging oral and poster presentations that sparked valuable discussions and enthusiasm among participants.



Recent Alumni

Graduate Students and Postdocs

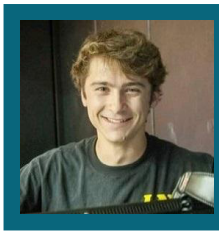
Ajinkya Hire
Ph.D., Univ. of Florida
Thesis: Exploring Superconductors: Insights from Density Functional Theory Calculations and Machine Learning

Alimohammed Kachwala
Ph.D., Arizona State U.
Postdoc, Jefferson National Lab
Thesis: Study and Characterization of Nano-structured Electron Sources Using Photoemission Electron Microscope

Gerard Lawler
Ph.D., UCLA
Sr Research and Dev. Engineer
TibayRay, Inc
Thesis: Study and Characterization of Nano-structured Electron Sources Using Photoemission Electron Microscope

Lucy Lin
Ph.D., Cornell U.
Postdoc, Brookhaven National Lab
Thesis: Improvements to Normal Conducting High Gradient Accelerator Performance at Cryogenic Temperatures

Chad Pennington
Ph.D., Cornell U.
Postdoc, UCLA
Thesis: Toward High Brightness Alkali Antimonides at High Gradients

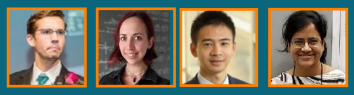


Chris Pierce
Postdoc., Univ. of Chicago
Assoc Scientist, Stealth Startup
Thesis: Towards High Beam Brightness from Photocathodes

Caleb Thompson
Ph.D., Univ. of Chicago
Asst Teaching Prof., Iowa State U.
Thesis: Distinguishing the Role of Structure, Composition, and Vibrational Dynamics on Electron-phonon Coupling of nb(100) Surfaces

Sarah Willson
Ph.D., Univ. of Chicago
Sr Scientist, KLA Corp.
Thesis: Growth of Niobium-Tin Films on Niobium Oxide Surfaces for Superconducting Radiofrequency Cavity Applications

Qinyuan(Amy) Zhu
Ph.D., Cornell U.
Thesis: Chemical Control of Semiconductor Surface: XPS and STM



More Alumni
Click>>

New CBBers

Graduate Students and Postdocs

Cecilia Abbamonte
Graduate Student
Cornell U.

Bariana Bowman
Graduate Student
Univ. of Florida

Truman Idso
Graduate Student
Arizona State U.

Jak Knefel
Graduate Student
Arizona State U.

Jake Parsons
Graduate Student
Cornell U.

Jackson Rozells
Graduate Student
UCLA

Brian Schaap
Postdoc
UCLA

Anagha Ullatuparambil
Graduate Student
Arizona State U.

More CBBers
Click>>

Awards and Honors

Monika Yadav

Monika Yadav was selected as a Lindau Nobel Laureate Meetings Fellow in recognition of her outstanding scientific accomplishments. This meeting, which is attended by 30 to 65 Nobel Laureates, promotes the exchange of scientific ideas across generations, cultures, and fields of study.

Liana Shpani

Liana Shpani has been selected as one of the 86 outstanding U.S. graduate students for the U.S. Department of Energy (DOE) Office of Science Graduate Student Research (SCGSR) program. Liana will be at Fermilab where she will work on advancing Nb_3Sn SRF cavities.

Steve Sibener

Steve Sibener was elected Fellow of the Royal Society of Chemistry in recognition of his distinguished research career, impact on scientific advancement and benefit to the application of chemical science through public service, outreach, policy development and change, and through connecting or leading the chemical science community to provide solutions for societal challenges.

Sarah Willson

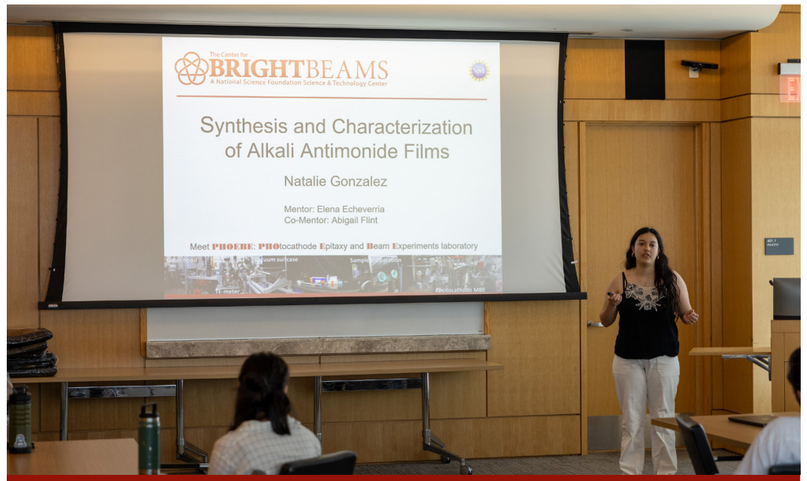
Sarah Willson won the 2024 Nellie Yeoh Whetten Award from the American Vacuum Society for her thesis research on superconducting materials. The award is one of the highest honors given to a female graduate student for their doctoral research.

Sadie Seddon-Stettler

Sadie Seddon-Stettler was awarded a National Science Foundation (NSF) Graduate Research Fellowship. The program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines.

More awards and honors please click >>

CBB REU

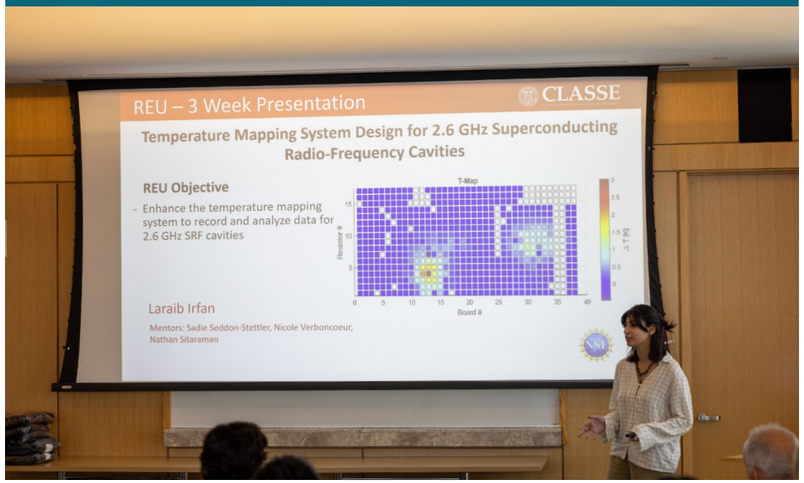


Natalie Gonzalez, St Olaf College

Project Title: Synthesis and Characterization of Alkali Antimonide Ailms

Laraib Irfan, Beloit College

Project title: Temperature Mapping System Design for 2.6 GHz Superconducting Radio-Frequency Cavities



Skyla Hong, Bowdoin College

Project title: Improving the Control GUI and Plasma System for Chemical Vapor Deposition

When asked what they'd say if they were recommending the REU program to a friend, one student stated, "It's one of the best ways (that I know of) to see what research is like and learn about different career paths in physics."

Felix Gonzalez, King's college

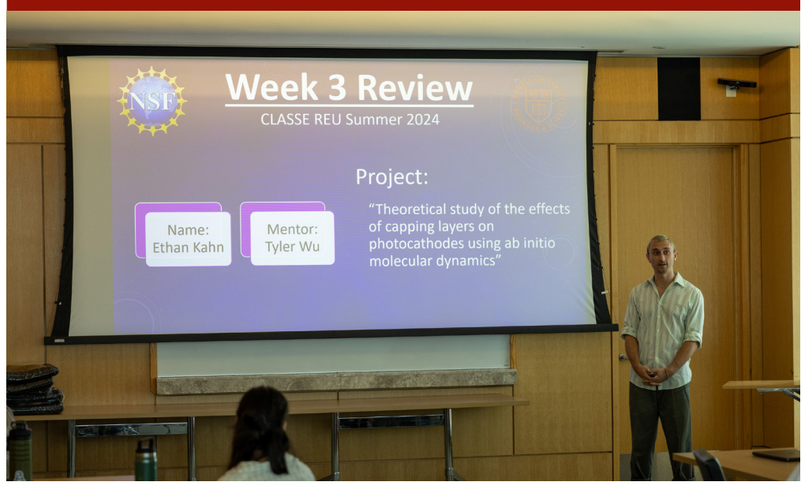
Project title: Studying Time-Dependent Ion-back Bombardment Effects in HERACLES

"This program has been one of the most transformative and enlightening experiences of my life. I got a crash course on quantum mechanics, material science, various mathematics, and learned first-hand what real research is like."

- Ethan Khan

Ethan Kahn, Butte College

Project title: Theoretical Study of the Effects of Capping Layers on Photocathodes Using Ab Initio Molecular Dynamics

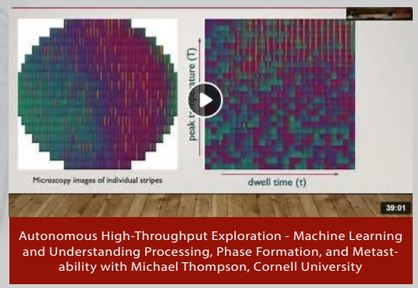


CBB REU Page Please click >>>

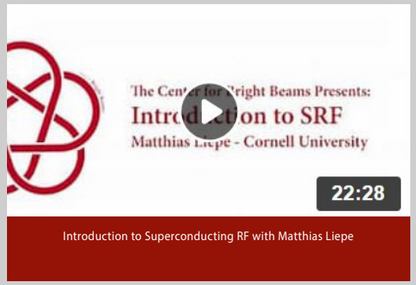
2024 Annual Meeting, Symposium, and Seminars

CBB held its in-person annual Meeting and Symposium in June. In addition to scientific presentations, pedagogy talks, symposium, and poster sessions, we enjoyed group activities such as bowling, painting, a team marshmallow tower challenge, and a BBQ at Treman State Park.

Pedagogical Videos



Autonomous High-Throughput Exploration - Machine Learning and Understanding Processing, Phase Formation, and Metastability with Michael Thompson, Cornell University



Introduction to Superconducting RF with Matthias Liepe

More Pedagogy Videos Please Click >>>

Congratulations to Poster Session Winners

Sadie Seddon-Stettler: *"Novel Materials for Beam Acceleration"*
Tyler Wu: *"First-principles Predicted Transverse Momentum Distribution for 2D Materials"*
Sarah Willson, Aiden Harbick, Liana Shpani, and Van Do: *"Impact of Sub-Micron Nb_3Sn Stoichiometric Surface Defects on High-Field SRF Performance"*
Charles Zhang: *"Updates on the Cornell Cryo-MTE-Meter Beamline"*

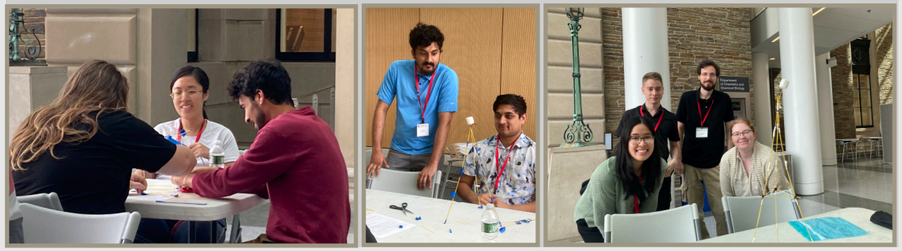
Celebrating Our Team

Bowling

BBQ at Treman State Park

Painting

Marshmallow Tower Challenge



Future Scientists

CBB Inspires Future Innovators Through Outreach Program

Top to Bottom: Prof. Karkare and graduate student Chris Knill presenting at ASU teacher workshop. Graduate student Zhaslan Baraissov at Binghamton High School. Graduate student Vivek Anil at the Greater Ithaca Activities Center.

Over the past year, the Center for Bright Beams (CBB) has expanded its outreach efforts to inspire K-12 students through hands-on learning.

CBB scientists developed educational kits and lesson plans aligned with the Next Generation Science Standards, designed to engage young learners nationwide.

Through the Educational Lending Library of Experiments, teachers across the country have access to these science kits, which saw a 229% increase in demand last year. Featured kits include:

- What is a Wave? – Students explore different wave types using hands-on materials.
- Airboats – Newton's laws of motion come to life as students build model airboats.
- Resistance Tube – A PVC pipe experiment teaches students about Ohm's Law and resistance.
- How Sticky is Your Tape? – Students measure friction using ramps and different types of tape.
- The Physics of Collisions – A 3D-printed ramp helps students explore energy conservation and momentum.

CBB continues to bridge science education and innovation, sparking curiosity in future innovators.

Post CBB Careers

2024 – 2025 Projects

PI Name	Projects	Theme	Students & Post-docs
Arias	Ab initio theory of many-body photoemission and of photomaterials	PHC	Tyler Wu (GRA)
Arias	Ab initio exploration of beyond-Nb SRF materials for low cooling power and high field performance	SRF	Cristóbal Méndez (GRA)
Chubenko	Monte Carlo modeling of photoemission from semiconductors	PHC	Daniel Franklin (GRA)
Chubenko	Photocathodes under realistic accelerator conditions	PHC	Tariqul Hasan (GRA)
Chubenko	Generation of Low-Emittance Beams Using a Low-MTE Photocathode Integrated in the AWA Photoinjector	BDC	Emily Frame (GRA)
Hennig	Machine learning for accelerated simulations for the synthesis and growth of photocathodes and superconducting thin films	PHC/SRF	Sam Dong (GRA)
Hennig	Machine learning potentials for multi-component systems and the enhancement of superconducting properties for topological materials	SRF/PHC	Bariana Bowman (GRA)
Karkare	Measurements of low energy electron distributions and cryogenic MTE	PHC	Truman Idso (GRA)
Karkare	Measure sub-nm emittance at the ASU DC cryogun	BDC	Peter Owusu (GRA)
Karkare	Development of nanostructured photoemission electron sources	PHC	Mansoure Reini Rizi (PD)
Karkare	Cathode characterization in PEEM	PHC	Anagha Ullattuparambil (GRA)
Kim	Generative-model-based phase space reconstruction method for high-dimensional characterization of coherent synchrotron radiation effects	BDC	JP Gonzalez Aguilera (GRA)
Liepe	Advancing RF Performance via Au Layering and Oxide Passivation	SRF	Sadie Seddon-Stettler (GRA)
Liepe	Advanced Material Systems for Enhanced SRF Performance	SRF	Nathan Sitaraman (PD)
Liepe	CVD Growth of Nb_3Sn Films	SRF	Gabriel Gaitan (GRA)
Liepe	High-performance Nb_3Sn	SRF	Liana Shpani (GRA)
Maxson	Molecular Beam Epitaxial Growth of Na- and K-containing Alkali Antimonide photocathodes	PHC	Elena Echeverria (PD)/Emily Flint (UNDERGRAD)
Maxson	Measuring the mean transverse energy of atomically ordered photocathodes	PHC	Charles Zhang (GRA)
Maxson	Demonstration of improved robustness of CsI surface-treated GaAs photocathodes in a high average current DC electron gun.	PHC	Samuel Levenson (GRA)
Muller	Electron Microscopy characterization of the microsctructure of materials for SRF cavities	SRF	Zhaslan Baraissov (GRA)
Muller	Machine Learning for precise phase space control of electron microscope	BDC	Desheng Ma (GRA)
Musumeci	Testing of advanced photocathodes at UCLA Pegasus photoinjector	PHC	David Garcia (GRA)
Musumeci	Demonstration of 100 nm transverse emittance with 100 pC beam charge	BDC	Atharva Kulkarni (GRA)/ Brian Schaap (PD)
Rosenzweig	Extreme High Brightness Electron Source from Intense Laser Illumination of Nano-Blades	PHC	Joshua Mann (GRA)
Rosenzweig	Optimization of ultra-compact free-electron laser performance and UED sources with very low MTE photocathodes	BDC	Fabio Bosco (PD)
Shen	Atomically Ordered & Engineered Materials for Photocathodes	PHC	Vivek Anil (GRA)
Sibener	Investigating the Atomic and Micron-Scale Morphological Development of Nb_3Sn Leading to Smooth Homogeneous Thin Films	SRF	Van Do (GRA)/ TBD
Sibener	Optimization of Nb SRF Surfaces: Atomic Visualization of Zr-Nb Alloy Growth and Oxide Suppression Using Au Overlayers	SRF	Van Do (GRA) / TBD
Sibener	Investigating the Effect of Atomic Scale Surface Structural and Composition Changes from Alloying, Doping, and Defects on the Superconductivity of Nb, Nb_3Sn and Zr with Simultaneous In Situ High Temperature Atomic-Scale Surface Structure and Surface Electron-Phonon Coupling Constant Measurements	SRF	Michael Van Duinen (GRA) / TBD
Sibener	In Situ Measurements of High Temperature Surface Structure, Bonding, and Dynamics of Doping N and Alloying Sn or Zr from Initial Behavior to Resulting Film Growth	SRF	Michael Van Duinen (GRA)/ TBD
Transtrum	Mesoscopic Modeling of Dissipation in SRF	SRF	Aiden Harbick (GRA)