The Center for BRIGHTBEAMS

A NATIONAL SCIENCE FOUNDATION SCIENCE & TECHNOLOGY CENTER

NEWSLETTER 2025

Materials for Bright Beams Workshop 2025 at Cornell

HAPPY HOLIDAYS

Season's Greetings from All Of Us at the Center for Bright Beams

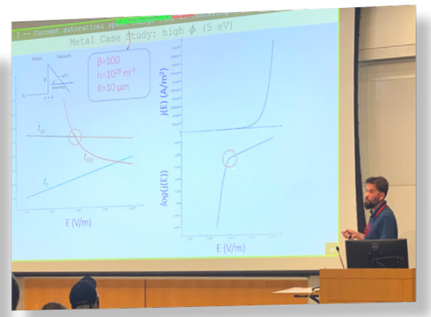
In This Issue

Editorial Team: Joan Curtiss and Lyanna (Xiangyu) Zhang

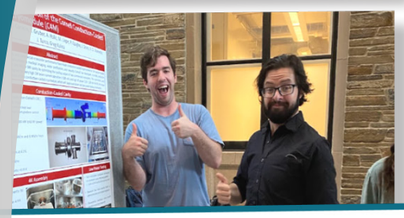
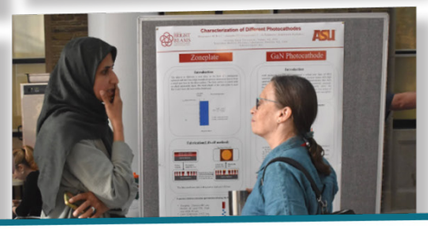
Materials for Bright Beams Workshop

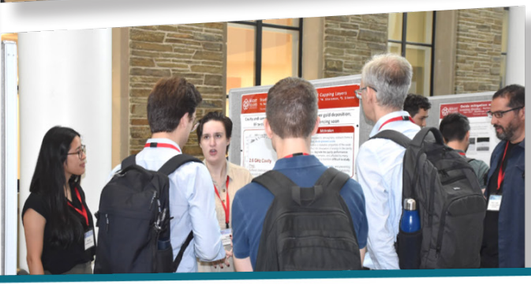
July 16–18, 2025

*Over the past decade, the **Center for Bright Beams** has been a leader in designing new materials to improve the performance of particle accelerators. CBB scientists apply advanced materials science to the devices that produce and accelerate beams, which operate in extreme conditions and must deliver performance at the edge of materials feasibility. **The inaugural Materials for Bright Beams Workshop,** held at Cornell University, marked a major milestone—bringing together researchers from across disciplines to dive into the science and chart the future of materials for accelerators.* Read more>>






Bringing together particle accelerator and materials scientists to identify, explore and solve the materials challenges presented by next generation particle accelerators.



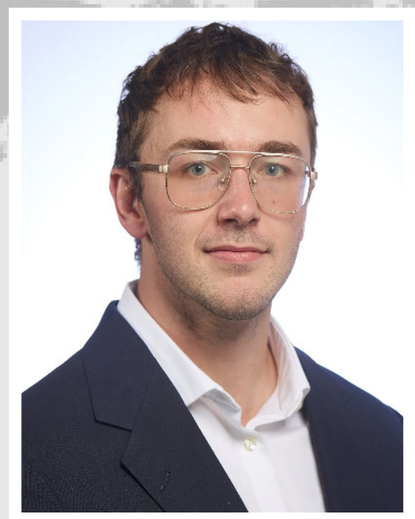







CBB Research at Work

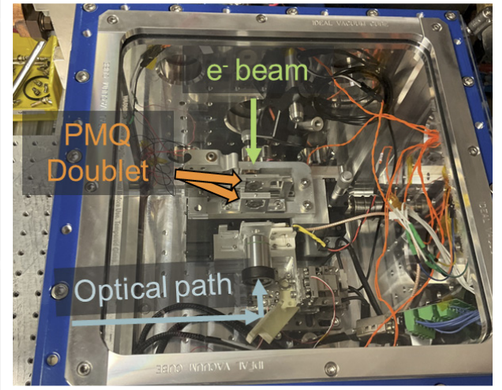
Accelerating the discovery of superconductors at Quantum Formatics



Jason Gibson, a CBB alumnus, has founded Quantum Formatics, a company that uses AI to build superconducting wires to scale up advances in nuclear fusion and power transmission. Two former CBB alumni, Michelle Kelley and Zeming Sun, are on the leadership team. In recognition of this work, Gibson was named to the Forbes 30 Under 30.

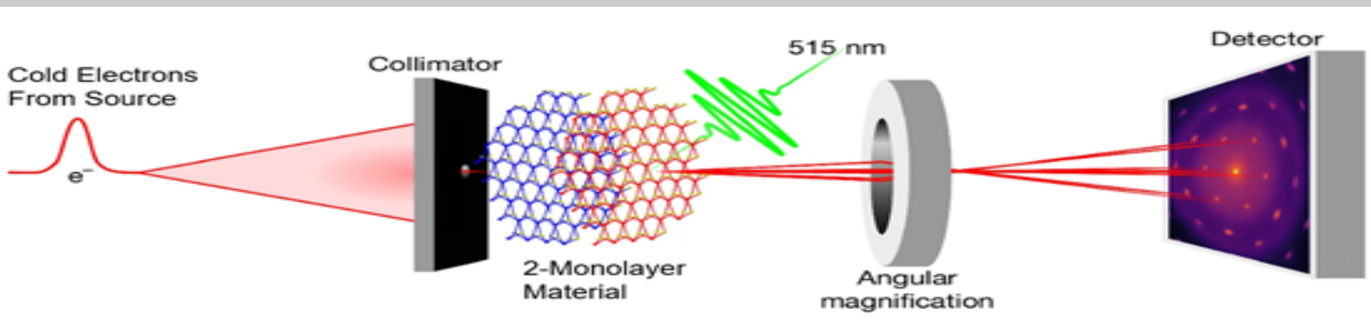
Studying the survivability of electronics in outer space

Research at the UCLA Pegasus Laboratory, led by Pietro Musumeci with CBB graduate student Atharva Kulkarni, advances predictive single-event-effects (SEE) testing by developing electron-beam irradiation techniques that faithfully reproduce heavy-ion charge tracks at the device level. The upgraded Pegasus SEE beamline has recently demonstrated sub-micron electron spot sizes at MeV energies, a prerequisite for matching heavy-ion transient amplitudes and shapes. Systematic spot-size sweeps demonstrate that transient peak response depends primarily on local charge density rather than total collected charge, establishing the physical basis for electron–ion equivalency. Comparative measurements show strong agreement between normal-incidence electron and ion data. This UCLA Pegasus-based program couples accelerator physics, advanced electron optics, and device-level testing to deliver a flexible, university-scale platform for SEE research and model validation. This work was partially funded by CBB and DARPA ASSERT program, in collaboration with JPL and Aerospace Corporation.



Caption: *Experimental test chamber with the permanent magnet quadrupole doublet and the high resolution microscope objective used to visually resolve micron spot sizes on a thin Yag screen. In vacuum translation stages are used to move into the beam path a microelectronics device for comparison with reference ion testing data.*

Observing a twisting motion between two monolayers of atoms



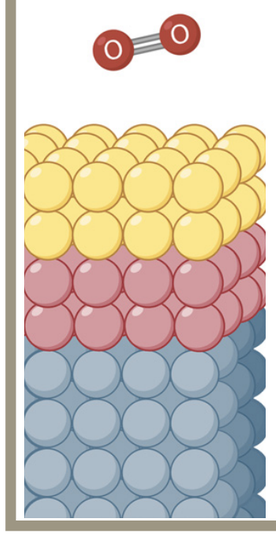
Caption: *Schematic of the experiment. Cold electron beams from a CBB photocathode and accelerator scatter off of a 2-monolayer thick sample. The resulting scattering pattern is captured on a downstream detector. The atoms of the sample are set in motion by a short light pulse less than a trillionth of a second in duration. Subtle features of the crisp scattering pattern show that the two layers twist and untwist in response to the light pulse. This twisting motion might be harnessed to modulate electronic material properties on ultrafast timescales.* Read more...

CBB researchers, led by Jared Maxson, recently used electron beams to observe, for the first time, an atomic twisting motion in a material only two monolayers thick. This motion is extraordinarily fast—the entire sequence occurs in just four trillionths of a second—and could one day be used to modulate exotic properties such as superconductivity on ultrafast timescales. Although this twisting had been predicted, it remained invisible to all previous probes because its signature is subtle and requires an exceptionally pristine electron beam. This is where CBB's contribution was critical. The accelerator commissioned within CBB used CBB-developed photocathode techniques to produce a markedly colder beam than found in comparable systems, and incorporated new methods to preserve that beam quality from source to detector. The result was a notably sharper electron-beam image—one crisp enough to directly reveal this elusive atomic twisting motion.

Research Highlights

Ab initio theory of eliminating surface oxides of superconductors with noble metal encapsulation

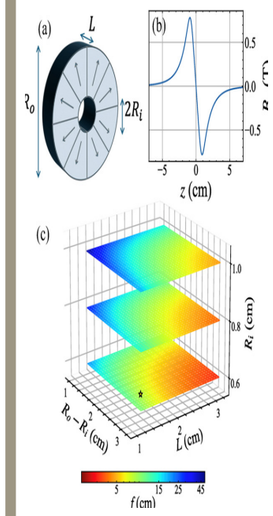
C. Méndez, N. Sitaraman, M. Liepe, and T. Arias,



Superconducting devices, from particle accelerator cavities (SRF) to quantum circuits, are incredibly sensitive to their surfaces. Even a few nanometers of oxide or absorbed hydrogen on niobium (Nb) or tantalum (Ta) can introduce defects that act as "two-level systems" (TLS), which degrade qubit coherence times and increase losses in SRF cavities. This makes surface chemistry one of the central bottlenecks for advancing both quantum technologies and superconducting accelerators. Protecting these surfaces requires ultrathin metallic caps—thick enough to prevent oxygen **Read More>>**

Focusing of relativistic electron beams with permanent magnetic solenoid

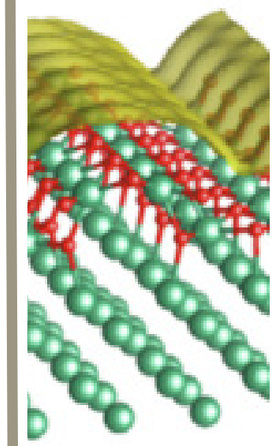
T. Xu, C. J. R. Duncan, P. Denham, B. H. Schaap, A. Kulkarni, D. Garcia, S. D. Anderson, P. Musumeci, and R. J. England



Achieving strong focusing of MeV electron beams is a critical requirement for advanced beam applications such as compact laboratory x-ray sources, high gradient accelerators, and ultrafast electron scattering instrumentation. To address these needs, a compact radially magnetized permanent magnetic solenoid (PMS) has been designed, fabricated, and tested. The solenoid provides a compact and inexpensive solution for delivering high axial magnetic fields (1 T) to focus MeV electron beams. Field characterization of the solenoid demonstrates good agreement with **Read More>>**

Ab initio electron-phonon-coupling theory of elastic helium-atom scattering

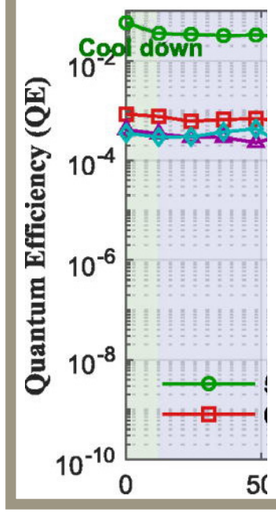
C. Méndez, C. J. Thompson, M. F. Van Duinen, S. J. Sibener, and T. A. Arias



We propose a fully *ab initio* approach to predicting thermal attenuation in elastic helium atom scattering amplitudes, validated through strong agreement with experiments on Nb(100) and (3×1)-O/Nb(100) surfaces. Our results reveal the relative contributions from bulk, resonant, and surface phonon modes, as well as from different surface mode polarizations, providing insights into differences between smooth and corrugated surfaces. These findings advance understanding of surface dynamics and electron-phonon coupling, laying groundwork for **Read More>>**

Characterization of Cs_3Sb photocathodes at cryogenic temperatures

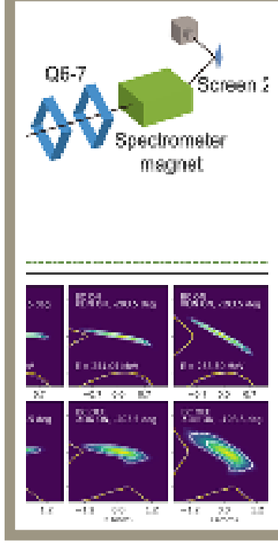
P. P. Owusu, J. Mama, T. Idso, A. Ullattuparambil, M. M. Rizi, J. Anawalt, and S. Karkare



We report measurements of quantum efficiency (QE) and mean transverse energy (MTE) from Cs_3Sb photocathodes in a wide range of photon energies at both room and cryogenic temperatures. Our measurements show a strong temperature dependence of MTE even at photon energies well above threshold, indicating the presence of strong inelastic scattering of excited electrons during transport before emission into vacuum. We also demonstrate a cathode cooling method that largely preserves the QE while reducing MTE , allowing us to achieve MTEs as low **Read More>>**

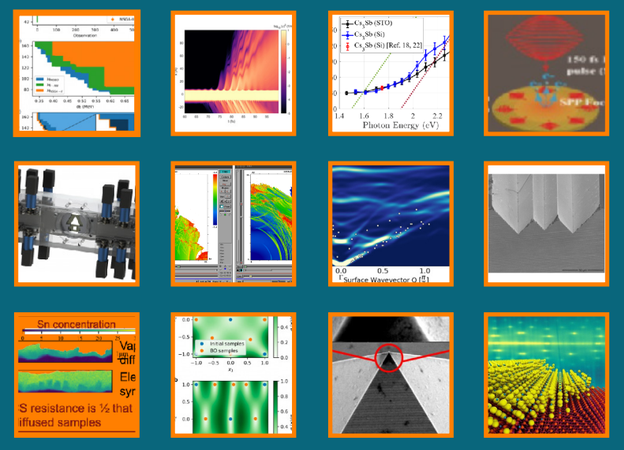
Six-dimensional phase space reconstruction in XFEL using standard accelerator elements

S. Kim, J. P. Gonzalez-Aguilera, R. Roussel, G. Kim, A. Edelen, M.-H. Cho, Y.-K. Kim, C. H. Shim, H. Heo, and H. Yang



Performance of free electron lasers is highly dependent of the beam phase space distribution. Characterizing the full six-dimensional phase space distribution is time consuming and often requires specialized diagnostics elements. Generative phase space reconstruction (GPSR) has been shown to provide fast and detailed reconstructions of the beam structure in six-dimensions. Nevertheless, previous implementations of GPSR rely on a transverse deflecting cavity (TCAV) , which is a specialized diagnostic element not available at every section of the beamline. This **Read More>>**

More Research Highlights



Click Here>>

Welcome New CBB Members

Robert Burnley
Postdoctoral Associate
University of Chicago

Joseph Devlin
Graduate Student
Cornell University

MaryKate Duncan
Graduate Student
University of Chicago

Alexis Grassl
Graduate Student
Cornell University

Travis Nichols
Graduate Student
University of California, Los Angeles

Jack Phillips
Graduate Student
University of California, Los Angeles

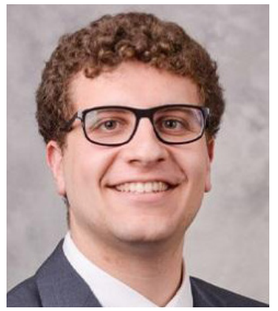
Ningdong Wang
Graduate Student
Cornell University

Recent Alumni

Emily Frame
Graduate Student
Northern Illinois University

Aiden Harbick
Graduate Student
Brigham Young University

Computational Multiphysics Engineer
Toyon Research Corporation



Sam Levenson
Graduate Student
Cornell University

Principal Microelectronic Semiconductor Engineer
Northrop Grumman

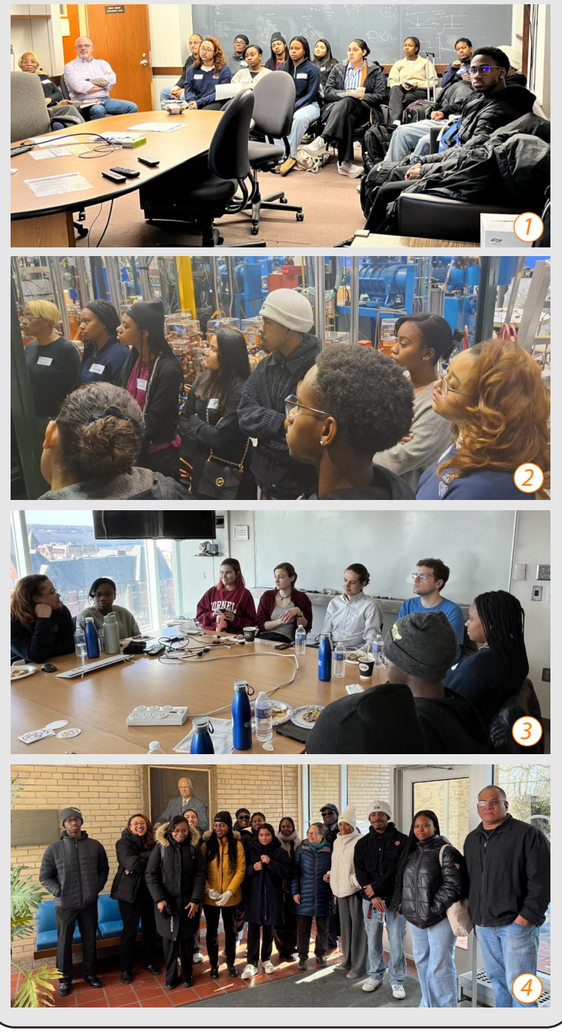
Desheng Ma
Graduate Student
Cornell University

Postdoctoral Research Associate
Brookhaven National Laboratory

2025-2026 CBB PROJECTS

	Project Name	Faculty/Student(s)
Beam Production	*Ab initio* theory of photoemission and of photomaterials	Tomás Arias / Tyler Wu (GRA)
	Monte Carlo modeling of photoemission from semiconductors	Oksana Chubenko / Daniel Franklin (GRA)
	Photocathodes under realistic accelerator conditions	Oksana Chubenko / Tariqul Hasan (GRA)
	Development of nanostructured photoemission electron	Siddharth Karkare / Mansoure Moeini Rizi (PD)
	Cathode characterization in PEEM	Siddharth Karkare / Anagha Ullattuparambil (GRA)
	Characterization of Alkali-antimonides and measure sub-nm emittance at the ASU DC cryogun	Siddharth Karkare / Peter Owusu (GRA)
	Operation of Alkali-antimonide cathodes in photoinjectors	Siddharth Karkare / Jak Knefel (GRA)
	Generation of bright electron beams using cryocooled cathodes	Siddharth Karkare / Truman Idso (GRA)
	Characterization of Timing Jitter in RF and Laser-Based Longitudinal Phase Space Manipulations	Jared Maxson / Cecilia Abbamonte (GRA)
	Molecular Beam Epitaxial Growth of Na- and K-containing Alkali Antimonide Photocathodes	Jared Maxson / Elena Echeverria (PD) / Abigail Flint (GRA)
	Measuring the mean transverse energy of atomically ordered photocathodes	Jared Maxson / Charles Zhang (GRA)
	Testing of advanced photocathodes at UCLA Pegasus photoinjector	Pietro Musumeci / David Garcia (GRA)
	Atomically Ordered & Engineered Materials for Photocathodes	Kyle Shen / Vivek Anil (GRA)
Beam Acceleration	Ab initio exploration of beyond-Nb SRF materials for low cooling power and high field performance	Tomás Arias (PROF) / Cristóbal Méndez (GRA)
	AI accelerated simulations for the design and growth of superconducting thin films	Richard Hennig / Ningdong Wang (GRA) / Bariana Bowman (GRA)
	CVD Growth of Nb_3Sn Films	Matthias Liepe / Gabriel Gaitan (GRA)
	CBD based growth of Nb-Zr	Matthias Liepe /Alexis Grassl (GRA)
	Conduction-cooled SRF Modules	Matthias Liepe / Jake Parsons (GRA)
	High-performance Nb_3Sn	Matthias Liepe / Liana Shpani (GRA)
	Advanced Material Systems for Enhanced SRF Performance	Matthias Liepe / Nathan Sitaraman(PD)
	Advancing RF Performance via Capping Layers and Oxide Passivation	Matthias Liepe / Sadie Seddon-Stettler (GRA)
	Electron microscopy characterization of the microstructure of materials for SRF cavities	David Muller / Zhaslan Baraissov (GRA)
	Impact of Nb_2O_5 Nanoscale Roughness on Sn Uptake and Nucleation Upon the Formation of Nb_3Sn	Steven Sibener / Jasper Brown (GRA)
	Optimizing Nb Surfaces – Oxide Passivation by Au Encapsulation	Steven Sibener / Van Do (GRA)
	Zr alloying, passivation, and interdiffusion with Nb substrates	Steven Sibener / Robert Burnley(PD)
	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	Steven Sibener / Michael Van Duinen (GRA)
Beam Dynamics	Generation of Low-Emittance Beams Using a Low-MTE Photocathode Integrated in the AWA Photoinjector	Oksana Chubenko / Emily Frame (GRA)
	Space charge dominated beams in EIC coolers and beam instability	Georg Hoffstaetter de Torquat / Ningdong Wang (GRA)
	Stability Thresholds in the IOTA Ring at Fermilab	Young-Kee Kim / MaryKate Duncan (GRA)
	Phase Space Reconstruction of Beams affected by Coherent Synchrotron Radiation	Young-Kee Kim / Juan Pablo González-Aguilera (GRA)
	Machine Learning for precise phase space control of electron microscope	David Muller / Desheng Ma (GRA)
	Demonstration of 100 nm transverse emittance with 100 pC beam charge	Pietro Musumeci / Brian Schaap (PD)
	Development of non-intercepting diagnostics for very intense beams	Pietro Musumeci / Travis Nichols (GRA)
	Synchronization of multiple frequency RF systems for longitudinal phase space manipulation	Pietro Musumeci / Atharva Kulkarni (GRA)
	Optimization of ultra-compact free-electron laser performance and UED sources with very low MTE photocathodes	James Rosenzweig / Fabio Bosco(PD)
	Diagnosis of beam properties in a plasma photocathode wakefield source	James Rosenzweig / Jack Phillips (GRA)
	Very high-power terahertz radiation from coherent Cerenkov radiation	James Rosenzweig / Jackson Rozell (GRA)

2025 In Pictures



1-4, Morgan State University Student Visit to Cornell University, February 7, 2025

5-9, CBB REU students 2025
10-15, CBB Annual Meeting, Ithaca NY, July 14-15, 2025

16-27, Materials for Bright Beams Workshop, Ithaca NY, July 16-18, 2025

28-31, NSBP-NSHP Joint Annual Conference, San Jose CA, November 19-23, 2025