



The Center for

BRIGHTBEAMS

A NATIONAL SCIENCE FOUNDATION SCIENCE & TECHNOLOGY CENTER

NEWSLETTER

FALL 2019

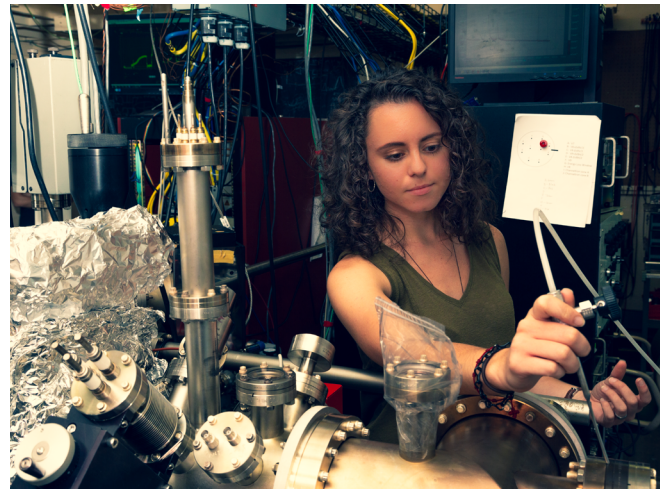
ISSUE 2

This was a busy summer for CBB. In June, we had our annual collaboration meeting, hosted a public symposium, met with our External Advisory Board, and had our annual site visit by the NSF. All in one week!

The collaboration meeting, described in this Newsletter, brought together CBB'ers for research, a communications workshop, and events that highlighted CBB's values of inclusion and teamwork. At the collaboration meeting, the senior investigators also adopted CBB Strategic Plan 2019, an annual update that responds to evolving world priorities and progress. This year's plan highlights semiconductor and novel photocathodes, new materials for accelerating cavities, and machine learning.

CBB is entering an important moment — our renewal for a second five year period. This has come quickly, as it feels like CBB, which is now starting its fourth year, has only just begun. We began our planning at the annual meeting and are now in the thick of it — stay tuned for more on that in the next newsletter. In the meantime, we are heartened by the assessment of the NSF Site visit committee: "Progress toward a successful renewal proposal is excellent." This is a tribute to the whole CBB team, and bodes well for Phase II !

Ritchie Patterson
Director of the Center for Bright Beams

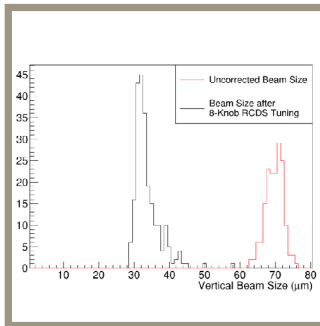


CBB REU Summer Student Grace Mattingly performing a leak test on a vacuum chamber with a Mott Polarimeter, used to measure polarization of GaAs photocathodes.

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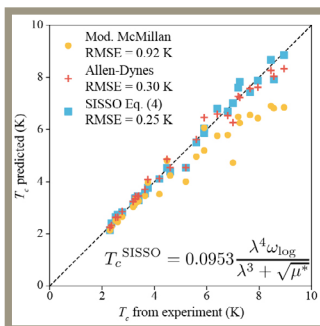


Online storage ring optimization using dimension-reduction and genetic algorithms

W. F. Bergan, I. V. Bazarov, C. J. R. Duncan,
D. B. Liarte, D. L. Rubin, and J. P. Sethna

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Image: Histogram of hundreds of experimental vertical beam size measurements both using the standard conditions for light-source operations with no additional tuning and after tuning with a local optimizer using the best 8 eigenparameters. A clear improvement is observed.

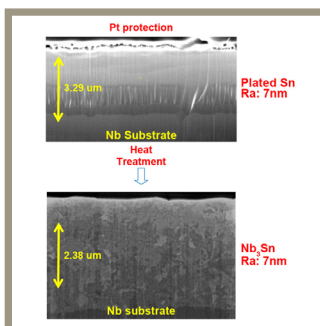


Functional form of the superconducting critical temperature from machine learning

S. R. Xie, G. R. Stewart, J. J. Hamlin,
P. J. Hirschfeld, and R. G. Hennig

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Image: Machine learning of optimal analytical expression for T_c . The 3-parameter machine-learned equation results in a smaller RMSE than the 4-parameter Allen-Dynes or the 3-parameter McMillan equation.

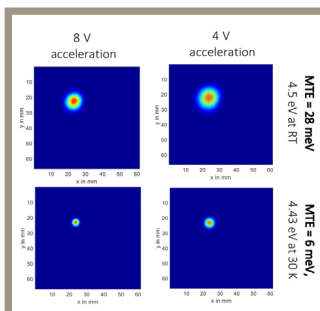


Electroplated Sn thin films enable low-roughness Nb₃Sn superconductor.

Zeming Sun, Ryan D. Porter, Katrina Howard, Thomas Oseroff, and Matthias U. Liepe (CLASSE, Cornell U); Nathan Sitaraman, Michelle Kelly, and Tomas Arias (Department of Physics, Cornell U); Kevin D. Dobson (Institute of Energy Conversion, U Delaware); Xiaoyu Deng (Chemical Engineering, UVA); Aine Connolly and Michael O. Thompson (Materials Science and Engineering, Cornell U)

[\(more\)](#)

Cross-section electron images of the electroplated Sn film (left) and thermally converted Nb₃Sn film (right), showing extremely low surface roughness.



Less than 10 meV from Cu

S. Karkare

[\(more\)](#)

With sub-meV energy resolution, researchers can now obtain complete energy/momentum distribution

New & Renewed Research Projects

1. 3-D energy-momentum distribution measurements from single crystal metals (Karkare / Knill)
2. *Ab initio* theory of photoemission from alkali antimonides and ordered semiconductors (Arias / Nangoi)
3. Air-stable, high performance photocathodes (Hines / DeBenedetti / Balajka)
4. Alkali Antimonide Photocathodes at High Gradient and High Laser Intensity (Maxson / Pennington)
5. Computational Screening of Materials for Low - Emittance Photocathodes (Hennig / Paul)
6. Development of nano-photoemission based sources (Karkare / Chubenko)
7. Exploring the role of surface order and band structure in bright photoemission sources (Maxson / Galdi)
8. Extreme High Brightness Electron Source from Intense Laser Illumination of Nano-Blades (Rosenzweig / Mann / Lawler)
9. Growth and characterization of alkali-antimonides (Karkare / Saha)
10. Measuring photoemission under extreme conditions (Bazarov / Pierce)
11. Nonequilibrium Femtosecond Photoemission and Ultrafast Electron Heating (Bazarov / Bae)
12. Study of Alkali Antimonide photoemission characteristics in very high gradient electron guns (Musumeci / Burger)
13. *Ab initio* theory of thin-film growth of Nb₃Sn (Arias / Sitaraman)
14. Alternative Materials for High Q0 and/or High Fields (Liepe / Oseroff)
15. Computational and experimental study of the synthesis and superconducting properties of the A15 phases. (Hennig / Hire)
16. Exploration of new materials and approaches for next-generation SRF surfaces (Liepe / Sun)
17. Field-Dependence of the BCS Surface Resistance and Impact of Impurity Doping (Liepe / Maniscalco)
18. Increasing Maximum Fields in Nb₃Sn (Liepe / Porter)
19. Microscopic imaging of defects and trapped flux and their impact on the SRF quench fields and residual resistances. (Muller / Cueva)
20. Periodically-driven and inhomogeneous superconductors: Theory and experimental predictions (Sethna / Liarte)
21. Rational design of Nb processing protocols (Arias / Kelley)
22. Studies of Nb Interfaces including Niobium Hydride Growth and Suppression using N Doping, and Local Tunneling Spectroscopy (Sibener / Veit / Thompson)
23. Surface Studies of Nb₃Sn Growth and Structure (Sibener / Farber / Graham / Veit / Thompson)
24. Vortex Nucleation and Dissipation in SRF Cavities (Transtrum / Pack)
25. Application of Machine Learning for Surrogate Modeling of FEL Processes for the LCLS (Kim / Oseroff)
26. Development of the ASU-DC cryogun and UED beamline (Karkare / Gevorkyan)
27. Emittance control in electron microscopy using Machine Learning (Muller / Cueva)
28. Experimental Demonstration of Quasi Integrable Octupole Lattice at the IOTA (Integrable Optics Test Accelerator) (Kim / Kuklev)
29. Investigation of a long-bypass for Optical Stochastic Cooling and Space-charge optimizations for low MTE photo-cathodes. (Bazarov / Andorf)
30. Investigation of Machine Learning based approaches in accelerator science for MOGA optimizations and transverse phase-space painting (Bazarov / Hua)
31. Machine-learning assisted ultralow emittance generation by flat beam transformation (Musumeci / Cropp)
32. Measuring <1nm normalized emittance and associated tradeoffs in space charge dominated bunches in the Cornell Cryogun (Maxson / Li)
33. Online tuning, real-time modeling, and aberration correction in electron microscopes (Maxson / Duncan)
34. Optical Transport and Beam Manipulation for Optical Stochastic Cooling (Piot / Dick)
35. Effects of zero MTE on electron brightness performance (Rosenzweig / Majernik / Robles)
36. The Effects of Stochastic Space Charge in High Brightness Photoelectron Beamlines for Ultrafast Electron Diffraction (Kim / Gordon)

Making Physics Relevant to Florida Middle Schoolers

Middle school teachers in Florida came to CBB with a challenge. Make physics relevant to our middle school classes! Get students to care about forces and actions!

In response, CBB graduate students and faculty developed a suite of experiments that illustrate the role of physics in a variety of water sports common in Florida. These experiments were designed to meet the Next Generation Sunshine State Standards for Science and were field tested at a teacher workshop at St Johns River State College in St. Augustine, Florida in July 2019. The activities were led by University of Florida (UF) Prof. Richard Hennig and Dr. Nancy Ruzycki.



Two of the experiments revolved around boat building and air boats. UF graduate students Joshua Paul and Eric Fonseca introduced the concept of buoyancy through a hands-on boat building activity. The goal of their experiment was to design an aluminum foil boat that could float while holding as much weight as possible. After constructing their boats, students test their design by carefully loading each boat with pennies until it sinks.

In a parallel activity, Cornell graduate student Christopher Pierce and UF undergraduate Devin Ritter introduced the concept of force using airboats. In the first part of the activity, students use a balloon and straw to construct an air-jet that can propel a paper boat across the floor. This activity is used to illustrate Newton's Third Law of Motion. Students then test the effects of balloon size on the distance the boat travels. Other activities were presented by Nathan Sitaraman, a Cornell graduate student. All of the experiments included a lesson plan, student worksheets, and assessment instruments.



Off to the races! Florida middle school teachers prepare to test their air boats while Prof. Richard Hennig looks on.

Field testing activities with teachers is an important step in developing effective activities that teachers will adopt in their classrooms. While field testing the airboat activity, a teacher pointed out that a number of cities in Florida are beginning to phase out plastic straws due to environmental concerns. To address this issue, CBB students are now revising the boat building activity to make it a greener choice. When the activities are complete, they will be made available to any teacher in the nation through our [online lending library](https://cbb.cornell.edu).

Recognitions



Stanislav Baturin

Assistant Professorship, Northern Illinois

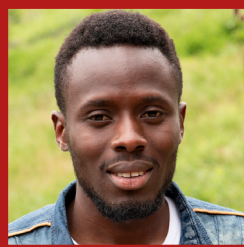
Postdoctoral Associate Stanislav Baturin, of the University of Chicago, has accepted an assistant professorship at Northern Illinois University.



Lipi Gupta

Office of Science Graduate Student Research (SCGSR) award

Graduate student Lipi Gupta, from the University of Chicago, has been selected by the U.S. Department of Energy Office of Science to receive an Office of Science Graduate Student Research (SCGSR) award.



Frank Ikponmwen

Ph.D. Recipient

CBB's Frank Ikponmwen received his Ph.D. in Physics from Clark Atlanta University. Thesis title: Quantum Efficiency of CsSb Photocathode and Study of Mg-Al Layered Double Hydroxide Intercalation. Dr. Ikponmwen will be joining the Food and Drug Administration.



Jared Maxson

Department of Energy Early Career Research Program Grant

Jared Maxson has become one of 73 scientists nationwide to receive an early career grant from the DOE. The program aims to bolster the nation's scientific workforce by supporting exceptional researchers during their crucial early career years.



Ryan Porter

Young Investigator Prize at SRF '19

Ryan Porter was recognized for the best oral presentation at SRF 2019 and awarded the Young Investigator prize. Criteria include relevance and impact of scientific work, novelty and quality of scientific work, quality of oral presentation, and interaction and professionalism towards the IPC.



River Robles

RadiaSoft scholarship

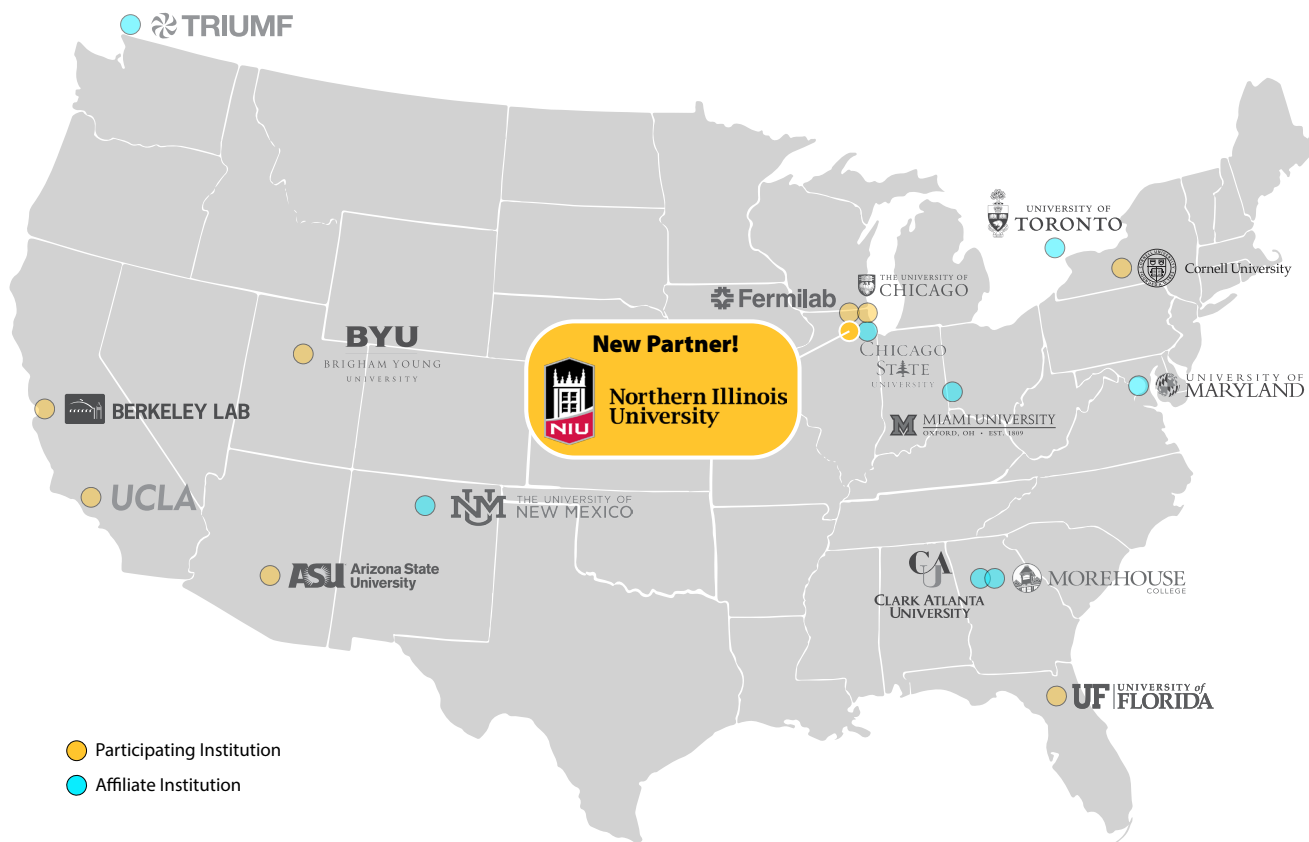
UCLA undergraduate student River Robles was selected to receive a scholarship to attend the USPAS summer 2019 session from RadiaSoft LLC.

CBB Welcomes New Partner, Northern Illinois!

PHILIPPE PIOT - Dr. Piot from Northern Illinois University joins the Center for Bright Beams.

Philippe did his doctoral work at Jefferson Lab (Ph.D. 99 from Universite de Grenoble-Alpes, France), and was a postdoc at DESY before joining Fermilab in 2002. Philippe is currently a faculty at Northern Illinois University jointly appointed with Argonne National Laboratory.

He will be collaborating with the BST team toward the development of the optical stochastic cooling technique. The research will initially focus on the development and experimental test of optical laser amplifier capable of amplifying radiation emitted by an electron beam. The system could eventually be used in future optical stochastic cooling experiments planned at the Fermilab IOTA ring. Likewise, the research will develop simulations of the planned proof-of-principle experiment at IOTA.



The 2019 Annual Meeting & Symposium

Particle accelerators, and the technology that enables them, are helping to shape the future. Things as diverse as extending Moore's law to combating climate change are being driven by the research being done at universities around the world, and particularly at the NSF-funded Center for Bright Beams.

To discuss and share these advancements, the Center for Bright Beams held its annual meeting and public symposium in late June on the Cornell University Campus. As CBB advances through its third year of funding, these meetings give CBB participants an opportunity to meet in-person, network, and build the camaraderie that is needed in order to operate an efficient science and technology center. [\(more\)](#)



Checking out the new handbook



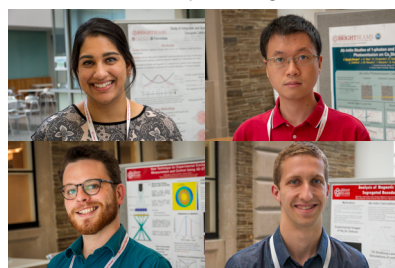
Rachel Farber presenting results



CBB Overview



Poster session



Poster winners



Post-meeting fun

The Alan Alda Workshop

The challenge in communicating science to the general public often lies in finding engaging hooks that draw the audience in without overwhelming them with background knowledge. The question is how to find these hooks, which can differ from person to person.

This is a problem that improv actors face all the time. Under WPA funding during the Great Depression, the renowned acting coach Viola Spolin developed a series of exercises to help actors communicate improvisationally while staying focused in the present moment. These exercises later informed the development of renowned acting troupes, such as Second City in Chicago.

One of Spolin's most famous students, Alan Alda, is best known for portraying iconic characters in TV shows such as M*A*S*H, ER, and The West Wing. While serving as the host of the television series Scientific American Frontiers, Alda realized that many of the scientists that he was interviewing could benefit from these same improvisational techniques.

This insight led to his creation of the Alda Method™ of science communication and the development of the Alan Alda Center for Scientific Communication at SUNY Stony Brook.



CBB graduate students Will DeBenedetti (left) and Lipi Gupta (right) practice Ta Da!

This summer two professional actors from Stony Brook led CBB students through a day-long workshop designed to develop these skills. In one exercise — known as Ta Da! — pairs of students practiced staying on their conversational task even in the face of errors and mis-steps. Every time someone made a mistake, the pair would celebrate the error with a big “Ta Da!” before immediately restarting their task. In a second exercise, each student had to hold up an invisible picture from their past and tell a story based on that picture to the audience. Using only words, could each student paint a vivid picture for their peers?



Summer Students - REU 2019

CBB strives to broaden the pipeline of accelerator scientists by increasing awareness of the discipline beyond the walls of national accelerator laboratories and by actively seeking out the participation of students and senior researchers from underrepresented groups. [The Research Experience for Undergraduates \(REU\)](#) has been a key component of this goal. Brigham Young University, the University of Chicago, and Cornell University hosted CBB REU programs again this summer.

Brigham Young University



Left to Right: David Diaz, Hera Wiegand, Emily Duden, Chris Layden, Wilber Dominguez.

Cornell University



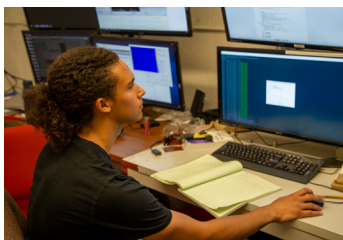
Left to Right: Brandon Hunt, Jamal Khayat, Grace Mattingly, Mathew Tao.

University of Chicago



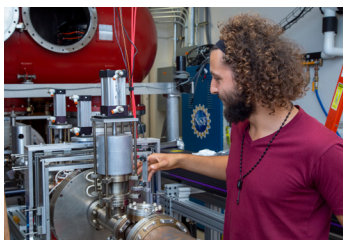
Left to Right: Andre Fonseca, Tamara Gonzalez-Acevedo, Chelsey Paola Gonzalez, Nikita Kuklev, & CBB Faculty.

Check out what a few REU students had to say!



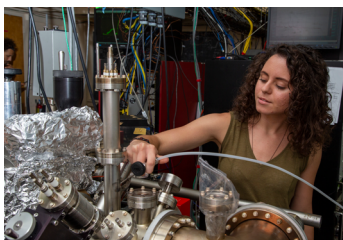
Brandon Hunt
Allegheny College

“By advancing my research, scientists will be able to develop a better understanding of the fundamental particle. This will allow for better technology to be developed, improving the lives of the general public.” [\(more\)](#)



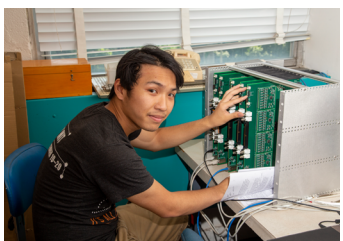
Jamal Khayat
University of Central Florida

“The part of this research that I found most challenging has been the same part that I enjoyed most: working on the boundaries of human scientific knowledge. In situations like these, there is no guidance on what to do or where to look next. It seems that a scientific intuition that one develops over time is what gives you guidance. And this is what I got to witness first hand by working alongside experienced researchers.” [\(more\)](#)



Grace Mattingly
Indiana University - Purdue University Indianapolis

“I believe that I am leaving here with a pretty complete grasp on experimental photocathode research and a better understanding of accelerator physics in general. Now the question of the type of research I want to pursue myself can be answered with slightly more completeness.” [\(more\)](#)



Mathew Tao
Purdue University

“I enjoyed interacting with my research group and being a member of the SRF team. The graduate and undergraduate students were insightful and always have interesting topics to talk about. The SRF BBQ's on Fridays in particular were among the highlights of my summer. While chowing down on hot dogs and hamburgers, conversation subjects ranged from Mellotrons to sea salt from France!” [\(more\)](#)

US Particle Accelerator School



The U.S. Particle Accelerator School will hold its next program in January 2020 in San Diego, CA. The courses offered at USPAS are intense and cover material not typically available at universities. The Center for Bright Beams presence at USPAS is strong with members spanning the Curriculum Sub-Committee, institutional board, advisory council, and attending students. In January 2020 the following courses will be taught by CBB members and affiliates.

Particle Driven Wakefield Accelerators

Instructors: James Rosenzweig, UCLA and CBB faculty member; Michael Litos, University of Colorado; Spencer Gessner, CERN

PhotoCathode Physics

Instructors: Ivan Bazarov and Jared Maxson, Cornell University; Sid Karkare, Arizona State University (all CBB faculty)

High Brightness Electron Injectors and Applications

Instructors: Daniele Filippetto (CBB affiliate) and Chad Mitchell, Lawrence Berkeley National Lab; Pietro Musumeci, UCLA (CBB faculty).

Happenings (stay up to date on CBB happenings cbb.cornell.edu/)

June 2019:

- CBB Seminar @ U Chicago: Dr. Sergey Baryshev, "Quantum Effects in Electron Emission from Nanodiamond"

July 2019:

- CBB/CLASSE Seminar @ Cornell: James Maniscalco, "Impurity-doped niobium and the field-dependent BCS resistance: The fundamental science of high-efficiency SRF cavities."

September 4 2019:

- CBB Special Seminar @ Cornell: Dr. John Smedley and Nathan Moody, "The LANL-BNL Collaboration." [Zoom](#) / [Poster](#)

September 9 2019 - 4:00pm:

- Communications Seminar co-sponsored by CBB @ Cornell: Eliza vanCort, "SPEAK AND BE HEARD: Communication Tools for Career Success." [Poster](#)

October 7 & 2019:

- CBB Workshop @ U. Chicago: "Electron-Ion Collider Cooling Workshop." [Indico](#)

October 21 2019 - 4:30pm:

- CBB Special Seminar @ U Chicago: Dr. Sandra Biedron: "Analytical Research Tools for Research - the systems that make them whole." [Zoom](#)

Recent Publications

- R. D. Veit, N. A. Kautz, R. G. Farber, and S. J. Sibener, "Oxygen dissolution and surface oxide reconstructions on Nb(100)," *Surface Science*, vol. 688, pp. 63-68, Oct. 2019.
- S. S. Baturin, "Hamiltonian preserving nonlinear optics," arXiv:1908.03520 [physics], Aug. 2019 [[Online](#)]
- C. Duncan et al., "A Generic Software Platform For Rapid Prototyping of Online Control Algorithms," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, Jul. 2019 [[Online](#)].
- A. Galdi et al., "Low energy photoemission from (100) Ba_{1-x}La_xSnO₃ thin films for photocathode applications," *Eur. Phys. J. Spec. Top.*, vol. 228, no. 3, pp. 713-718, July. 2019 [[Online](#)].
- O. Chubenko, S. S. Baturin, and S. V. Baryshev, "Theoretical evaluation of electronic density-of-states and transport effects on field emission from n-type ultrananocrystalline diamond films," *Journal of Applied Physics*, vol. 125, no. 20, p. 205303, May 2019 [[Online](#)].
- S. Keckert et al., "Critical Fields of Nb₃Sn Prepared for Superconducting Cavities," *Supercond. Sci. Technol.*, vol. 32, no. 7, p. 075004, May 2019.
- F.-H. Ji, D. Durham, A. Minor, P. Musumeci, J. Navarro, and D. Filippetto, "Ultrafast Relativistic Electron Nanoprobes," *Nature: Communications Physics*, vol. 2, no. 1, p. 54, May 2019.
- N. Kuklev, Y.-K. Kim, J. Jarvis, A. L. Romanov, J. K. Santucci, and G. Stancari, "Synchrotron Radiation Beam Diagnostics at IOTA-Commissioning Performance and Upgrade Efforts," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia* [[Online](#)].
- L. Gupta, S. S. Baturin, S. Nagaitsev, and Y.-K. Kim, "Study Integrable and Quasi-Integrable Sextupole Lattice," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- N. Kuklev, Y.-K. Kim, S. Nagaitsev, A. Romanov, and A. Valishev, "Experimental Demonstration of the Henon-Heiles Quasi-Integrable System of IOTA*," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- M. Gordon, Y.-K. Kim, and J. Maxson, "The Effects of Stochastic Space Charge in High Brightness Photoelectron Beamlines for Ultrafast Electron Diffraction," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- Maniscalco, J. T., M. Liepe, T. A. Arias, D. B. Liarte, J. P. Sethna, and N. Sitaraman, "Theoretical Analysis of Quasiparticle Overheating, Positive Q-Slope, and Vortex Losses in SRF Cavities," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- W. F. Bergan, I. V. Bazarov, C. J. R. Duncan, and D. L. Rubin, "Applications of Dimension-Reduction to Various Accelerator Physics Problems," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- S. Baturin, T. Nikhar, and S. Baryshev, "Field electron emission induced glow discharge in nanodiamond vacuum diode," *J. Phys. D: Appl. Phys.*, 2019 [[Online](#)].
- D. Hall, D. Liarte, M. Liepe, and J. Sethna, "Impact of Trapped Magnetic Flux and Thermal Gradients on the Performance of Nb₃Sn Cavities," *Proceedings of the 9th Int. Particle Accelerator Conf., IPAC2017, Copenhagen, Denmark*, May 2017 [[Online](#)].
- L. Gupta, S. S. Baturin, S. Nagaitsev, and Y.-K. Kim, "Study Integrable and Quasi-Integrable Sextupole Lattice," *Proceedings of the 10th Int. Particle Accelerator Conf., IPAC2019, Melbourne, Australia*, May 2019 [[Online](#)].
- W. F. Bergan, I. V. Bazarov, C. J. R. Duncan, D. B. Liarte, D. L. Rubin, and J. P. Sethna, "Online storage ring optimization using dimension-reduction and genetic algorithms," *Phys. Rev. Accel. Beams*, vol. 22, no. 5, p. 054601, May 2019.
- S. Karkare, J. Feng, J. Maxson, and H. A. Padmore, "Development of a 3-D energy-momentum analyzer for meV-scale energy electrons," *Review of Scientific Instruments*, vol. 90, no. 5, p. 053902, May 2019.
- D. H. Koh and S. S. Baturin, "Analytic model of 3D beam dynamics in a wakefield device," *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 925, pp. 128-132, May 2019.
- J. B. Rosenzweig et al., "Next generation high brightness electron beams from ultrahigh field cryogenic rf photocathode sources," *Phys. Rev. Accel. Beams*, vol. 22, no. 2, p. 023403, Feb. 2019.