UC Berkeley–led Nuclear Science and Security Consortium enters its eleventh year

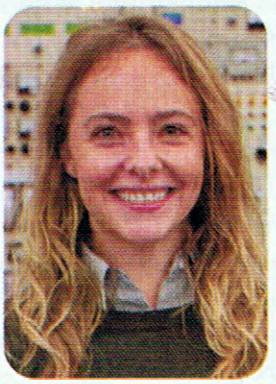
The Nuclear Science and Security Consortium (NSSC), led by the University of California–Berkeley, has begun its second decade as of 2022. The university–national laboratory partnership is funded by the Department of Energy's National Nuclear Security Administration, at first as a five-year program (NSSC1) awarded a $25 million grant in 2011 to develop laboratory-integrated experts in nuclear energy. In 2016, the NNSA extended the NSSC program for five more years (NSSC2) with another grant of $25 million. The NNSA renewed the NSSC with yet another five-year, $25 million grant in 2021. NSSC3 involves 11 universities and five national labs (see sidebar).

Consortium objectives

Vujic

The NSSC is directed by Jasmina Vujic, a professor of nuclear engineering at UC Berkeley who has extensive nuclear experience, including as chair of that university's Department of Nuclear Engineering and as director of the UC Berkeley Nuclear Research Center. At the consortium's NSSC3 Kickoff and Advisory Board Review meeting this past April, Vujic described the collaborative's three primary objectives as recruiting and training top students in relevant nuclear disciplines, connecting students with a core set of disciplines that support the nonproliferation and nuclear security mission, and expanding university–national laboratory collaboration to provide students with the opportunity to engage in basic and applied research under the guidance of academic advisors and lab scientists.

Vujic noted at the kickoff meeting that the consortium has successfully developed "a thriving pipeline from recruitment and mentorship of top students to a large pool of skilled talent [that has] transferred to careers [in] the national laboratories, academia, and industry. In addition, the NSSC has demonstrated scientific excellence in innovative basic and applied research in nuclear security science and engineering."



Goldblum

Bethany L. Goldblum, a research engineer in UC Berkeley's Department of Nuclear Engineering and a staff scientist at Lawrence Berkeley National Laboratory, is the NSSC's executive director and education lead. In summarizing the consortium's objectives, she said, "In short, we aim to support the education and training of talented scholars in nuclear science and engineering and create opportunities for high-impact, collaborative research with our national laboratory partners."

NSSC research activities

The research and development activities of the NSSC are organized into two main themes. One theme—fundamental nuclear sciences—consists of the focus areas of nuclear physics and nuclear data, radiochemistry and nuclear chemistry, and nuclear materials science. The other theme—applied nuclear science and engineering—includes the focus areas of radiation detection and nuclear

NSSC partners

More than 150 professors, researchers, and students are currently involved in the NCCS's work at the following universities and national labs:

Air Force Institute of Technology
George Washington University
Michigan State University
North Carolina State University
Texas A&M University
University of California–Berkeley
University of California–Davis
University of Illinois–Urbana-Champaign
University of Nevada–Las Vegas
University of New Mexico
University of Tennessee–Knoxville
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Sandia National Laboratories

chemical engineering/nuclear engineering. These R&D areas are linked with the two cross-cutting activities of computing and optimization in nuclear applications and education in nuclear science, technology, and policy. Each university student is matched to one of the research areas for academic and laboratory mentorship.

The focus area of nuclear physics and nuclear data has the goal of training scholars through joint work with academic and national lab leaders in nuclear physics and nuclear security, as well as moving students and innovative ideas from the university into nonproliferation work. Examples of specific topics covered in this area include rare isotopes, neutrino nuclear physics, and nuclear matter at extreme energy and density.

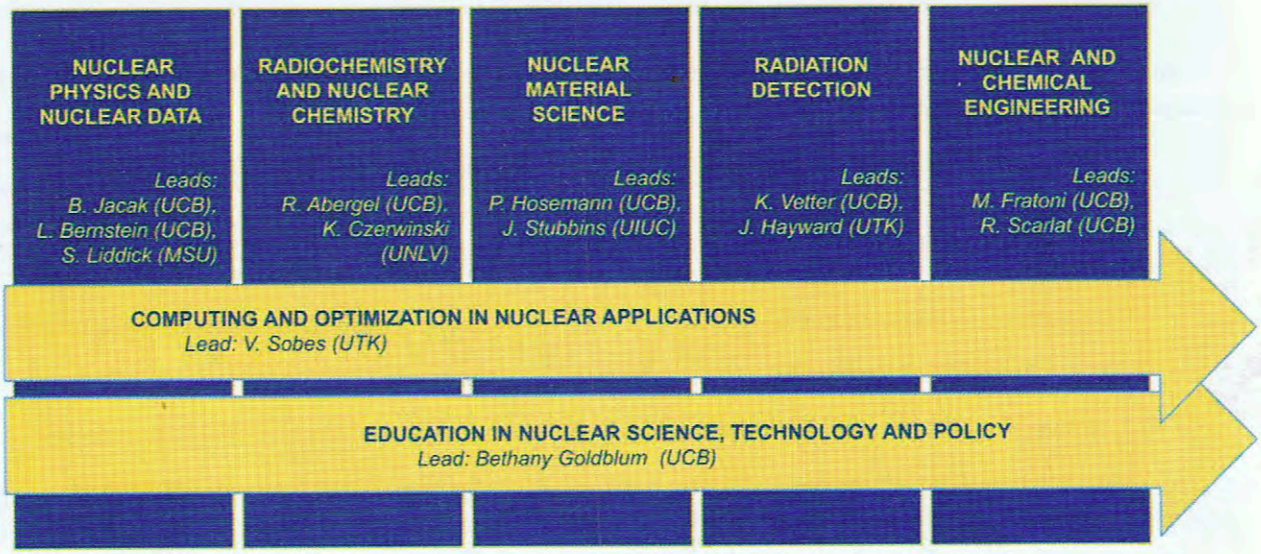
Students in the radiochemistry and nuclear chemistry area are exposed to such topics as chemical synthesis and speciation, advanced spectroscopic techniques, and chemical separations. The area of nuclear materials science covers radiation effects in materials, advanced manufacturing and materials synthesis, and predetonation and postdetonation nuclear forensics, among other topics. The focus area of radiation detection addresses such subjects as radiation imaging systems; detector materials; and detector development, readout, and characterization.

These NSSC research areas provide excellent opportunities for students and researchers to collaborate in cutting-edge technology. The NSSC website summarizes some of the advanced radiation detection technologies to which students are exposed: "Multi-modality fusion allows us now to see the nuclear world in three dimensions and in real time; machine learning algorithms will provide unprecedented means to use information to segment and track objects in complex scenes, predict radiological backgrounds, estimate relevant physical quantities and their uncertainties, and visualize scenes and objects with the embedded and quantifiable radiological information via advanced concepts in computer vision."

The NSSC website further notes, "The potential development and deployment of advanced and alternative [nuclear] fuels and the associated fuel cycle facilities pose new challenges to the NNSA mission to detect, secure, and dispose of nuclear and radiological materials." Such challenges are addressed in the consortium's research area of nuclear chemical engineering/nuclear engineering. Some of the topics covered in that focus area are in situ monitoring of alternative fuel cycles; safeguards for emerging fuel cycles; radioisotope production; proliferation-resistant fuel technology; and volatility, solubility, and speciation.

In the NSSC's research focus area of computing and optimization in nuclear applications, students, educators, and researchers work

Education continues



NSSC students collaborate with national laboratory scientists to conduct cutting-edge research in five focus areas and two crosscutting activities. (Image: NSSC)

together on such complex technological issues as stochastic media radiation transport and nuclear signature analysis, artificial intelligence optimization and networked detection, AI-based identification of nuclear resonances, characterization of reactor fuel isotopes, and optimization of neutron spectra tailoring.

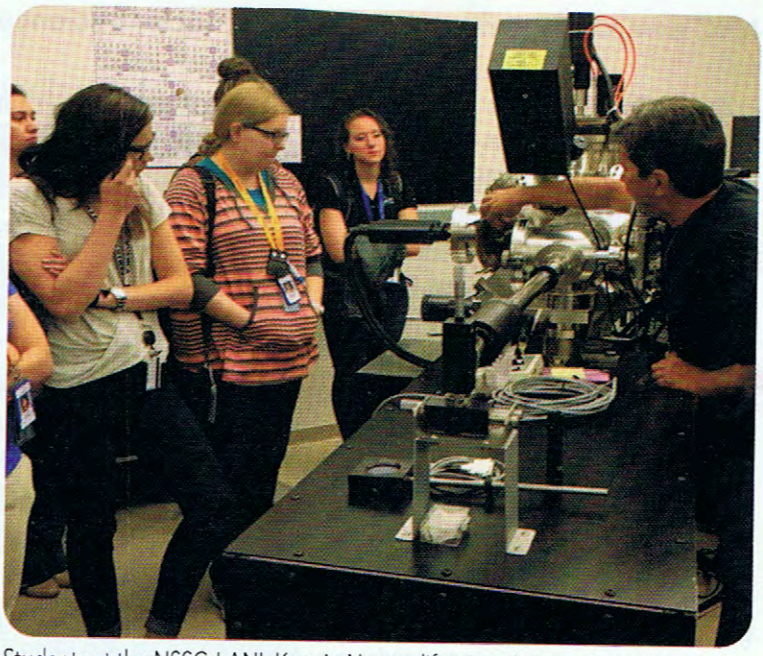
NSSC educational activities

Education in nuclear science, technology, and policy is at the heart of the NSSC's mission and involves such activities as national lab mentorships and fellowships, classroom-based and online learning, workshops, conferences, and summer school programs. All of these activities are designed to produce students with strong science and engineering foundations and broad nuclear security perspectives.

The consortium awards fellowships to students, postdoctoral researchers, and research specialists selected by faculty at partner universities based on academic merit and demonstrated competence. NSSC fellows are trained in disciplines required for careers in national labs or other nuclear-related positions. They train with mentors, attend professional conferences and workshops, and participate in summer programs to further develop their research skills and technical expertise. NSSC education lead Bethany Goldblum explains, "Every NSSC scholar is required to have both an academic advisor and a national laboratory mentor. This is designed to facilitate student engagement with cutting-edge research at the national labs, including in-residence research with students working hand in hand on-site with national lab scientists." More than 160 lab researchers have mentored NSSC fellows and affiliates since 2016.

The NSSC has also offered research fellowships and awards for students from minority communities through its MSI (minority serving institution) Initiative. During NSSC1, five multiyear research awards and 18 summer research fellowships were granted to university students through the MSI Initiative.

The consortium has sponsored courses and lectures on the campuses of partner schools, along with online recorded lectures. Examples of lecture titles include "Nuclear security: The nexus between policy and technology," "A hands-on introduction to radiation detection," and "The science of nuclear materials." Webinars have included a presentation in January 2022 on "Nondestructive characterization techniques used to secure air, land, and sea ports" and a speaker series in the spring of 2021 featuring recent NSSC program alumni. During 2020 and 2021, a virtual learning series supported continued connections between students and national lab experts during the COVID-19 pandemic.



Students at the NSSC-LANL Keepin Nonproliferation Science Summer Program. (Photo: NextEra Energy Resources)

Recent NSSC workshops and conferences include the 2022 NSSC3 Kickoff and Advisory Board Review, a virtual event held in April to introduce the consortium's new university partners and research directions, survey past accomplishments, and showcase research by NSSC scholars. Additionally, Virtual Scholar Showcases, with representatives from national labs and other government agencies, have featured research presentations from graduate students and postdoctoral fellows. In-person workshops have featured oral presentations from NSSC fellows, poster sessions, and tours of national laboratories.

Upcoming, the NSSC–Los Alamos National Laboratory Keepin Nonproliferation Science Summer Program will be an eight-week extended research internship held June 21–August 12, 2022. As in previous years, students in this program will gain access to mentors from LANL and Sandia National Laboratories and opportunities for lab-directed research in physics, nuclear engineering and nonproliferation, space research, international and applied technology, and national security. Also scheduled for 2022 are the Nuclear Data Summer School and the Nuclear Analytical Techniques Summer School.

One more highlight, the NSSC's Public Policy and Nuclear Threats Boot Camp, was hosted by the Institute on Global Conflict and Cooperation at the University of California–San Diego in 2021. That summer workshop-in-residence was designed to give participants "the knowledge and analytic tools to contribute to the debate on future U.S. nuclear policy," according to the website. A 2022 version is slated for July 31–August 12.

Accomplishments

The foremost desired result of the NSSC is to transition students into careers in the national laboratories or other institutions supporting the NNSA's nuclear security agenda. As of early 2022, 141 NSSC alumni, or about 45 percent of NSSC scholars, are employed in national labs or other government institutions. Approximately 60 NSSC alumni are working in nuclear security–related careers in academia, while other alumni are in positions within the commercial nuclear industry.

Since its establishment in 2011, the efforts of the NSSC have supported 182 undergraduate students, 277 graduate students, 52 postdoctoral scholars, 17 research specialists, and 83 faculty—a total of 611 individuals. The consortium's work has also supported or contributed to hundreds of oral presentations, poster presentations, and peer-reviewed publications.

Reflecting on the NSSC's accomplishments in April 2022, Vujic observed, "The UC Berkeley Department of Nuclear Engineering faculty had the vision, the knowledge, and the experience to assemble the multi-institutional winning team . . . and to foster the development of science and technology underlying the nuclear security mission, with long-term investments in our greatest asset of today and tomorrow—our incredible students, who will contribute to a safer and more peaceful world."

Education continues