

The G. Robert Keepin Nonproliferation Science Summer Program

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INTRODUCTION

Los Alamos National Laboratory (LANL) has provided decades of leadership in nonproliferation. Fifty years of end-to-end international safeguards support to the International Atomic Energy Agency (IAEA) has included developing technology, training inspectors, and providing experts. Much of the laboratory's legacy in this area was built on the shoulders of giants like G. Robert Keepin, the first pioneer of physics-based safeguards. Keepin believed that the United States should take a lead in nonproliferation and that Los Alamos was the right place to grow safeguards science and technology because of its unique mission, technical expertise, and facilities necessary for the required research and development (R&D). In 2017, LANL established the G. Robert Keepin Nonproliferation Science Summer Program, honoring this champion of international safeguards. The program was jointly established with the University of California–led Nuclear Science and Security Consortium (NSSC) with the goal of exposing students to the broader nuclear nonproliferation mission that is underpinned by advances in R&D. During the program's inaugural summer, a cadre of 20+ undergraduate and graduate students from 14 top-tier universities were provided an opportunity to spend an entire summer learning about how game-changing science, engineering, and technology are applied to reduce the dynamic threats of nuclear proliferation. The students spent a majority of their time performing research on real-world projects with a Los Alamos mentor. The program was designed such that the research experience was complemented by weekly activities that aimed to provide broad exposure to the nonproliferation mission space through lectures, hands-on training, and technical tours. Proximity to Sandia National Laboratory (SNL) afforded the students an opportunity to spend two days exploring the facilities unique to Sandia. With excellent reviews from both the LANL mentors and students at the conclusions of the both the 2017 and 2018 summers, the program was hailed as a tremendous success and a useful model for continued efforts to strengthen the national security workforce pipeline. A majority of students stated that they plan to continue working in careers supporting the nonproliferation mission, and most of them intend to do so at Los Alamos.

MOTIVATION

The National Nuclear Security Administration’s (NNSA) Office of Research and Development (NA-22), established three large university-led consortia for multi-disciplinary R&D, education, and training in nuclear nonproliferation: the NSSC run by the University of California at Berkeley, the Consortium for Verification Technology (CVT) led by the University of Michigan, and the Consortium for Nonproliferation Enabling Capabilities (CNEC) out of North Carolina State University. LANL provides consortia students and faculty access to unique technical capabilities, facilities, and expertise in order to help them understand tackle dynamic national security challenges through game-changing science and engineering.



2018 Keepin Program flyer

Under the purview of NA-22, LANL and the NSSC jointly established the Keepin Program in 2017. During the program, the students participate in more than 10 facility tours at LANL and SNL, experience more than 20 unique lectures related to nonproliferation and nuclear safeguards, and complete a summer internship outside of these activities. These elements of the Keepin Program allow the students to connect the basic science they perform at their home universities to real-world national security challenges in the nonproliferation mission space. Ultimately, the Program’s goals are: 1. To create working relationships between students and LANL scientists, 2. To increase the number of students performing lab-directed research at LANL, and 3. To turn research and training into careers for those students at the national laboratories.

LECTURES

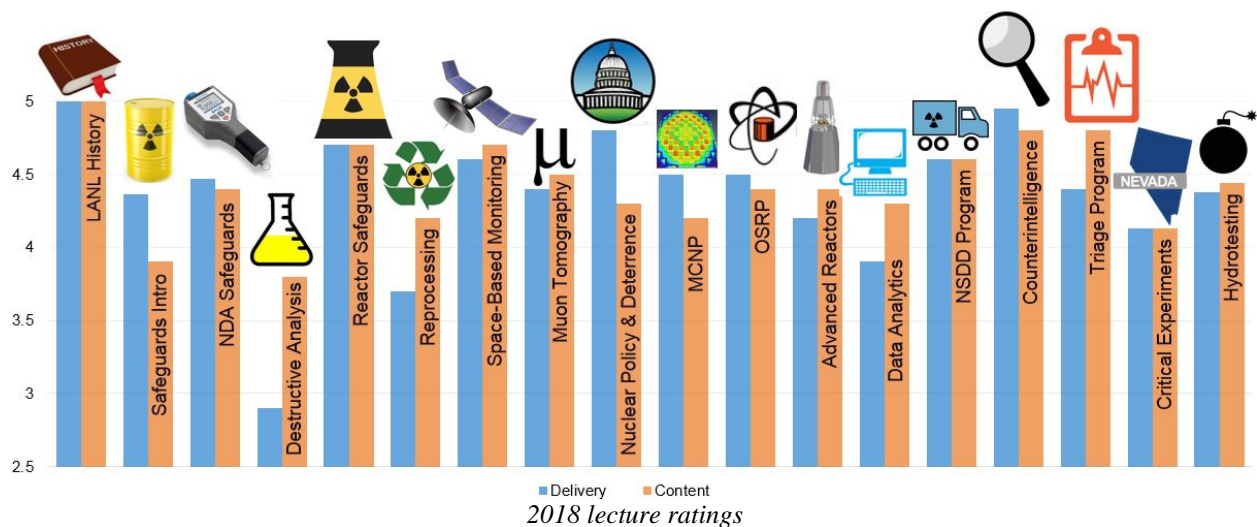
Eighteen lectures were given at LANL as part of the Keepin Program’s 8-week duration during the summer of 2018. The program organizers identified topics with relevance to nuclear nonproliferation, ranging from data analytics to reprocessing safeguards. With a list of topics in mind, LANL subject matter experts (SMEs) in those fields were polled for availability and interest in speaking with a group of students. To ensure the quality of the presentations, the SMEs were asked to prepare their talks two months in advance of the summer program and deliver them to an audience of year-round students and early career staff at LANL. The audience provided anonymous, candid feedback on the presenter’s delivery and lecture content which was then shared with each of the SMEs. The lecturers were given time to make changes to their presentations as needed, allowing for more effective delivery to the Keepin students later in the summer.

Lectures took place nearly every Monday and Wednesday of the summer, allowing for students to spend the rest of their weeks on project work for their laboratory mentor. A complete list of technical lectures given at LANL in 2018 is included below.

Overview of International Safeguards	Nuclear Policy & Deterrence Issues
Critical and Subcritical Experiments with Special Nuclear Material	Nuclear Deterrence and Vigilance: Space-Based Explosion Monitoring

Destructive Analysis Technology Overview	Reactor and Spent Fuel Safeguards
The Radiological Triage Program	Data Analytics for Nonproliferation
Fuel Fabrication Safeguards, Reprocessing Safeguards Instrumentation	Computational Modeling and Simulation for Nonproliferation
A Case Study in Counterintelligence	Non-Destructive Assay Technology Overview
Nuclear Smuggling, Detection, and Deterrence Program	National Security Through Radioactive Source Removal
Proliferation Footprints: Hydrotesting Around the World	Small Special Purpose Nuclear Reactors for Government Use

After each day of lectures, the students were asked to provide ratings and commentary on the talks that they heard. During both the summers of 2017 and 2018, the delivery and content of all presentations averaged excellent ratings: over 3.5 out of 5. The aggregate survey results from each talk in 2018 is included below.



TOURS

The lectures throughout the summer were supplemented by tours of the unique facilities at LANL and SNL. Experienced tour guides gave students an idea of the day-to-day operations at these facilities, answered thoughtful questions, and connected the basic science back to the bigger national security picture. A list of the Los Alamos tours is included below:

- Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT)
- Supercomputing Complex
- Los Alamos Neutron Science Center (LANSCE)
- Bradbury Science Museum
- Space Detection Instruments Laboratory



Keepin students operating an interactive hot cell at LANSCE, LA-UR-18-27867

Given the proximity of LANL to Albuquerque, the students have had the opportunity to spend two full days at Sandia National Laboratory both years of the program. The program's Sandia counterparts prepared an exciting series of tours, talks, and hands-on exercises that also earned high ratings from the Keepin students:

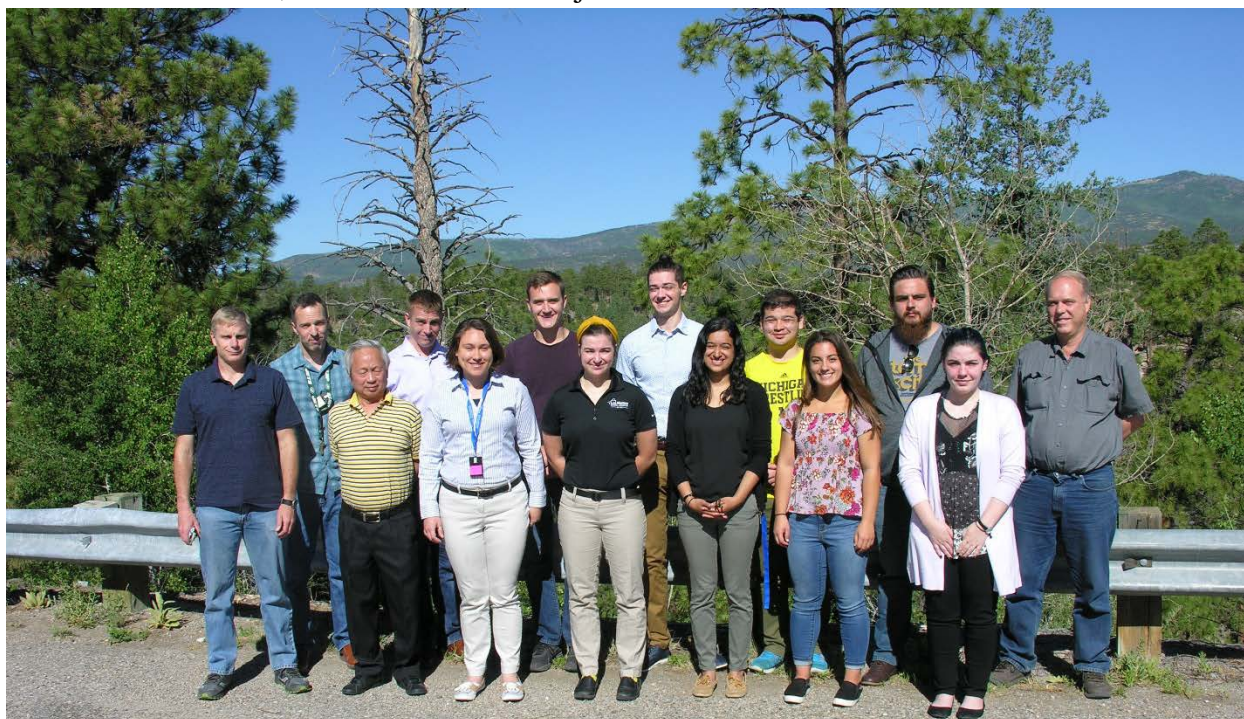
- Unclassified Nuclear Weapons Museum
- Source Search Exercise
- Z-Machine
- Laser Applications (LAZAP) facility
- Gamma Irradiation Facility (GIF)



Students participating in the outdoor source search activity at Sandia National Laboratory

According to student ratings, the most popular tours have been DARHT, the Unclassified Nuclear Weapons Museum, and the Source Search Exercise that took place at Sandia.

Several of the Keepin students also participated in an optional, week-long training course on nondestructive assay (NDA) techniques. The LANL course, which has been used to train IAEA inspectors since the 1980s, was designed to provide trainees with hands-on experience in measuring special nuclear materials. The course content includes laboratory exercises in neutron and coincidence counting, passive and active assay, gamma spectroscopy, radionuclide identification, uranium enrichment, plutonium isotopic composition, and verification. When surveyed, the students unanimously agreed that the course quality was high, that the practical exercises were useful, and that the course objectives were met.



Participants from the 2018 Fundamentals of Nondestructive Assay course

A second optional part of the Keepin Program that was unique to the summer of 2018 was a trip to the Nevada National Security Site's (NNSS) Device Assembly Facility (DAF). Nearly all of the 2018 Keepin students participated in the optional trip, and quite a few of them reflected on the experience as being the highlight of the summer. On their first morning at the NNSS, the students visited the Sedan Crater, a 1,280-foot wide by 320-foot deep crater formed in 1962 during an excavation experiment using a 104 kiloton thermonuclear device. The rest of the afternoon was spent at the National Criticality Experiments Research Center (NCERC), where the students heard lectures about critical and subcritical experiment design, execution, and measurement. One of the most exciting activities involved a hands-on demonstration with 4.5 kilograms of weapons-grade plutonium in which the students got to handle the material and learn about neutron multiplication. Pictures from the Nevada trip are below:

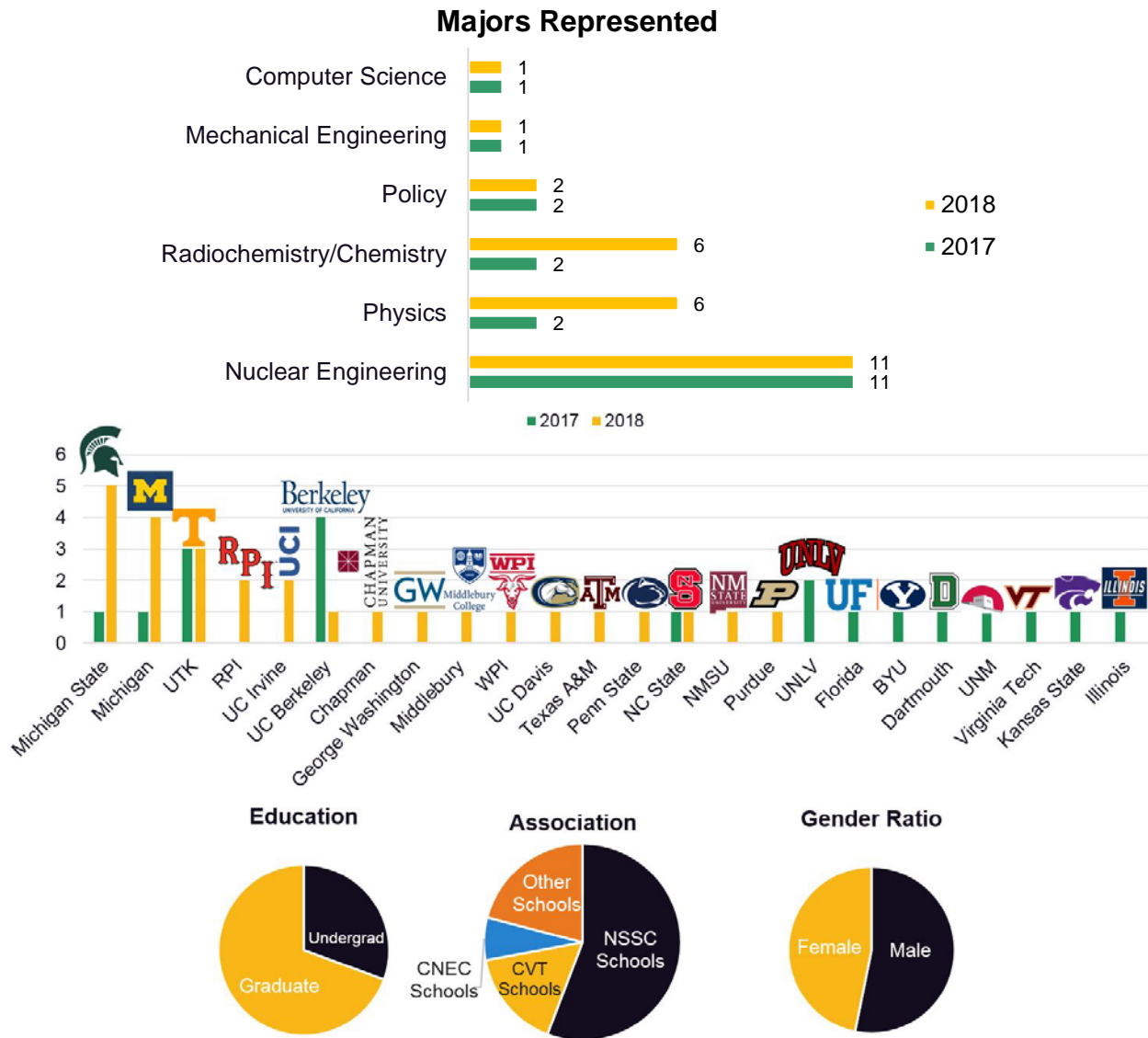


Top left: students receiving a lecture at NCERC; Top right: Keepin student Kim Pestovich handling 4.5kg of plutonium; Bottom: Students at the Sedan Crater site

INTERNSHIP

The lectures and tours mandated as part of the Keepin Program only accounted for 15% of the students' total time during their 8 weeks at LANL. The remaining 85% was dedicated to a technical project that the student worked on for their laboratory mentor. These projects have ranged in scope from detector characterization to the creation of an international nuclear threat matrix, depending on the student's academic background.

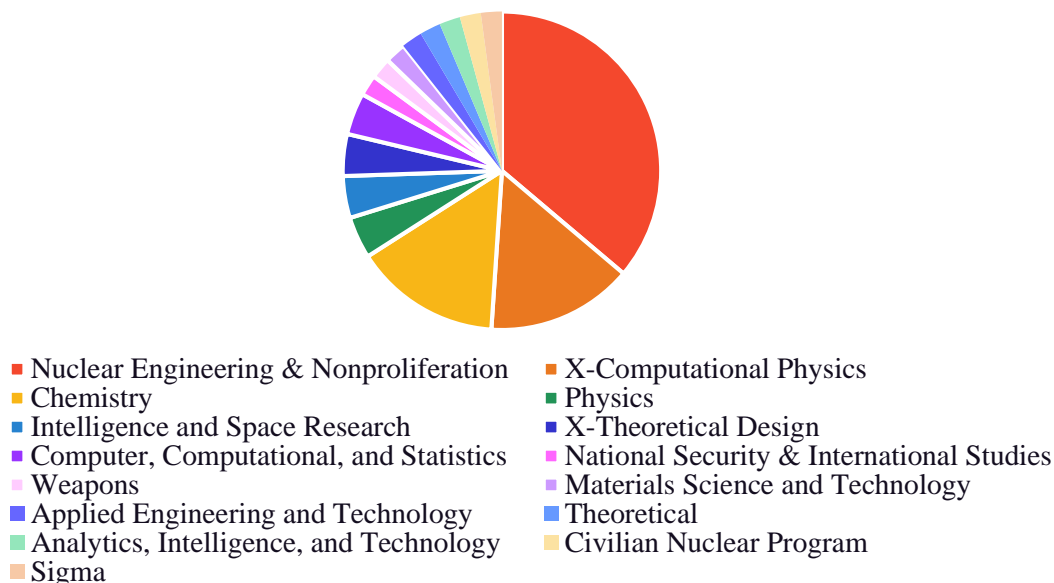
In addition to the NSSC fellows that are required to attend the Keepin Program each year (about half of the participant cohort), the program organizers have opened applications to undergraduate and graduate students across the country. The acceptance rate for external applicants has averaged 45% across the two summers. The students themselves represent a diverse of cross-section of individuals, as shown by the aggregated demographics for 2017 and 2018 below.



Aggregated demographic information for all Keepin students 2017-2018

In addition to a strong application, student acceptance into the Keepin Program is contingent upon finding that student a mentor at the laboratory with a suitable technical project. As the most time intensive part of preparing for the program, mentor matching required a constant dialogue between program coordinators and various LANL staff members. Once a funded project and mentor was identified, the program organizers would facilitate a conversation among the mentor, the student, and the student’s faculty adviser. The conversation would lead to the formation of a hiring package, which program coordinators would track from inception to acceptance. The below graph illustrates the diversity of laboratory groups that have received Keepin students over the last two summers:

Mentor Divisions



As a result of performing a summer-long research project together, the students and mentors have built positive relationships with each other. The mentors who responded to the 2017 and 2018 feedback surveys averaged a rating of 4.75 out of 5 for their students’ performance, and many of them expressed interest in continuing to mentor Keepin students. In holding personal debriefs with small groups of the students (and one-on-one in some cases), we learned that most of them would like to continue working with LANL in some capacity as they continue or finish their degrees.

LOOKING AHEAD

Lauded as “an emerging best practice” by all stakeholders, the Keepin Nonproliferation Science Summer Program has continued to be critical to the strengthening of the national laboratory pipeline. This pipeline includes students at the undergraduate and graduate level, students that have completed their terminal degree (post-bachelors, post-masters, and post-doctoral), and laboratory staff members that are early in their careers. By advertising the game-changing science and technology that underpins nonproliferation missions through programs like Keepin, LANL is able to attract some of the best talent coming out universities and beyond.

In the 2017 and 2018 Keepin Program closeout surveys, the students were asked about their plans for the future. Nearly every student respondent indicated that they planned to continue working

with LANL in some capacity, including internships, remote work, thesis collaborations, or post-doctoral work. A majority of respondents said that the Keepin Program increased the likelihood of their doing dissertation research at LANL, and many were more likely to consider careers in nonproliferation at the national laboratories, the Department of Energy, or the IAEA. Of the student cohort in 2017, almost half of the students returned to Los Alamos in the summer of 2018 to continue their technical projects – one of whom became a permanent LANL staff member. These numbers are indicative of success across the board, and it is hoped that such success will attract new, bright students to apply to future iterations of the Keepin Program.

ACKNOWLEDGEMENTS

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The 2018 Keepin Nonproliferation Science Summer Program students and staff