Pathways to Improved Representation in Advanced Nuclear Science (PIRANS)

Final Technical Report

DOE-SMCCCD-SC0021954

Prepared by:
Emilie Hein
Skyline College
Physics and Astronomy Department
3300 College Dr, San Bruno, CA 94066

Grant Number:
DOE DE-SC0021954

Sponsoring Program Office:
U.S. Department of Energy Office of Science (Office of Nuclear Physics)

Recipient:
San Mateo County Community College District/Skyline College
3300 College Dr, San Bruno, CA 94066

Funding Period:
07/01/2021-08/31/2023

Team:
PI: Kolo Wamba; Co-PI: Emilie Hein
Lab Coordinator: Marco Wehrfritz

Acknowledgement of Federal Support:
This material presented is based upon work supported the U.S. Department of Energy Office of Science (Office of Nuclear Physics), Pathways to Improved Representation in Nuclear Science under Award Number DE-SC0021954.

Disclaimer

This work was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third partys use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, its contractors or subcontractors.

Table of Contents

Abstract

This is the final technical report on Pathways to Improved Representation in Advanced Nuclear Science (PIRANS) DOE Award No. DE-SC0021954. This project was funded by the US DOE Office of Science (Office of Nuclear Physics) under its Research Traineeships to Broaden and Diversify Nuclear Physics initiative and started at Skyline College, San Bruno, California, in the Summer of 2021. Skyline College is a federally recognized Minority Serving Institution (MSI) and the only institutional member of nEXO that is a community college, creating a unique, accessible, and rigorous research hub to its students. Over the duration of the project, 13 student trainees were able to make significant contributions to nEXO detector R&D and to nEXO DEI initiatives. They had opportunities to present their work locally, as well as at national conferences, engage in public outreach, and contribute to various programs across campus, expanding the impact of the project to the wider college community.

1. Introduction

1.1 What is nEXO?

nEXO is an international collaboration comprising some 150 individuals representing 40 institutions. Its mission is to perform a nuclear physics experiment that will search for and possibly discover neutrinoless double-beta decay in ^{136}Xe.

Skyline College, one of the three community colleges that form the San Mateo County Community College District in California, joined the nEXO collaboration in January 2021. Skyline College, a minority-serving institution (MSI), is the first community college to join the nEXO collaboration.

1.2 Project Goals

The primary goal of the project was to support Skyline College student involvement in ongoing research and development for nEXO. Ultimately, the project's outcome is to increase the number of students from underrepresented populations who choose to pursue graduate studies in nuclear physics. Given that student trainees are community college students, they are in the early stages of their educational journey, and it is therefore difficult to assess their future in the field of nuclear physics. In order to assess the success of the project, a number of learning outcomes were identified. After completing the program, trainees should: (1) be acquainted with the field of experimental nuclear physics; (2) have confidence in their ability to independently pursue graduate studies in experimental nuclear physics; (3) have a clear sense of the career possibilities in nuclear physics; and (4) have seen firsthand and understand how a modern experimental nuclear physics project is run.

They were also expected to acquire the following skills: (1) computer programming; (2) electronics test and assembly; (3) rapid prototyping; and (4) design of experiments.

1.3 Timeline

Student trainees were divided into several cohorts. They were to receive technical training and work on nEXO related projects under the guidance of the PI and co-PI, as well as other members of the nEXO Collaboration, specifically from the Stanford University and SLAC National Accelerator Laboratory groups. They worked on a full time basis in the summer (36.25 hours per week), and part-time during the academic year (7.5 hours per week).

A first cohort of four students joined PIRANS on July 1, 2021 and were part of the program until the end of Spring 2022. Subsequently, four student trainees started in Summer 2022 for the academic year 2022-2023. Another student joined the group in the Spring 2023, after two of them had to leave the project. Finally, four other students joined the nEXO group at Skyline College to complete summer internships in the Summer 2023.

1.4 Collaborating Organizations

nEXO Collaboration (https://nexo.llnl.gov/), in particular

- nEXO DEI Committee (https://nexo.llnl.gov/diversity-equity-inclusion)
- nEXO group at SLAC National Accelerator Laboratory
- nEXO group at Stanford University

INSIGHT Resource Center
https://www.insightnp.org/

1. Project Activities

2.1 Workshops

Every new group of students who joined the project completed a series of workshops.

Technical Workshops

To attain the project goals and prepare student trainees to work on their individual projects, they all completed a series of hands-on workshops, gaining technical skills, in the following areas:

- Soldering
- 3D design and printing
- Arduino programming
- Eagle circuit design and Printing Circuit Board (PCB) milling
- Laser cutting

- Python programming

This also allowed them to build confidence to use the tools available to them in the Fabrication Lab at Skyline College.

Physics of nEXO

The student trainees also participated in activities to learn about the Physics of nEXO, so they would understand the context of the experiment and how they would be contributing. It was also expected that they would be able to explain the motivations for nEXO when presenting their work. They also attended nEXO collaboration meetings, remotely or in person, depending on the location of the meeting. In addition to providing an opportunity for networking with nEXO collaborators, it allowed them to learn about more aspects of the experiment in more depth.

Diversity, Equity, and Inclusion (DEI)

In addition, student trainees explored Diversity, Equity, and Inclusion (DEI) related topics and tools to help them overcome barriers that often affect underrepresented students pursuing an education in physics, such as imposter syndrome. Most student trainees joined the nEXO DEI committee, which was a great experience to network with nEXO collaborators, in a non-technical context.

2.2 Individual Projects

Each student trainee was given an individual nEXO project to work on, based on their interests. Most of the projects involved collaboration with mentors at SLAC National Accelerator Laboratory. For some projects, they were able to complete part of the work there, and completed training to allow them to do so and obtain badges. Otherwise, the work was done at Skyline College, in the Physics Lab or the Fabrication Lab.

Some of the student projects focused on the hardware and software of the Xenon Purity Monitor (XPM), located at SLAC National Accelerator Laboratory. For example, one of the student projects was to improve an optical shutter control box. An optical shutter switchbox is used to electronically open and close a shutter to either block or allow laser light into the xenon vessel. An enhanced switchbox was designed, prototyped, and tested in the Fabrication Lab at Skyline College, then brought to SLAC National Accelerator Laboratory for assembly and installation.

Another project was focused on recovering the performance of used quartz optical fibers that are used on the liquid xenon purity monitor at SLAC National Laboratory. Due to long exposure to UV light, the quartz fibers on the liquid xenon purity monitor have developed color centers that reduce the transmissivity of the fibers and make it difficult to collect results in the XPM.

Many more projects were completed, such as SLAC Rn-still scale calibration to monitor the liquid xenon or charge readout tiles assembly and testing. Student trainees also assembled small cosmic ray detectors, used for outreach.

Student trainees also built ePortfolios to record and share their progress, as well as reflect on their experiences.

2.3 Presentations

All student trainees were given opportunities to present their work either locally or at a national conference.

A number of students presented posters at the SACNAS National Diversity in STEM (NDiSTEM) Conference in 2021 and 2023. They were scheduled to attend and present at SACNAS NDiSTEM in 2022 but the trip was ultimately not approved, due to uncertainty following a hurricane in Puerto Rico. Instead, they were able to attend APS DNP in New Orleans, Louisiana.

Students also participated in the annual Undergraduate Symposium of Academic Research (uSOAR) at Skyline College, where they gave oral and poster presentations. They also contributed to the Science in Action seminar series by presenting posters and to Expanding Your Horizons, a conference for middle school girls interested in learning about career opportunities in math and science.

2. Products

3.1 Conference Publications

Pathways to Improved Representation in Advanced Nuclear Science
Emilie Hein, Kolo Wamba, 2021 Fall Meeting of the APS Division of Nuclear Physics, Virtual, October 11-14, 2021
https://meetings.aps.org/Meeting/DNP21/Session/QM.10

Pathways to Improved Representation in Advanced Nuclear Science
Emilie Hein, Kolo Wamba, Kolo, Marco Wehrfritz, Brendan Murtagh, Shannon Hoang, Madeleine McSwain, Jiries Kaileh, APS April Meeting 2022, Virtual, April 19-22, 2022
https://ui.adsabs.harvard.edu/abs/2022APS..APRB13003M/abstract

Pathways to Improved Representation in Advanced Nuclear Science: Year 2 Status Report
Kolo Wamba, Emilie Hein, Marco Wehrfritz, Sara Ellingsworth, Jonathan Mariano-Smith, Carol Sanders, Paul-Frederik Schubert, Fall 2022 Meeting of the APS Division of Nuclear Physics, New Orleans, Louisiana, October 27-20, 2022

https://meetings.aps.org/Meeting/DNP22/Session/EM.5

3.2 Posters

Bad@Math Podcast: DEI Issues and its Effects on the STEM Workforce
Shannon Hoang, 2021 SACNAS National Diversity in STEM (NDiSTEM) Conference, Virtual, October 25-29, 2021

Synchronization of Multiple AD2 (Analog Discovery 2) USB Oscilloscopes for Low Cost Per Channel Digitization
Jiries Kaileh, 2021 SACNAS National Diversity in STEM (NDiSTEM) Conference, Virtual, October 25-29, 2021

Improved Technique for Measuring LXe Chemical Purity
Madeleine McSwain, 2021 SACNAS National Diversity in STEM (NDiSTEM) Conference, Virtual, October 25-29, 2021

Recovering the Performance of Damaged Quartz Optical Fiber
Brendan Murtagh, 2021 SACNAS National Diversity in STEM (NDiSTEM) Conference, Virtual, October 25-29, 2021

nEXO Xenon Purity Monitor (XPM) Laser Attenuator Control
Codie Lai, 2023 SACNAS National Diversity in STEM (NDiSTEM) Conference, Portland, Oregon, October 26-28, 2023

3.3 Website

Project page: https://skylinecollege.edu/physics/#nexo

3.4 Other Products

Inclusive Excellence Workshop Session
Emilie Hein, Kolo Wamba, Low Energy Community Meeting 2001, Virtual, August 9-11, 2021
https://indico.frib.msu.edu/event/41/attachments/162/1351/InclusiveExcellenceWorkshop_program.pdf

Skyline College Receives US Department of Energy Grant Award to Work on nEXO
Shannon Hoang, Jiries Kaileh, Madeleine McSwain, Brendan Murtagh, Emilie Hein, Kolo Wamba, Skyline Shines, September 2, 2021
https://skylineshines.skylinecollege.edu/uncategorized/skyline-college-receives-us-department-of-energy-grant-award-to-work-on-nexo/

Skyline College nEXO Group Participate in and Present at National Scientific Conferences

Shannon Hoang, Jiries Kaileh, Madeleine McSwain, Brendan Murtagh, Emilie Hein, Kolo Wamba, Skyline Shines, November 5, 2021
https://skylineshines.skylinecollege.edu/uncategorized/skyline-college-nexo-group-participate-in-and-present-at-national-scientific-conferences/

Student Research Panel: nEXO
Shannon Hoang, Jiries Kaileh, Madelaine McSwain, Brendan Murtagh, Science in Action Seminar, Skyline College, San Bruno, California, November 30, 2021
https://skylinecollege.edu/scienceinaction/archive.php

Women in STEM Panel: A Collaboration with Associated Students of Skyline College in honor of Women's History Month
Jing Folsom, Emilie Hein, Kirsten McMichael, Science in Action Seminar, Skyline College, San Bruno, California, March 16, 2022
https://skylinecollege.edu/scienceinaction/

Creation of Cosmic Watch Muon detectors
Jiries Kaileh, 2nd Annual Undergraduate Symposium of Academic Research (uSOAR): Promoting Academic Excellence, Skyline College, San Bruno, California, April 27-28, 2022
https://skylinecollege.edu/usoar/presenters.php

Student Keynote Speaker
Jonathan Mariano-Smith, 2nd Annual Undergraduate Symposium of Academic Research (uSOAR): Promoting Academic Excellence, Skyline College, San Bruno, California, April 27-28, 2022
https://skylinecollege.edu/usoar/panelists.php

Faculty Research Panelist
Kolo Wamba, 2nd Annual Undergraduate Symposium of Academic Research (uSOAR): Promoting Academic Excellence, Skyline College, San Bruno, California, April 27-28, 2022
https://skylinecollege.edu/usoar/panelists.php

nEXO Group Embarks on Second Year of Research
Emilie Hein, Sara Ellingsworth, Jonathan Mariano-Smith, Carol Sanders, Paul-Frederik Schubert, Anthony Tran, Kolo Wamba, Skyline Shines, September 9, 2022
https://skylineshines.skylinecollege.edu/uncategorized/nexo-group-embarks-on-second-year-of-research/

Skyline nEXO Group Presents at the 2022 APS DNP Conference in New Orleans
Sara Ellingsworth, Jonathan Mariano-Smith, Carol Sanders, Paul-Frederik Schubert, Kolo Wamba, Emilie Hein, Skyline Shines, November 18, 2022
https://skylineshines.skylinecollege.edu/uncategorized/skyline-nexo-group-presents-at-the-2022-aps-dnp-conference-in-new-orleans/

Particle Detectives Workshop
Emilie Hein, Sara Ellingsworth, Carol Sanders, Paul-Frederik Schubert, Valeria Zarco, 40th Annual Expanding Your Horizons in Math and Science conference for young women, Skyline College, San Bruno, CA, March 18, 2023
https://skylinecollege.edu/eyh/

The TMT Controversy: What it is and What it Means for nEXO
Kolo Wamba, nEXO DEI Seminar, Virtual, April 24, 2023

Broadening Nuclear Physics: A Feminist in a Feynmanist World
Sara Ellingsworth, 3rd Annual Undergraduate Symposium of Academic Research (uSOAR): Promoting Academic Excellence, Skyline College, San Bruno, California, May 2-3, 2023
https://skylinecollege.edu/usoar/presenters.php

How to Navigate Parenthood as a Physicist
Emilie Hein, nEXO DEI Seminar, Virtual, May 15, 2023

nEXO Group Wraps Up Its Second Year
Sara Ellingsworth, Carol Sanders, Paul-Frederik Schubert, Chase Marangu, Phone Thant Myo, Kolo Wamba and Emilie Hein, Skyline Shines, May 26, 2023
https://skylineshines.skylinecollege.edu/uncategorized/nexo-group-wraps-up-its-second-year/

nEXO Summer Interns Conclude Productive and Enriching Research Experience
Simon Hermann, Codie Lai, Phone Thant Myo, Emma Redalen, Emanuel Gonzalez, Ethan Kong, Kolo Wamba, Marco Wehrfritz, Emilie Hein, Skyline Shines, August 24, 2023
https://skylineshines.skylinecollege.edu/uncategorized/nexo-summer-interns-conclude-productive-and-enriching-research-experience/

3.5 Honors and Awards

- *Student Presentation Award SACNAS NDiSTEM 2021*

3.6 nEXO publications

Development of a ^{127}Xe calibration source for nEXO
B.G. Lenardo et al 2022 JINST 17 P07028

3. Impact, Lessons Learned and Next Steps

In many ways, the PIRANS project accomplished the goals that had initially been set, while impacting more students than what had originally been proposed.

The first cohort of trainees all successfully graduated from San Mateo Community College District and transferred to the University of California, Berkeley in the Fall 2022 and will be graduating with their bachelor's degrees at the end of academic year 2023-2024. Most of them plan to go on to graduate school.

The second cohort of trainees are also preparing for the next step in their educational journey. One of them is now an Electrical and Computer Engineering graduate student at the University of California, Santa Cruz. Another one is in the process of applying for graduate school. One is also completing coursework while working full time at a startup specializing in AI.

Three of the four student trainees who had been part of the Summer 2023 program are now continuing working on nEXO related projects, as part of the new NP-RENEW award (DE-SC0024677), while the other one transferred to the University of California, Davis. All the student trainees presented the work they completed over the summer on August 3, 2023, with family and friends in attendance, as well as SLAC National Accelerator Laboratory mentors, the Interim Dean of STEM and Vice President of Instruction, during a special presentation session open to the public.

During the second year of the PIRANS project, two student trainees left the program during the academic year. The factor that led students to leave the program early was the high cost of living in the Bay Area and the necessity to seek external employment to earn a living. This was considered in the NP-RENEW grant proposal, since the 7.5 hours per week dedicated to the program during the academic year was not enough to keep students engaged in a way that they could continue taking classes, while being able to afford living expenses.

The PIRANS mentors and students gave some visibility to advanced nuclear physics projects they were working on, through outreach efforts and presentations on various platforms, such as Expanding Your Horizons geared toward middle school girls, SACNAS NDiSTEM, or APS DNP. These efforts inspired about a dozen additional students to sign up for nEXO related projects as honors projects, creating an even larger group of students with a newfound interest in nuclear physics. In addition to the technical and academic training the students received, they also learned about the importance of DEI in physics and beyond. Having community students present on complex projects on national platforms also helped bring awareness about the potential for advanced research that can be carried on by community college students. This can inform REU programs to expand recruitment efforts to their local community colleges and reach a student population that may not have access to such opportunities otherwise.

The nEXO group at Skyline College will be able to continue and expand these efforts thanks to the Department of Energy's Nuclear Physics – Reaching a New Energy Sciences Workforce (NP-RENEW) Award No. DE-SC0024677.