COVER PAGE

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Principal Investigator Information: Dr. Nathaniel T Klema	**Recipient Organization:** Fort Lewis College 1000 Rim Dr Durango, CO 81301-3908 Country: USA **UEI:** G595XDTMK443

ACCOMPLISHMENTS

The primary goal of the program Engaging Indigenous Women in Nuclear Physics is to provide students of Fort Lewis College with experience engaging in Nuclear Physics research at Los Alamos National Labs, toward both expanding the particle physics workforce and strengthening educational opportunities in the Four Corners region. Specifically students are expected to learn the necessary skills to work in the Nuclear Physics field from theory and experimental design, to reporting and dissemination of results. Students are prepared for the internship by participating in focused meetings and workshops throughout the academic year, where they build on foundations of their undergraduate education to gain the specialized knowledge required to succeed in applied research. These meetings are facilitated by Co-PI Cesar Da Silva of Los Alamos National Labs, who in the final months of the academic year works with each student individually to identify a project aligned with their skills and interests, which will be their focus during the summer months. Over the summer students live in Los Alamos where they work in person with Co-PI DaSilva for 15 consecutive weeks. As part of the internship participants travel to partner labs, where they take part in data collection and analysis alongside leading researchers who help them develop the critical approach that will lead them to competency in the field. Upon completion of the internship students present results both at a local research symposium at Fort Lewis College, and at a national conference. This program is an extension of the pilot program “Engaging Indigenous Women in Gluon Saturation Search in Nucleus” initiated by the DOE NP.

In 2025 grant approval occurred late in the Fort Lewis spring semester, and so it was not possible to onboard students in time to do preliminary workshops and meetings. Three students were selected who had some background in the field of Nuclear Physics having participated in the DOE pilot that preceded the current program. These students were selected specifically as there was insufficient time to onboard new students and give them the requisite knowledge to succeed in the summer program. Each of these students worked on distinct projects, all of which were rooted in outstanding questions in the study of nuclear processes. The three projects are outlined briefly below.

The first project focused on developing an AI model to identify Inverse Compton photons, which come directly from particle interactions between gluons and quarks, and are thus a direct way to explore gluon distributions within an atomic nucleus. The student, a computer engineering major at Fort Lewis College, developed a Convolutional Neural Network that takes as inputs all spatial and momentum asymmetries, and identifies whether a photon is coming directly from a gluon or from a regular meson decay. The model achieved 92% accuracy on simulated data, an unprecedented level of accuracy within the momentum range at which these processes are explored. The student is working to submit these results to a technical journal by December 2025. In addition the approach is being adopted by scientists at the Large Hadron Collider Beauty (LHCb) at CERN and will soon be applied to real data from proton-lead collisions to better understand inverse Compton processes.

The second student worked on ongoing efforts to identify theoretically predicted "glueballs" in LHCb data. Glueballs are a bound state of gluons that are difficult to identify as they have the same quantum numbers as scalar and tensor mesons. To search for them the student identified resonance peaks in collision environments thought to be rich in gluons. In particular they measured the ratio between hypothetical glueball candidates and the better-understood Φ meson in both proton-lead and lead-proton collisions. Such states should be preferentially produced in proton-lead collisions, so looking at ratios of resonances between the proton-lead and lead-proton collisions. The student found promising results, which were presented at the Fort Lewis College Fall Research Symposium, and which will be submitted to an academic journal in the coming months. In addition the results will be presented at the annual American Physical Society Division of Nuclear Physics conference in Chicago in October 2025.

The third project looked at collective particle behavior in heavy-ion collisions by studying azimuthal anisotropies within quark-gluon particle flows. There is a history of studying particle flow using azimuthal anisotropy, but so far most studies use 1-d Fourier expansions in which it is difficult to remove secondary effects of the particle flow, such as di-jets that make it difficult to determine the background plane. The student worked to address this challenge by instead implementing a spherical harmonic decomposition better suited to the dimensionality of the problem. While finding appropriate spherical harmonic fits is difficult given the myriad of secondary di-jets produced in such particle flows, the method has produced promising results with potential to aid in understanding complexities of non-perturbative QCD. While the results are not yet ready for publication they were presented at thee Fort Lewis College fall research symposium, and will be presented at the American Physical Society Division of Nuclear Physics conference in Chicago in October 2025.

The results outlined above demonstrate the efficacy of the program in preparing students for doing applied research in Nuclear Physics. However it is important to note that each of these students participated in the pilot program, and thus these results are not reflective of participation in a single grant cycle. However, these students will assist in the training and professional development of the next cohort of participants as they will in-part mentor the new students through the early stages of the program.

In the next reporting period we plan to recruit students throughout the fall 2025 semester so that they have sufficient time to learn background information before starting the internship in summer 2026. As outlined in the proposal this will be accomplished through weekly meetings with Co-PI DaSilva and his team at Los Alamos in addition to regular meetings and discussions with PI Klema. In addition PI Klema is working with alumni from the 2025 program to develop outreach an outreach program to help make regional high-school and college students aware of opportunities in Nuclear Physics in the Four Corners region. As an example PIs Klema and DaSilva are working to build a portable cosmic ray detector that can be taken to regional high schools and be used as a demonstration to get students interested in Nuclear Physics and associated career paths. In addition a small portion of the program budget will go to making videos outlining the science in a format accessible to non-specialists. Each project will be outlined in short format (~5 min) videos that demonstrate both the underlying theoretical concepts, and the advancement made by participating students. These can be shown in outreach demonstrations and posted online to be made accessible more broadly. We expect these videos to be highly effective in helping prospective physics students see career potential in the Nuclear Physics field. This will serve to increase awareness of, and participation in, the Fort Lewis College Physics program and make for a more competitive pool of students to pursue future opportunities through the Los Alamos collaboration. In addition this effort will complement the dissemination of results in academic journal and at professional conferences and make the products of the internship program accessible to a wider audience.

PRODUCTS

The products shown below include only Publications with a 'Published' status and Intellectual Properties with a 'Granted' status. Products with other statuses are not included in this report. The Revision Type indicates whether a product is New (newly added), Updated (existing product modified), or No Change (existing product reported without modifications) during the current budget period. Note that 'Updated' statuses may appear more frequently as products progress through the publishing process. All products listed have been reported for the current project period of this award.

PUBLICATIONS

There are no publications to report.

INTELLECTUAL PROPERTIES

There are no intellectual properties to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

The table below only contains participants who have identified an affiliation with the Awardee Institution. Participants from any associated subawards may not be included in this count.

PARTICIPANTS DETAIL

Project Role	Number of People	Total Person Months Worked
Co-Investigator	1	1
Principal Investigator/Project Director	1	2
Undergraduate Student	3	12
Total Responses	**5**	**15**

PARTNERS DETAIL

Partner: Los Alamos National Labs, Los Alamos, NM, USA

IMPACT

- What was the impact on the development of the principal discipline(s) of the project?

The three participants in the summer internships provided by this grant during the summer of 2025 each did their own research project, each of which contributed to our understanding of the behavior and makeup of fundamental particles. All three projects were focused on advanced data-processing techniques that provide potential improvements to the processing and interpretation of highly messy data from collisions in particle accelerators. The three projects specifically are outlined below.

The first project focused on developing an AI model to identify Inverse Compton photons, which come directly from particle interactions between gluons and quarks, and are thus a direct way to explore gluon distributions within an atomic nucleus. The student, a computer engineering major at Fort Lewis College, developed a Convolutional Neural Network that takes as inputs all spatial and momentum asymmetries, and identifies whether a photon is coming directly from a gluon or from a regular meson decay. The model achieved 92% percent accuracy on simulated data, an unprecedented level of accuracy within the momentum range at which these processes are explored. The student is working to submit these results to a technical journal by December 2025. In addition the approach is being adopted by scientists at the Large Hadron Collider Beauty (LHCb) at CERN and will soon be applied to real data from proton-lead collisions to better understand inverse Compton processes.

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- What was the impact on other disciplines?

While their are no direct impacts on other disciplines, participation of Fort Lewis students in research at this high a level allows them to bring valuable skillsets and scientific insight back to be shared with their peers studying in adjacent fields of Physics and Engineering.

- What was the impact on physical, institutional, and information resources that form infrastructure?

Each of the three students who participate in this program developed software that aids in the interpretation of particle collision data. In the academic tradition these software resources will continue to be built upon by the Los Alamos National Labs High Energy Nuclear Physics group toward improving the institutional ability to interpret particle collision data.

- What was the impact on technology transfer?

At least two of the projects conducted during the summer of 2025 are likely to be published in peer-reviewed journals, and so the data processing techniques, and the resulting data interpretations, will be available to the general public. In addition the further development of the resulting software resources will further development of state-of-the-science data interpretation workflows.

- What was the impact on society beyond science and technology?

This internship is specifically tailored to women from indigenous communities, which are historically not represented in the field of High Energy Nuclear Physics. Their skillsets and accomplishments thus contribute to workforce development in the Four Corners region, where job opportunities in theoretical physics exist but have not seen much engagement from regional communities. Thus these internships both contribute to local workforce development in theoretical physics, but also provide job pathways for regional communities that have historically not participated in the physical sciences.

- What was the impact on the development of human resources?

This project contributes greatly to the development of human resources on the campus of Fort Lewis College (FLC), and specifically the Applied Physics program. As a small regional college FLC does not have the resources to help students build skills in modern theoretical physics, which can limit the degree to which the school can prepare students for modern science careers. Thus this internship provides valuable professional development for the students, who in turn bring back a strong foundation of knowledge and experience that can be shared with the rest of the student population. In addition the returning students help with the development of educational resources that strengthen the FLC physics program, and thus contribute to workforce development in the Four Corners region.

- What percentage of the award's budget was spent in foreign country(ies)?

12.9% of this years budget was used for lodging during student visits to the Large Hadron Collider in Geneva, Switzerland. This part of the budget is only to support student travel and does not otherwise contribute to foreign organizations.