Advanced Scientific Computing Research (ASCR): RENEW Awards

QIST in the CSU: Expanding Access to Quantum Information Science and Technology

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Quantum Information Science and Technology (QIST) has been identified as an important component of U.S. scientific leadership, national security, and economic competitiveness. As such, developing a workforce capable of thriving in a quantum landscape is crucial. The goal of this project is to help meet this need and broaden participation in the QIST field. This goal will be achieved through a two-pronged approach; 1) focusing on providing student opportunities and support in the QIST field, and 2) focusing on faculty professional development aimed at building capacity within the California State University (CSU) system to provide sustained pathways into the QIST field. Student-focused activities include high school to undergraduate bridge programs, cohort-based learning communities, and hands-on research experiences, while faculty-focused activities will include workshops focusing on QIST concepts and effective pedagogy, faculty online learning communities supporting the incorporation of QIST topics into undergraduate curriculum, and QIST resource sharing across the CSU. By incorporating separate student-focused and faculty-focused activities, this project will have both immediate and long-term impacts on QIST workforce training and education.

This research was selected for funding by the Office of Science Advanced Scientific Computing Research Program.

Toward Efficient Quantum Algorithm Execution on Noisy Intermediate-Scale Quantum Hardware

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The future of computing is quantum, an emerging computing paradigm that will offer a computational speedup for critical applications. Near-term quantum computers, referred to as Noisy Intermediate-Scale Quantum (NISQ) computers, are expected to have a transformative impact on applications demanding intense computation, such as machine learning and physical and chemical simulations. While these computers are very promising, they are fragile and operate in the presence of errors. As a result, there is a gap between current and near-term quantum hardware capabilities and quantum algorithms, which should be addressed to exploit the power of quantum computers. Although error correction is the ultimate solution to suppress errors and enable the correct execution of quantum algorithms, they are infeasible for near-term quantum computers due to the massive number of physical qubits required to correct errors. Existing software techniques to optimize the design of quantum algorithms mainly focus on reducing the number of quantum gates and circuit depth. To extract useful information from these devices we need to better understand the noise in quantum systems and develop scalable software techniques to minimize errors, known as error mitigation techniques, which are applied to quantum circuits that run on the quantum computers, and compilation techniques informed by the behavior of the errors.

To this end, this project will provide research and training programs to enable efficient and reliable executions of quantum algorithms on large-scale quantum computers.

The proposed research project will (i) build a theoretical foundation of quantum noise modeling and its impact on quantum circuit design and (ii) develop a robust and scalable software package for error mitigation that requires minimum interaction with quantum computers and noise-aware quantum circuit optimization methods. The research project will deliver innovative error mitigation tools applied before and after the execution of quantum circuits and noise-aware quantum circuit optimization tools to enable reliable executions of quantum algorithms on near-term quantum machines. Hence, the project will enable optimizing large-scale quantum circuits for different quantum algorithms (e.g. dynamic quantum simulation and approximate optimization algorithms).

The project also aims at building the next generation of quantum computing experts and increasing both the capacity and quality of traditionally underrepresented minorities (URM) participation in quantum computing. The project will foster research on quantum computing for a diverse student body, enable collaboration across different disciplines, and support individual growth and professional development in quantum computing. In addition, it will build a strong foundation in quantum information science and quantum computing for the broad community at the City College of New York (CCNY) through collaboration with the Co-Principle Investigator from Lawrence Berkeley National Laboratory (LBNL) to ensure the success of the proposed research program and provide a theoretical foundation of the proposed research project. Toward this end, the project will provide an extensive two-pronged training program involving onsite training at the CCNY open to all the CCNY community including students, faculty, and staff to increase participation of underrepresented groups in the quantum computing workforce and summer research at LBNL to enable interacting with a broader team of quantum focused researchers with a diverse background including physics, computer science, and applied mathematics at the laboratory. Throughout the project period, the Principle Investigators will synergize their expertise in circuit synthesis and testing and quantum computing to push forward the proposed training and research program to increase the participation of underrepresented groups in the quantum computing workforce.

The success of the proposed research will facilitate the deployment of reliable quantum computing systems that can serve several applications such as healthcare, energy, and financial applications, and broaden the impact of quantum computers, which can potentially enable breakthroughs in scientific research. This project will (i) build a strong collaboration with experts in quantum computing (i.e. Lawrence Berkeley National Laboratory), (ii) foster multidisciplinary research and workforce development (computer science/engineering, physics, and math), which can be integrated with on-going research in CCNY's School of Engineering programs, and (iii) broaden participation in quantum computing including underrepresented groups. To engage and teach the next generation of quantum computing experts, the project uses several mentoring activities for URM in various capacities including undergraduate and graduate students and even post-graduate. Several metrics will be used to evaluate the increase in participation of underrepresented groups and institutions in the quantum computing workforce.

The results of the research will be disseminated and published at premier conferences and journals in the areas of quantum computing, electronic design automation, and architecture. These journal and conference papers will be accessible from the publisher's electronic library for validation of results. Student theses will also be produced in this project and will be accessible through City College libraries.

This research was selected for funding by the Office of Science Advanced Scientific Computing Research Program.

Training a Diverse Quantum Workforce in Carolinas through Establishing the Winston-Salem Quantum Education Collaboratory (WS-QEC)

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Quantum Information Science and Engineering (QISE) is an emerging field of technology with potential to revolutionize the world of computation in the near future and push the frontiers of science and engineering. This project addresses the increasing needs for a diverse quantum workforce by establishing the Winston-Salem Quantum Education Collaboratory (WS-QEC). The Collaboratory led by the Winston-Salem State University (WSSU) centers its focus on working with regional education centers in developing curricula for QISE that support the needs of the quantum industry. Through partnership with Clemson University WS-QEC provides access to state-of-the-art research facilities to complement the in-class learnings with hands-on experiences for its participants. As a regional hub for QISE workforce development, WS-QEC has the goals of 1) training a diverse pool of undergraduate students in QISE from women and underrepresented minorities of Carolinas; 2) providing opportunities for hands-on research experiences for its trainees through summer internships; 3) supporting instructors from other regional colleges and universities in the Carolinas (NC and SC) in developing introductory QISE coursework for their students. The program contributes to sustainable pathways for the underrepresented students to participate in QISE workforce upon college graduation or after attending MS/PhD program at Clemson or other R1 institutions. Ultimately, the education and infrastructure developed by the WS-QEC will serve as a model for producing a diverse QISE workforce.

This research was selected for funding by the Office of Science Advanced Scientific Computing Research Program.

Biological and Environmental Research (BER): RENEW Awards

Climate-Ready Engineers for Water Resources Applications

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Climate change is expected to enhance the water cycle and alter the characteristics (e.g., frequency, severity) of extreme events (e.g., droughts, floods, extreme precipitation, heatwaves, wildfires) around the world. Extreme events can have significant societal, environmental, infrastructure, and economic impacts, yet many questions remain about the impact of climate change on water and energy supplies and how a better understanding of the changing extremes and their impacts can be translated into direct use (e.g., engineering design, resource management, risk assessment, adaptation and mitigation practices). Engineers must be prepared to address such challenges that climate change and extremes pose to our natural and built systems (e.g., water, food, energy, and transportation systems and infrastructure). To develop a climate-literate and prepared future engineering workforce, engineering students need to be engaged with current climate science, especially since existing design standards and codes were not created to account for climate change-fueled extremes and may need to be reevaluated and updated. Since engineers are vital boundary spanners in making climate science actionable and translatable into sustainable practices, this project aims to lead the development of a climate-ready engineering workforce that is prepared and trained to address water challenges across a variety of spatiotemporal scales. We propose to create the 4-year Climate-Ready Engineers for Water Resources Applications (CREW-RA) program at California State University, Long Beach (CSULB) in partnership with the Calibrated & Systematic Characterization, Attribution & Detection of Extremes (CASCADE) Science Focus Area (SFA) at Lawrence Berkeley National Laboratory (LBNL) to train engineering students through hands-on experience and mentorship at the intersection of engineering and climate science. Via collaboration and co-mentorship, graduate and undergraduate students will engage in Earth and environmental systems modeling under the overarching theme of identifying, characterizing, and quantifying climate extremes, their drivers, and translating impacts to the water and energy sectors. CREW-RA alumni will possess distinct skill sets rooted in climate and hydrologic modeling, statistical data analysis, and scientific supercomputing that will enable them to become our future leaders, founded in their ability to integrate climate science into engineering applications. Such training and cultivated skills are vital, yet often missing for engineering students, especially for underrepresented and minority groups in the field. CREW-RA will act as a critical paradigm for integrating climate science into other fields of engineering in the future by equipping a diverse, next generation of engineers to excel and lead projects that address climate change challenges across sectors. CREW-RA will also serve as a means to develop a sustained collaboration beyond the project duration between CSULB and LBNL.

This research was selected for funding by the Office of Science Biological and Environmental Research Program.

From forests to floodplains to functioning watersheds: Catalyzing collaborative research and inclusive training partnerships between Western Colorado University and DOE's National Laboratory system

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Changing climate and disturbance regimes are driving major changes to forest ecosystems and watershed function. These changes pose direct risks to current and future human generations, especially socio-economically disadvantaged communities. Improving our understanding of the causes and consequences of these ecosystem changes, and what kinds of actions would improve outcomes, requires new collaborations that bring together researchers in physical and biological sciences to test hypotheses with landscape-scale experiments. Addressing these issues also compels strong and sustained investment in inclusive training for scientists representing all affected human communities.

To meet these needs, this project will advance new and long-term partnerships between faculty and students at Western Colorado University and researchers at the Lawrence Berkeley and SLAC National Accelerator Labs, focusing on the meeting the two key objectives. First, we will develop **collaborative research on climate-driven impacts to ecosystems and watershed system functionality,** linking forests to floodplains in western Colorado. Second, we will create new **educational opportunities that provide innovative training to diverse students** through immersion in real-time research that can provide new knowledge essential to improved social and ecological outcomes.

Over a four-year timeframe, we will develop a suite of synergistic research activities linking current and planned DOE research in watershed function with Western's growing expertise in ecological and environmental sciences and engagement with land management agencies planning large-scale interventions. Together, these endeavors will allow us to test hypotheses around effects of disturbances such as fire, novel silvicultural treatments, and stream restoration, on ecosystem function under a changing climate. Our research will further serve as the foundation for three innovative and linked training initiatives at Western, a small, rural university uniquely situated to support students from underserved rural communities in western Colorado. These include: a) a new Environmental Science program that immerses diverse students directly into cutting-edge research, b) expanded fellowship opportunities for underrepresented and first-generation students in Western's MS and MEM programs, and c) mentoring and curriculum that builds data and narratives from our research activities into engaging classroom materials and activities.

The initiatives we propose will advance critical science questions and provide inclusive training for students who would not otherwise have access to such opportunities. These in turn will facilitate the development of long-term partnerships between DOE and a rural university, to link the next generation of diverse, innovative scientists to fulfilling career opportunities addressing environmental challenges.

This research was selected for funding by the Office of Science Biological and Environmental Research Program.

Reaching a New Energy Sciences Workforce Through Atmospheric Research at The University of Puerto Rico Rio Piedras (RENEW-AR-UPRRP)

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The **vision** of *Reaching a New Energy Sciences Workforce Through Atmospheric Research at The University of Puerto Rico Rio Piedras* project is to serve as a Community of Research Practice that has been conceptualized to build a pipeline into the new energy workforce that will impact underrepresented minority students in higher education at the undergraduate and graduate level by preparing them for careers where they can contribute to and address the science challenges of the United States Department of Energy's Earth and Environmental Systems Sciences Division. The **goal** of the project is to build capacity in the Environmental Sciences Program of the University of Puerto Rico at Rio Piedras, a predominantly Hispanic minority-serving institution. The project has **three objectives**. First, it will develop new partnerships with the National Laboratories of the Department of Energy (Brookhaven National Laboratory, Argonne National Laboratory) to enable sustained undergraduate and graduate student research and training through research-focused collaborations centered on atmospheric aerosol observations, characterization, modeling, and climatic feedbacks. Second, it will facilitate undergraduate and graduate student engagement in training and outreach activities that promote the interest in, and awareness of atmospheric research carried out under the Energy's Earth and Environmental Systems Sciences Division programs and user facilities. Last, it will foster the development of climate and environmental science training capacity and atmospheric sciences research (with emphasis on atmospheric aerosols) at The University of Puerto Rico, Rio Piedras campus.

Funds will support experiential training to graduate and undergraduate students, will provide multi-layered mentoring to students, and will support collaborative activities that build institutional capacity in partnership with scientists from the University of Puerto Rico scientists affiliated with the US Department of Energy's Brookhaven National Laboratory and Argonne National Laboratory in Process-

level Advancements of Climate through Cloud and Aerosol Lifecycle Studies, a Science Focus Area supported within Department of Energy's Earth and Environmental Systems Sciences Division.
The proposed research and training activities not only promote advances in aerosol research but are also relevant to the overall goals of the United States Department of Energy's Reaching a New Energy Sciences Workforce Through Atmospheric Research initiative. By targeting students at a minority-serving institution, the proposed project contributes to engaging students that are largely underrepresented in the Atmospheric Sciences workforce.

This research was selected for funding by the Office of Science Biological and Environmental Research Program.

Training a diverse STEM workforce to measure and model energy, water, and carbon budgets

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The need to recruit and retain underrepresented minorities in science, technology, engineering, and mathematics (STEM) is a national security issue impacting U.S. governmental agencies of the 21st century. The overarching goals of this proposed project are to: 1) build climate and environmental science programs at Lincoln University of Missouri (LU) to ensure long term training and research collaboration between LU and Oak Ridge National Laboratory (ORNL), 2) train a diverse STEM workforce including hands-on research experiences at the Missouri Ozarks AmeriFlux site (MOFLUX) and ORNL, and 3) foster career development of students from underrepresented groups in ORNL's Terrestrial Ecosystems Sciences Scientific Focus Area (TES-SFA). To achieve these goals, four specific project objectives include: (i) prepare LU undergraduate and graduate students to conduct novel independent scientific research by mentoring through research projects at MOFLUX, (ii) development of student-friendly learning materials and training modules to streamline hands-on student research activities at MOFLUX, (iii) developing and delivering case study curricula for physical hydrology and geographic information systems (GIS) courses at LU, and (iv) providing LU students with an immersive experience at ORNL where they will attend a short course focused on measuring and modeling ecosystem processes, meet with TES-SFA scientists, and tour lab facilities. Graduate students will lead a journal club to equip students with fundamental background information to set the stage for hands-on research activities at MOFLUX. Hands-on research activities at MOFLUX will involve data collection and maintenance of an existing network of six weather stations deployed within the footprint of the MOFLUX tower. Students will analyze and synthesize data collected from weather stations with MOFLUX data streams. Science-based information (i.e. data) and lessons learned from research activities at MOFLUX will be used to develop geoscience case study curricula for physical hydrology and GIS at LU. To deepen and broaden students' research experiences, select LU students will visit ORNL to undergo training in environmental systems science and learn about research activities within the TES-SFA and other ORNL research areas. When students visit ORNL, they will be trained on the theory and practice of ecosystem monitoring and modeling. Taken together, the ORNL workshop is designed so that students will develop a range of skills relating to making measurements and modeling. As a capstone graduate experience, graduate students will attend Fluxcourse at the University of Colorado Mountain Research Station at Niwot Ridge, USA. Additionally, a DOE RENEW session proposal will be submitted to American Geophysical Union (AGU) where RENEW students across the U.S. will be invited to share their research findings and experiences. Results will also be disseminated to a diverse network of students and faculty at 1890 Association of Research Directors (ADR) Symposium held annually at LU. Data collected and curriculum developed will be shared with other HBCUs and MSIs and made publicly available with citable DOIs on DOE's Environmental Systems Science Data Infrastructure for a Virtual Ecosystem (ESS-DIVE).

This research was selected for funding by the Office of Science Biological and Environmental Research Program.

Basic Energy Sciences (BES): RENEW Awards

Controlling Additive Manufacturing Properties of Surfaces (CAMPS)

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The project, Controlling Additive Manufacturing Properties of Surfaces (CAMPS), is a collaboration between Navajo Technical University (NTU) and Lawrence Berkeley National Laboratory (LBNL). CAMPS will address critical scientific questions related to the effects of reactive gasses on the structure of metals formed through additive manufacturing, which is relevant to future nuclear energy materials.

CAMPS addresses the Department of Energy's priority in science for Transformative Manufacturing. CAMPS's research objectives are: (i) Understanding whether non-equilibrium incorporation of these species can be realized through solute trapping at the solid-melt interface and enabling routes to microalloying not realizable through conventional processing routes; (ii) Understanding how the presence of these gasses trapped near the surface can alter phase microstructure and control mechanical behavior; and (iii) Studying whether their incorporation leads to the formation of nanoclusters (oxides, nitrides, carbides) providing a route to produce dispersion strengthened alloys that traditionally rely on more expensive and energy-intensive manufacturing routes.

CAMPS aims to bridge these fundamental concepts to additive manufacturing applications, including novel advanced nuclear reactor designs and the creation of tailored materials with local control of mechanical and chemical properties.

The CAMPS education initiatives are to increase enrollment of American Indians in Engineering and NTU engineering programs and to provide context and theory to American Indian students. The students will receive practical experience and aptitude in scientific theory and engineering principles required for synthesizing and characterizing materials for various technological applications.

The CAMPS educational and engineering pipeline activities include a joint research project between NTU and LBNL, joint journal and conference publications, summer student internships at LBNL for research and career development activities, monthly technical meetings, co-advising of undergraduate students with LBNL scientists, education and training from LBNL staff to integrate NTU students and researchers into DOE user facilities, integration of new additive manufacturing modules, modeling, and characterization into NTU engineering courses, and teaching of dual-credit Engineering Graphics at Gallup McKinley County schools (GMCS) whose students population is 90 percent American Indians.

CAMPS aims to create a lasting collaboration and connection between LBNL and NTU that will ultimately increase LBNL and DOE's relationship with American Indian students and lead to a more diverse and inclusive workforce.

Controlling reaction pathways under the non-ideal conditions of seawater electrolysis

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Faculty and students at the University of Guam (UOG) will work with scientists at Pacific Northwest National Laboratory (PNNL) to perform research in science for clean energy (hydrogen (H_2) and catalysis). The project aims at understanding the complexity of the electrode/liquid interface and controlling reaction pathways for H_2 and O_2 evolution in seawater electrolysis through planned activities suitable to teach students the fundamentals of catalysis and electrochemistry. We will focus on understanding the influence of organic matter on the electrochemistry of water splitting. We hypothesize that by manipulating the concentration of ion and organic molecule concentrations at the electrode interface we can enhance the electrochemical H_2 transfer at the cathode while suppressing the electro-oxidation of chloride at the anode. In order to facilitate the training of students on the use of equipment used to measure and evaluate electrochemical performance and the transitioning of research activities between PNNL and UOG, activities will be broken down into three main tasks.

Task 1 will focus on understanding the reactions at the cathode, investigating the routes for the H_2 evolution reaction (HER) and electrochemical reduction reaction (ECR), including competing reactions at the cathode surface under targeted conditions.

Task 2 will focus on understanding the anodic reactions and the competing pathways of the O_2 evolution reaction (OER) and Cl_2 evolution reaction (CER). In task 2, we will also investigate the effects of carbonaceous compounds and the corresponding electrochemical catalytic oxidation (ECO) pathways has on the OER/CER selectivity.

Task 3 will generate atomically-precise models for the most promising systems at both the cathode and the anode to investigate electrolyte/electrode interfacial properties and reaction mechanisms.

This proposal addresses the scientific challenges pertinent to two Science for Clean Energy Focus Areas: Hydrogen and Catalysis. The overarching goal is to engage UOG student and early-stage investigators in both research and workforce relevant training opportunities, equipping them with the tools and skills necessary to contribute as members of a diverse and inclusive STEM workforce. This proposal will employ a STEM learning ecosystem where student and early-stage researchers at UOG, scientists at PNNL, and additional collaborators, work together to achieve our scientific goals while providing the foundations for Office of Science (SC) research and training of UOG in the SC research portfolio. A particular objective of UOG is to build a diverse, equitable, and inclusive research community in the region focused on promoting clean energy research and energy self-sufficiency. Through our collaboration, UOG aims at establishing the foundation for clean energy research in Micronesia to facilitate engagement with students and faculty from other colleges in the region.

Hydrogen Interfaces - Preparing and Obtaining a Workforce in Energy Research (HI-POWER)

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Use of fossil fuels, including coal, oil, and natural gas, is ubiquitous in our daily lives, including powering automobiles, generating electricity and heating homes. However, use of this non-renewable resource results in a primary source of greenhouse gas emissions. In the Department of Energy's energy roadmap hydrogen is identified as an important energy source to reach net zero carbon emission by 2050. Understanding the impact of prolonged hydrogen exposure on structural materials performance and developing hydrogen-tolerant materials that can survive exposure to the extreme environments associated with hydrogen storage, production, and use are emergent needs to enable a sustainable and economical hydrogen infrastructure. However, rapid diffusivity of hydrogen in metals, high chemical reactivity of metals with hydrogen, and the phenomenon of hydrogen embrittlement make the design of hydrogen-tolerant alloys very challenging. With the US's pursuit to create and scale a new hydrogen infrastructure, there will be an immediate need for a skilled energy science workforce. Concurrently, there is a need to create a diverse, equitable, and inclusive research community, which requires recruitment, training, and retention of students from underrepresented groups. To address both these significant technical and socioeconomic challenges, this project will embrace interfaces and diversity in the scientific and social contexts by studying a diverse set of material-hydrogen interfacial problems, at the interface between diverse disciplines, and by bringing together students, postdoctoral researchers, and faculty from institutions that serve underrepresented groups.

The underlying science driver of this research project is the understanding of hydrogen interactions at interfaces, including crystal and phase boundaries. Research results will reveal how atomic-through-microscale structures, composition, and crystallographic orientation affect the properties of alloys when exposed to hydrogen environments. The goal of the proposed research effort is the realization of new strategies for resisting hydrogen embrittlement at extreme temperatures. The strategies are based on recent advances in tailoring of complex material interfaces, including alloys containing shape-memory phases, high-entropy alloys, and 2D materials.

The HI-POWER Basic Energy Sciences RENEW program aims to create interdisciplinary research and training opportunities addressing critical needs for the next-generation energy sciences workforce. It will broaden the participation of underrepresented minority students and faculty members in cutting-edge materials research at FAMU, NC A&T State University and Ames National Laboratory. Innovative research, education, and outreach activities include individualized mentorship programs, student summer internships at Ames National Laboratory or a partner energy company, and research opportunities for a faculty member recruited from a historically black college or university.

This research was selected for funding by the Office of Science Basic Energy Sciences Program.

Nanopore Characterization for Geologic Storage of H2 and CO2: A CSUB-LBNL BES Pathway Program

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The eventual successful development of large-scale low-carbon energy will rely on new, or vastly expanded, uses of Earth systems. The Earth's subsurface will be used for carbon sequestration to curb emissions during the transition from fossil fuels. Moreover, geologic rock formations are the only option for large-scale transient storage of hydrogen gas, which is receiving unprecedented attention as an energy storage medium and chemical fuel. **A new generation of skilled geoscientists is urgently needed**. Developing a strong geoscience workforce will require recruiting and training students from the fullest diversity of backgrounds. However, diversity in the Earth sciences is lowest among all STEM disciplines for decades.

To address the critical need for a diverse geoscience workforce, we will establish a **CSUB-LBNL BES Pathway Program** to provide students at California State University, Bakersfield (CSUB) with new opportunities for geoscience education, research experiences, and long-term mentoring. Under the guidance of instructors from CSUB and Lawrence Berkeley National Laboratory (LBNL), student participants will investigate the nanoscale pore structure of caprocks in San Joaquin Basin of California and their interactions with fluids under in-situ temperature-pressure conditions. Caprock samples will be chosen based on their association with possible H_2 and CO_2 storage formations.

Within the initial 3-year award period, the goal of this program is to increase the number of graduate applications in Earth science from CSUB. Beyond this 3-year period, the ultimate goal is to provide new career pathways for students from underrepresented groups to join LBNL or other university or national lab groups funded by BES. The program is a partnership between faculty and staff at CSUB, BES-funded scientists and staff in the Earth and Environmental Sciences Area (EESA) at LBNL, and the Workforce Development & Education (WD&E) department at LBNL, with the following components:

1. **An innovative two-way engagement program** composed of 1) CSUB students and faculty visiting LBNL and 2) LBNL scientists engaging in CSUB seminar, teaching, and student recruiting events.
2. **A new course** offered at CSUB co-developed by instructors from CSUB and LBNL that will train students in cutting-edge approaches to understand Earth materials for achieving sustainability.
3. **Summer internships** for students in the CSUB course that provide research experiences, mentoring, peer-to-peer engagement, and geoscience focused career guidance.
4. **Hypothesis-driven basic research** on nanoscale pore network of caprocks in San Joaquin Basin.
5. **A long-term mentoring plan** (up to 2-year) with CSUB and LBNL researchers to accomplish research, education, and career objectives.

This research was selected for funding by the Office of Science Basic Energy Sciences Program.

Partnership to Increase Representation in Energy Research in Puerto Rico (PIRES – PR)

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The sluggish kinetics of the oxygen reduction reaction (ORR) and degradation of catalysts for the oxygen evolution reaction (OER) are known to be the limiting step in the mass production and use of alkaline membrane fuel cells. This proposal seeks to increase our understanding of non-platinum group metal (non-PGM) and non-metal catalysts for the ORR and OER to tune their activity and durability via two main thrusts.

Thrust 1 (T1), led by Santiago, will study the specific location of the catalytic site for the ORR on non-PGM catalysts. Doping of non-PGM is one of the most promising strategies to increase catalysis efficiency, but mechanisms and catalytic sites are not well understood. Carbon nanoparticles can influence the catalytic activity together with the doping of different heteroatoms, but the mechanism is not yet understood. As part of this project, we will focus on locating and identifying the position of the catalytic site within the unit cell of the semiconductor to understand how the position of heteroatom-doping (i.e., nitrogen, phosphorus, and boron) on onion-like carbon nanoparticles and ZnO affect the catalytic efficiency of non-metal catalysts for the ORR using in situ and operando techniques. As delineated in the Basic Research Needs (BRN) for Catalysis Science report by DOE-BES, the use of advanced computational approaches in

T1 for the catalysts developed by the researchers in this proposal will provide predictions of mechanistic information and more efficient catalyst structures to target during syntheses.

Thrust 2 (T2), led by Colón, will study the separation of catalytic sites from the reacting molecules by using intercalations of bimetallic, trimetallic, and tetrametallic non-PGM catalysts to decrease degradation at high potentials required for the OER and control of catalytic activity. As part of T2, we will focus on the study of catalysts using materials with void spaces for off-site catalysis. Exposing catalytic sites to the OER has shown to increase degradation due to the requirement of high potentials. T1 and T2 will support Goals 1 and 2 while intersecting in support of Goal 3. In this proposal, our long-term goal (Goal 3) is to train a pool of talented young scientists, chemists, and engineers from underrepresented groups with the critical skills and expertise needed for the full breath of research in basic energy sciences. To reach this goal, an interdisciplinary research team underrepresented in the energy workforce will train Hispanic undergraduate and graduate students in fundamental research on catalysis science for the oxygen reduction and evolution reactions. Training students with the knowledge to perform basic energy research provides the best opportunity to reach this ambitious goal while building a pipeline and capacity for a diverse STEM workforce.

This research was selected for funding by the Office of Science Basic Energy Sciences Program.

Fusion Energy Science (FES): RENEW Awards

Data-Driven Modeling and Control of Systems with Plasma-Surface Interactions

Principle Investigator: Dr. Xuewei Zhang, Associate Professor
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Kingsville, Texas 78363

The objective of the proposed research is to investigate the physical mechanisms and processes underlying the formation of structures and patterns in systems with plasma-surface interactions. In the past decades, there have been extensive studies on the interaction of glow discharges, dielectric barrier discharges, and arc discharges with confining or intervening surfaces. The advancement of the understanding of these phenomena is not only of fundamental scientific interest and relevance to the knowledge of the plasma state, but also with profound implications in various technological applications. The research will integrate theoretical, computational, and experimental work within an innovative framework of data assimilation, i.e., optimally combining model predictions with measurements. The scientific merit of this research has three aspects. Firstly, it extends the studies of plasma-surface interactions to systems with insulator surfaces and multi-layer systems, while existing studies are predominantly on electrode surfaces. Secondly, it expects to develop a novel data-driven modeling approach based on data assimilation to enhance the predictive and control capabilities, which could make transformative contributions to basic plasma research. Thirdly, it will shed new light on outstanding problems related to formation of patterns interfacing plasmas.

This project also aims to launch an education and outreach initiative at Texas A&M University-Kingsville, a non-R1, minority-serving institution in South Texas. The initiative is structured as a four-tier pyramid. Tier one will be a webinar series for culture and capacity building to inform broader audience in the region about the research fields of plasma science and engineering. Tier two will be the creation and offering of an upper-level undergraduate course on introductory plasma physics, which will help with the recruitment for the upper tiers. On tier three, we will engage and mentor senior design students to conduct work toward the research goal of this project. There will also be a certificate program on general plasma science for undergrad and graduate students, part of which will be lab training at Princeton University. Tier four will be the supervision and mentoring of Ph.D. students. Therefore, this project will systematically expand the talent pipeline, broaden participation from communities historically and geographically underrepresented in DOE SC research portfolio, significantly improve the research and education capacity at the Principle Investigator’s institution, and contribute to developing a diverse workforce in plasma science and engineering.

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

Design and Analysis of Sparging Systems for Tritium Removal from Fusion Energy Liquid Breeder Blankets

Principle Investigator: Dr. Subash L Sharma, Assistant Professor
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Lowell, MA 01854

Co-Principle Investigator(s): Dr. Thomas F. Fuerst and Dr. Chase N. Taylor
Idaho National Laboratory
Idaho Falls, ID 83415

The breeder blanket is an essential component for the future needs of a self-sufficient fusion power plant. Liquid breeders are attractive due to negligible radiation damage, ease of lithium replenishment, shielding capability, and heat transfer properties. There are three primary candidates for liquid breeder materials: lithium-lead eutectic alloy (PbLi), the lithium-beryllium-fluoride molten salt (FLiBe), and pure lithium (Li). The Fusion Energy Sciences System Studies has historically focused on PbLi with the Fusion Nuclear Science Facility, and the budding private fusion industry focuses on PbLi – General Fusion and ZAP Energy, and FLiBe – Commonwealth Fusion Systems. Similarly, there are many conceptual forms of the Tritium Extraction System (TES) for removal of tritium from the liquid blanket materials. Sparging systems, also known as gas-liquid contactors or bubble columns, are considered a high TRL option and planned for the TES in EU ITER-TBM program. They operate by bubbling an inert gas (He) through the liquid material and tritium evolves to the gas phase. Tritium is then collected from the inert gas and routed to the fueling system. However, limited comprehensive studies have investigated design and optimization of these sparging systems using Computational Fluid Dynamics (CFD). **The First goal of this research is to analyze and inform the design of sparging systems to have a comprehensive US framework for tritium extraction systems for fusion energy liquid breeder blankets.** Various modes of operation (co-current, counter-current flow, with and without packing of bubble column) for different liquid blanket breeder materials will be modeled and simulated computationally, and a final optimized conceptual design for sparging system will be proposed for PbLi and FLiBe. The optimized design will be quantitatively compared to other TES concepts to guide future research & development activities. **The Second goal is to foster a diverse and inclusive workforce for US blanket and fuel cycle research and development community, and provide a research and student training opportunity between University of Massachusetts Lowell (UML) and Idaho National Laboratory (INL), which includes summer research opportunities at Idaho National Laboratory for participating students.** These two goals will help achieve this proposal, i.e., to bring new and diverse talent into the US workforce for fusion blanket technology development.

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

Internship program for Minority Serving Institution undergraduates at LaserNetUS facilities

Principle Investigator: Dr. Félicie Albert, Deputy Director
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Co-Principle Investigator(s): Dr. Charles Weatherford
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Dr. Aurora Pribram-Jones and Dr. David Strubbe
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Dr. Eddie Red
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The objective of this project is to establish a partnership between LaserNetUS, a network of ten high-power, high-intensity lasers in North America, and three Minority Serving Institutions (MSIs) to attract, train and retain undergraduate students from underrepresented populations. The program will collaborate closely with faculty advisors while building the students' capabilities at the host MSIs and leveraging the LaserNetUS network to promote diversity, equity, and inclusion (DEI). The goals and approach of our program are to:

(1) Expose and train students and faculty from underrepresented groups to LaserNetUS science, infrastructure, and community by developing pedagogical resources for MSIs.
(2) Host cohorts of undergraduate MSI students at LaserNetUS facilities and experiments, with faculty and staff mentoring from selected LaserNetUS hosts and selected MSI faculty champions.
(3) Support ongoing engagement with the students to bring them into the field.
(4) Develop capabilities at the MSIs over time to create new science programs.

Our program, by enabling students to have a strong sense of belonging and high chance of success, regardless of their gender, race/ethnicity, or other personal and scientifically irrelevant characteristics, will empower them to remain in the plasma and fusion energy sciences research community, which is critical for FES missions.

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

Novel additive manufacturing for plasma facing materials - creating a research pathway for minority students

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Co-Principle Investigator(s): Dr. Vadym Drozd and Dr. Andriy Durygin
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Dr. Cristian Penciu
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Dr. Xiaoyuan Lou
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The proposed collaboration bridges the largest minority serving teaching institution in the nation (Miami Dade College or MDC), a minority serving research university (Florida International University or FIU), and a leading research university with a strong nuclear engineering program (Purdue University) to support minority workforce development and research for fusion energy and related materials. Through an emergent topic - additive manufacturing of tungsten plasma facing components for fusion energy applications, the primary goal of the project would be to explore innovative pathways to develop sustainable research workforce from underrepresented student bodies. In particular, the project aims to raise awareness of fusion science and related engineering at FIU and MDC and develop collaborative relationships among FIU, MDC, and Purdue Nuclear Engineering. FIU and MDC provide an excellent pool of traditionally underrepresented talents to recruit from and mentor. Through a series of high-quality lectures/workshops as well as research opportunities in fusion energy materials, the project will prepare students in all three institutions with a strong background to pursue future graduate study and careers in related fields. Student visits and exchange among the three institutions will also reinforce academic collaborations and broaden the perspectives of students in this field. A portfolio of education and research training activities will be designed and implemented to increase the number and quality of underrepresented students to pursue and succeed at careers in fusion science and advanced manufacturing. Meanwhile, the project will integrate the complimentary expertise at FIU and Purdue to develop innovative manufacturing approaches and understand the fundamentals about materials processing using new flashing sintering technology to fabricate complex tungsten plasma facing components for potential fusion energy applications.

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

Pathways to Fusion - A Collaborative Center for Workforce Development

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Co-Principle Investigator(s): Dr. Royce W. James, Captain/Permanent Commission Teaching Staff, USCGA/AFIT
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With the recent developments in fusion energy sciences and technology and the US momentum towards commercialization of fusion, the need for a talented workforce to join the US fusion community has never been greater. An intentional strategy must be undertaken to recruit and retain a diverse and qualified workforce. This is particularly true of populations that have historically been excluded from the fusion ecosystem: women, LGBTQ+, and BIPOC communities. Under the FES RENEW initiative, FES is undertaking a strategy of supporting collaborations between institutions that have been historically funded by FES (primarily national labs and a few R1 and R2 institutions) and potential new members to the FES-funded fields from minority serving institutions, which include Historically Black Colleges and Universities. The Pathways to Fusion collaborative center's mission is to serve as a "user facility" for these (and other) bourgeoning collaborations by providing resources for students, faculty and staff; develop and implement assessment tools to gauge the DEIA climate within the institutions to ensure the experience for all is safe and conducive to academic/professional growth; and provide guidance to optimize the collaborations with the help of subject matter experts. Led by PPPL, the US Coast Guard Academy, and Howard University, the Pathways to Fusion collaborative center is composed of 16 institutional partners, all subject matter experts in plasma science, fusion engineering, science education/outreach, and/or DEIA. Guided by the peer-reviewed "Healthy-to-Innovative" DEIA framework[1], the center is led by a steering committee composed of the center's Principle Investigator's and Co-Principle Investigators' institutions plus affinity groups in fusion, and DEIA/workforce development subject matter experts. This steering committee will create and implement the strategy and assessment tools, as well as meet with the center "users" to work with them on a plan of action that is customized to each collaboration. Once that is developed, the relevant partners within the broader center will support the steering committee in providing the resources (such as developing and deploying customized workshops) to support the user. The center's goal is to make sure that each new collaboration is a well paved pathway towards the mission of fusion energy and plasma science and technology that centers the experience of all members and ensures a safe environment for their academic and professional growth.

[1] Beyond Buzzwords and Bystanders: A Framework for Systematically Developing a Diverse, Mission Ready, and Innovative Coast Guard Workforce. (2019) K. Young-McLear, S. Zelmanowitz, R. James, D. Brunswick, T. DeNucci

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

Simulation of nonresonant stellarator divertor

Principle Investigator: Dr. Alkesh Punjabi, Professor
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Co-Principle Investigator(s): Dr. Halima Ali
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There are two types of stellarator divertors: The island divertor and the nonresonant divertor. The island divertor requires the plasma to be bounded by a low-order rational surface. The W7-X stellarator has shown the attractive properties of island divertor including detachment. In detached divertor, most of the power is radiated before the plasma enters the divertor chamber from where it is pumped away.

The nonresonant stellarator divertor can work even when the outermost confining surface has a dynamically evolving rotational transform. The nonresonant divertor appears to impose fewer constraints on the plasma; however, it is far less studied. Recently (2018-2022), Punjabi and Boozer have shown that some of the magnetic field lines just outside the outermost confining magnetic surface strike the wall through magnetic turnstiles, and that the locations on the wall where the lines strike the wall have a certain robustness. However, there is much that remains to be explored, studied, and to be understood. This includes, but not limited to, the design and control of appropriate magnetic field configurations, plasma exhaust, and plasma detachment in nonresonant stellarator divertor. Some axisymmetry-breaking magnetic perturbations can be made consistent with axisymmetric confinement in the plasma core by doing a stellarator-like optimization for quasiaxisymmetry.

A question of great practical importance for the tokamak program is: Can carefully chosen non-axisymmetric perturbations produce better control over the diverted plasma? Another equally important and interesting question is: When does a perturbed axisymmetric divertor act as a non-resonant stellarator divertor? The goal of this research project is to explore, study, and understand the properties of the nonresonant stellarator divertor and the perturbed axisymmetric divertor to answer the questions posed above. The project will be in collaboration with Dr. Allen Boozer and Dr. Elizabeth Paul of Columbia University, New York. The Principle Investigator and the Co-Principle Investigator will mentor, train, and provide research
experiences in fusion science to two undergraduate students at an HBCU. The overarching goal of this project is to achieve the goals of diversity, equity, and inclusivity (DEI) articulated in the vision of the Fusion Energy Science – Reaching a New Energy Sciences Workforce (FES-RENEW) solicitation DE-FOA-0002758.

This research was selected for funding by the Office of Science Fusion Energy Sciences Program.

High Energy Physics (HEP): RENEW Awards

RENEW-HEP: U.S. CMS SPRINT - A U.S. CMS Scholars Program for Research INTernship

Principal Investigator: Dr. Santanu Banerjee, Department of Chemistry and Physics, (Award #1)
Tougaloo College
Tougaloo, MS 39174

Principle Investigator: Dr. Tulika Bose **(Award #2)**
University of Wisconsin-Madison
Madison, WI 53706

Principle Investigator: Dr. Sudhir Malik, Physics Department **(Award #3)**
University of Puerto Rico-Mayaguez
Mayagu¨ez, 00681 - 9000, PR

Principle Investigator: Dr. Meenakshi Narain, Physics Department **(Award #4)**
Brown University
Providence, RI 02912

Students from underrepresented populations, including those at minority serving institutions have traditionally faced many barriers that have resulted in their being under-represented in high energy physics. These barriers include lack of research infrastructure and opportunities, insufficient mentoring, lack of support networks, and financial hardship, among many others. This proposal attempts to address these barriers via a 10-week paid internship program, **U.S. CMS SPRINT**, an acronym for **U.S. CMS S**cholars **P**rogram for **R**esearch **INT**ernship for undergraduates.

The **U.S. CMS SPRINT** internship program incorporates software and instrumentation training, a series of lectures covering a broad range of topics, and a structured research experience. Students will participate in a two-week long summer program at a DOE national laboratory (Fermilab) and subsequently, over an eight-week period, gain hands-on experience via research projects under the close mentorship of U.S. CMS scientists based at U.S. universities, or at Fermilab. Asubset of students will take on research projects during the academic year working in collaboration with U.S. CMS scientists. All students will be exposed to cutting-edge particle physics research and will develop a broad set of skills in software, computing, data science, and machine learning.

The internship program will provide networking opportunities and professional development including opportunities for oral and written science communication. A strong mentoring component will be implemented by leveraging the existing tools developed within the U.S. CMS Collaboration. Career development and cohort-building activities will be included with the goal of increasing the retention of a diverse group of students. Overall, the program aims to empower students by enabling them to develop a skillset that is eminently transferable and highly valued by research, industry, and many other employment sectors.

This proposal brings together a historically black college (Tougaloo College) and a strong U.S. CMS team (Brown University, University of Puerto Rico at Mayaguez, University of Wisconsin- Madison) that has an established record in research, training, and mentoring. Team members have experience with managing large projects within international collaborations, they have taken on major administrative roles at their universities and have also demonstrated a strong commitment to diversity and inclusion. They propose to work together with the U.S. CMS Collaboration and use the internship program to convey the excitement of particle physics to a cohort of students from minority serving institutions with the aim of broadening and diversifying the high energy physics workforce. The proposal will help integrate Tougaloo College within the U.S. high energy physics community thereby providing new opportunities at an institution that has traditionally not been part of the particle physics portfolio.

This research was selected for funding by the Office of Science High Energy Physics Program.

Neutrino Physics for Undergraduate Minority Advancement in Science (NuPUMAS)

Principal Investigator: Dr. Daniel Cherdack
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Houston, TX 77004

Co-Principle Investigator(s): Dr. Barbara Szczerbinska
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Corpus Christi, TX 78412

There are many barriers to entry for Underrepresented Minorities (URMs) in Physics and other STEM fields. Many of these barriers come out of a lack of opportunities for minority students throughout the education process. While students may find their way to post-secondary education, they may do so at institutions without educational tracks catering to their career goals or without graduate programs that allow them to find mentors and the research opportunities where the can demonstrate their skills. These issues limit the ability of these students to find jobs in their intended field and/or limit their graduate school opportunities. Even when opportunities exist at their institutions, financial constraints often limit their ability to take advantage of them. This program aims to help students overcome these barriers by setting up a Texas-based traineeship program – **Neutrino Physics for Undergraduate Minority Advancement in Science** (NuPUMAS) – to recruit cohorts of URM students and provide them with a program allowing to overcome these barriers.

NuPUMAS addresses the needs of URM students in several key ways. Since undergraduate research results in increased STEM retention rates, improved self-efficacy, enhanced content knowledge, and professional communication skills, NuPUMAS is designed around multiple research opportunities. The heart of the program is an eight-week long paid traineeship program hosted at University of Houston (UH) for the first six weeks, followed by travel to Brookhaven National Lab and the Sanford Underground Research Facility for two week-long National Laboratory Experiences. This traineeship program will give the students skills and knowledge that will aid them in their studies, experience that will allow them to develop their own research interests, and provide ways to build their resumes so they can stand out amongst their peers. The eight-week traineeship is followed by a two-semester financially-supported research project to be completed at their home institution. This will create additional opportunity to gain skills and experience, as well as to enhance the resume for a career in academia or industry. This program is designed to develop a culture of inclusion, inquiry, achievement and STEM identity.

NuPUMAS is a collaborative project between the UH and universities from the Texas Physics Consortium (TPC): Texas A&M University - Corpus Christi (TAMUCC), Texas A&M University - Kingsville (TAMUK), and Tarleton State University (TSU). All three of UH, TAMUCC and TAMUK are certified Hispanic Serving Institutions (HSIs) and TSU is working towards an HSI designation. All three of TAMUCC, TAMUK, and TSU are members of the TPC which work together to provide the full suite of undergraduate major courses required to earn a Bachelor's degree in physics. Students in their junior and senior years attend hybrid style classes offered in-person to local students and online for participants attending from other institutions. As the host institution, UH will provide a variety of resources for the students including classrooms, computing hardware and software, and personnel. The participating faculty, students, and staff, many of them volunteers, will serve as instructors, lead activities based on their own research, and coach the participants through a variety of exercises. The diverse backgrounds and research programs of this team will allow students to find mentors who they identify with, and who spark their interest and imagination.

This research was selected for funding by the Office of Science High Energy Physics Program.

Experiencing Physics and Inspiring Communities (EPrinciple InvestigatorC)

Principal Investigator: Dr. Sara Callori
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Co-Principal Investigator(s): Dr. Matteo Crismani and Dr. Fadi Muheidat
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Evangelina Shreeve
Pacific Northwest National Laboratory
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Senior Personnel: Ann Wright- Mockler and Dr. John Orrell
Pacific Northwest National Laboratory
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The EPrinciple InvestigatorC project supports a partnership between California State University San Bernardino (CSUSB) and Pacific Northwest National Laboratory (PNNL) for a program designed to promote a pathway towards STEM careers, broadly, with a focus on participation in high energy physics (HEP). CSUSB is a primarily undergraduate university and Hispanic-Serving Institute (HSI) located in Southern California, which primarily serves the Inland Empire outside Los Angeles. This region is one of the most economically and educationally disadvantaged in the state, resulting in challenges faced by our student body that are obstacles to participation in STEM research and training activities, particularly when they are outside the local area. PNNL is a DOE lab, with facets of experimental design, instrumentation, detection, and analysis in nuclear and particle physics. CSUSB has programs focused on building experimental and instrumental skills in students, in particular the physics and computer engineering programs. As a result, students from these and other disciplines are well positioned to participate in research both at PNNL and remotely.

Major activities of this partnership will provide CSUSB students with research and STEM skill building opportunities both at PNNL and on the CSUSB campus. Central to this proposal are research traineeships, where students participate in summer research at PNNL followed by remote continuation of their work at CSUSB during the academic year. Students will be supported throughout their experiences by a CSU/PNNL mentor pair, addressing student needs regarding not only their scientific projects, but also academic, career, and personal growth. CSUSB faculty will also work with PNNL staff on how best to include HEP activities in course curriculum, including upper division laboratory experiments, computational exercises, and instrumentation projects. This will support the sustainability of efforts to expose students to HEP topics and their connection to students' academic experiences. Our partnership will be modeled to include many of the TEAM-UP recommendations as well as follow other successful programs that have focused on both undergraduate research and mentoring. We anticipate a range of HEP and STEM pipeline building outcomes will result from this partnership. In a short time, CSUSB students will gain hands-on experience with technical and scientific skills invaluable for participation in HEP and other STEM disciplines. Knowledge about and interest in careers at PNNL and DOE laboratories will increase, with a longer term goal of increasing the number of students from the region entering careers at DOE facilities.

This research was selected for funding by the Office of Science High Energy Physics Program.

Creating a pipeline of underrepresented minorities in applied superconductivity for high energy physics

Principal Investigator: Dr. Fumitake Kametani, Associate Professor
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FAMU-FSU College of Engineering and the Applied Superconductivity Center
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The goal of our RENEW program (Reaching a New Energy Sciences Work Force) is to develop a strong pipeline that recruits, trains, and retains larger numbers of underrepresented minority undergraduate and graduate engineering students in the field of applied superconductivity relevant for the Department of Energy - High Energy Physics Accelerator R&D program. Our RENEW program is unique because it leverages the strengths of an HBCU and a Research-1 University through the joint College of Engineering. The FAMU-FSU College of Engineering is the nation's only engineering college that is joint between an HBCU (Florida Agricultural and Mechanical University – FAMU) and a Research-1 University (Florida State University – FSU). We Principle Investigators are faculty members at both FAMU and FSU through the FAMU-FSU College of Engineering. We are also members of the Applied Superconductivity Center (ASC), which has done state-of-art research on superconducting materials and magnets for DOE-HEP for nearly 40 years. The strength of our program is integrating the solid academic base for underrepresented minority students that FAMU and the FAMU-FSU COE provide with the research infrastructure that ASC provides. We will actively recruit underrepresented minority students at FAMU, we will leverage our experience of successfully mentoring students in the lab at ASC, and we will create a nurturing environment designed to help students overcome obstacles they face, often as first-generation college students. Despite having the same drive, motivation, intellect, and capability as students of other races and ethnicities, underrepresented minority engineering students are more likely than other students to transfer to non-STEM majors before graduating, or to drop out entirely because they face academic and/or family challenges. Only a small fraction of the FAMU students admitted to the FAMU-FSU COE earn a BS in engineering. This RENEW program will increase the number of underrepresented minority students earning BS degrees in engineering and, we anticipate, increase the pipeline of underrepresented minority students who go on for graduate studies. The program synergistically combines active advising and teaching at the FAMU-FSU College of Engineering, strong hands-on research mentoring at ASC, and an overarching nurturing structure designed to help students identify and resolve challenges they face early on. Key aspects of the RENEW program are:
We will reach out to FAMU preengineering freshmen telling them about opportunities to do research in the ASC to recruit them into the program. We will show them the ASC lab facilities and have them job shadow undergraduate students already working at ASC so they can see the breadth of research areas available to them within ASC and visualize themselves working in ASC. We will help the RENEW students take advantage of existing academic assistance, which students often ignore, by requiring that during the first two weeks of each semester they go to office hours to meet their course instructors and TAs, and they go to the academic Help Center to meet the upperclassmen who are there to assist underclassmen with core courses. We believe that nudging the RENEW students to meet their instructors and learn about mentoring available in the Help Center early in the semester will increase their success in classes. We will create a nurturing environment for the RENEW students by having weekly meetings that focus on the students' welfare, where we can learn about, and help them address, the challenges they face in college. We believe that focusing on the students' holistic wellbeing will be a key component for the success of this RENEW program.

This research was selected for funding by the Office of Science High Energy Physics Program.

Growth and Research Opportunities with Traineeships in High energy physics at Minority Serving Institutions (GROWTH-MSI)

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Dr. Wing To **(Award #2)**
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In 2020, the American Institute of Physics's TEAM-UP Report details how the physics community can increase African American and other Underrepresented Minority (URM) participation in Physics and Astronomy. It emphasized the need to increase students' sense of belonging & physics identity, to support them academically & personally, and to offer leadership positions & structures to the students. This project is led by two Principle Investigators from Minority Serving Institutions (MSI), CSU-Stanislaus (Stan State) and Sonoma State University (SSU), who have 12 combined years of experience in increasing URM participation in Physics and Astronomy. The project will (1) create a 1.5 year long traineeship program for 20 undergraduates from six MSIs: CSU-Stanislaus, Sonoma, Fresno, East Bay, San Francisco, and University of California Merced; (2) develop research infrastructure in High Energy Physics (HEP) at Stan State and SSU, which are both institutions that have not traditionally been part of the particle physics portfolio; and (3) foster a multi-institutional consortium for HEP in Northern California with a collaboration between the aforementioned MSIs, SLAC National Accelerator Lab (SLAC), Lawrence Berkeley National Lab (LBL), Lawrence Livermore National Lab (LLNL), UC Berkeley, and UC Santa Barbara.

The first part of this program is a 1.5-year traineeship, which will support the students academically and offer the structure necessary to explore the subfields and careers in HEP. The trainees will be required to complete an introductory course in Particle Physics, work on a research project in HEP, and take part in the HEP community. These activities will ultimately help them to develop a sense of belonging and physics identity in the field. In order to accomplish this, the students will receive financial support for all three academic semesters to work 15 hours per week on research and professional development activities. During the summer between their junior and senior years, they will also be paid a stipend and housing allowance to do research at a participating National Lab or R1 university. Upon entering the program, each trainee will be assigned a personal mentor from their home institution. In their first semester with the program, the trainees will attend a weekly seminar on research and careers in HEP offered by the participating institutions. This seminar will run in parallel with an introductory HEP course. During this semester, the students will choose or be assigned a research mentor who matches their research interests, chosen from the list of topics below. This dual mentorship is designed to offer the trainee both academic and personal support during the entire traineeship. The results from these high levels of support per trainee, such as retention, engagement, and community activity, will be evaluated yearly in order to better guide the project. These results will also serve as proof of principle for future grants, such as the NSF-Improving Undergraduate STEM Education or Research Traineeship Program. The second part of this program will be to fund two Principle Investigators at MSIs to build-up their HEP research portfolios and local infrastructure. Prof. Wing To of Stanislaus State is an experimentalist working in astroparticle physics, while Prof. Alexandra Miller of Sonoma State is a theoretical physicist in Quantum Gravity. Each of these faculty members is the only HEP researcher at their respective institution and neither institution has ever been funded externally in HEP. At Stan State, this grant will fund the development of computing infrastructure and research equipment in particle physics detectors and electronics. Both of these are not currently available and create a barrier to participation for both the Principle Investigator and students at Stan State. At Sonoma State, it will fund the theoretical research infrastructure via a series of primer articles on various topics in the field of Quantum Gravity. These articles will be a form of intellectual infrastructure that will help future students to quickly gain the knowledge necessary to start working with Prof. Miller in her research. This support will benefit these two MSIs and equip them to be highly competitive in future HEP grant proposals. The third part of this program will fund a consortium of HEP institutions in Northern California. This consortium will foster communication, engagement and collaboration between the students, professors, and research scientists from all of the participating institutions. This will be done using online tools, such as Slack, to allow for easy communication. In-person interactions will include the weekly visits from seminar speakers and a yearly symposium hosted at the lead institutions. The symposium will gather the HEP community, celebrate the trainees' progress & accomplishments, and engage the local campuses and rural community in HEP. This consortium is not limited to only Northern California, but could grow as the project progresses to include additional MSI and research institutions. The online aspect of this program can be maintained indefinitely with a small amount of funding to pay for the subscription fee per member. This will greatly benefit institutions located geographically farther away from National Labs and R1 universities and promote future collaborations and cohortship beyond the timeline of this project.

This research was selected for funding by the Office of Science High Energy Physics Program.

CANDID – Collider physics, Artificial intelligence, Neutrinos, Dark matter, and heavy Ions for Diversity

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The CANDID program is a traineeship program targeted at underrepresented minority (URM) students enrolled at minority-serving institutions (MSIs) to perform high-energy physics (HEP) research at ORNL. By coupling the research capabilities at ORNL with dedicated mentoring of students from partnering institutions for two years, we can open the field of HEP as a career possibility for this cohort of promising students. The program is designed to overcome barriers associated with educational access and success for the nation's marginalized citizens by acknowledging the importance of MSIs in degree attainment for URMs and leveraging the resources available at ORNL. The overarching goal of this program is to increase the likelihood of the cohort obtaining a graduate degree in STEM and increase the retention of URM students in STEM fields, especially in HEP, by providing more prosperous career development paths.

The CANDID program features several vital aspects to ensure our goal is met and make this traineeship experience different from other DOE-funded internship programs. These elements are informed by the recent TEAM-UP report, including financial support for students during the academic year to relieve financial stress and the possibility of focusing on coursework and research activities. The program will include immersion in particle physics research, professional development, technical skills workshops, and social and networking activities. Students in their junior/senior college years and first-year graduate students will be the target for this program. Additionally, CANDID will focus on faculty engagement and building infrastructure for institutions that are not traditionally part of the HEP portfolio. Faculty can expand their training and research laboratories, visit ORNL during the summer with students, and get trained in cutting-edge research areas such as QIS and machine learning.

This research was selected for funding by the Office of Science High Energy Physics Program.

Inland Northwest STEM Preparation for Inclusive RENEW-HEP Experiences (INSPIRE)

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The Inland Northwest STEM Preparation for Inclusive RENEW-HEP Experiences (INSPIRE) project (1) will encourage science, technology, engineering, and mathematics (STEM) career paths for underrepresented students by providing inclusive, collaborative, and supported traineeships for students from underserved communities and the faculty who support them and (2) will create and expand an enduring regional network to provide traineeships featuring interdisciplinary nuclear and particle physics research opportunities, mentoring, and institutional support.

Pacific Northwest National Laboratory (PNNL), Columbia Basin College (CBC), and Wenatchee Valley College (WVC) will pioneer an extensible framework of STEM traineeships in nuclear and particle physics for potential future use by DOE-SC HEP, other national laboratories, and two-year, minority-serving institutions.

Trainees will build knowledge and skills, engage in mentoring and hands-on research and presentation experiences, discover career opportunities and access points to STEM degree opportunities in pursuit of those careers, and receive compensation to reduce barriers and sustain engagement. INSPIRE will also engage faculty to learn from PNNL's researchers.

This research was selected for funding by the Office of Science High Energy Physics Program.

Isotope Production (IP): RENEW Awards

Isotope Production Education and Research via a Systematic Study of Photo-nuclear Reaction Yields and Excitation Functions

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This project is a collaboration of the New Mexico Institute of Mining and Technology (an HSI institution with greater than 40% undergraduate Hispanic enrollment), Idaho National Laboratory and Idaho State University that is focused on undergraduate and graduate education and research in isotope production and related science and technology of measurements, separations and applications. The three institutions together provide broad expertise to this education and research activity. The program will include undergraduate and graduate coursework (both face-to-face and distance education), short courses, internships at the national labs, training, experiments and measurements at all three institutions, and technical and career mentorship of these students by each participating institution. The student "pipeline" that this collaboration will support will start with outreach and recruiting for undergraduate students, with a focus on minority students, and extend to graduate students and support for job placement and career advising. All students engaged in this program, both undergraduate and graduate, will be involved in basic research which will support their B.S. senior project, M.S. thesis or Ph.D. dissertation.

We will conduct a systematic study of promising photonuclear reactions for many radioisotopes listed in the 2015 NSAC Isotope Subcommittee report "Meeting Isotope Needs and Capturing Opportunities for the Future: The 2015 Long Range Plan for the DOE-NP Isotope Program" resulting in:

1. Measurements of the bremsstrahlung-weighted excitation functions and inference of cross sections to fill in some of the many gaps in the world's photonuclear data, as documented in the IAEA "Handbook on Photonuclear Data for Applications". Reactions that will be addressed will include (γ, α), (γ, p), (γ, n), (γ, np), and possibly other reaction channels.
2. Measurements of Figures-of-Merit (FOM) for isotope production for selected reactions versus bremsstrahlung end-point energy, both for enriched and natural targets.
3. Investigations of the potential use of nanomaterials for kinematic recoil separations of radioisotopes, in which the daughter nuclide may recoil from one material into another of different chemical composition. This will address the isotope separation challenge of using (g, n) reactions for isotope production.

4. Student engagement in research internships at a DOE IP isotope production site (INL), thus broadening their education to other production and separations approaches, techniques and facilities, thereby providing a well-rounded education in isotope production.

This program will provide support and education each year for roughly seven graduate students and seven undergraduate students, as well as training and experience in world-class nuclear facilities. Students will also continue their studies utilizing DOE IP isotope production laboratory training activities, such as hands-on research, MCNP-X training and Nuclear Physics Summer Schools. They will contribute to the research program with simulations of target designs and construction, photonuclear simulations, measurements of photonuclear yields and data analysis. The results of this program will inform the next-generation isotope production capabilities of DOE laboratories, as well as provide critical human capital in support of domestic efforts in isotope science.

This research was selected for funding by the Office of Science Isotope Production Program.