Conference on Science at the Sanford Underground Research Facility

Report of Contributions

Contribution ID: **1** Type: **not specified**

Welcome

Tuesday, May 14, 2024 8:20 AM (5 minutes)

Presenter: Dr ANDERSON, Laurie (South Dakota School of Mines and Technology)

Session Classification: Plenary: Underground Science & Native American Heritage

Track Classification: Plenary

Contribution ID: **4** Type: **Oral**

The Past Lives in Our Present: Black Hills History and Community Engagement Efforts at SURF

Tuesday, May 14, 2024 8:25 AM (25 minutes)

Presenter: ZENS, Rochelle (SURF)

Session Classification: Plenary: Underground Science & Native American Heritage

Track Classification: Plenary

Contribution ID: **11** Type: **Oral**

Advanced Germanium Detectors for LEGEND

Thursday, May 16, 2024 8:30 AM (30 minutes)

Primary authors: RADFORD, David (ORNL); RADFORD, David (Oak Ridge National Laboratory)

Presenters: RADFORD, David (ORNL); RADFORD, David (Oak Ridge National Laboratory)

Session Classification: Plenary: Advanced Materials, Geology, Advanced Data Analysis

Track Classification: Materials Science

Contribution ID: **21** Type: **Oral**

Unraveling Light Dark Matter and Rare B Decays: $L_\mu - L_\tau$ Model Enhanced by Scalar Leptoquark

Wednesday, May 15, 2024 4:20 PM (20 minutes)

We investigate the phenomenology of light GeV-scale fermionic dark matter in $U(1)_{L_\mu - L_\tau}$ gauge extension of the Standard Model. Heavy neutral fermions alongside with a $S_1(\overline{3},1,1/3)$ scalar leptoquark and an inert scalar doublet are added to address the flavor anomalies and light neutrino mass respectively. The light gauge boson associated with $U(1)_{L_\mu - L_\tau}$ gauge group mediates dark to visible sector and helps to obtain the correct relic density. Aided with a colored scalar, we constrain the new model parameters by using the branching ratios of various $b \to sll$ and $b \to s\gamma$ decay processes as well as the lepton flavour non-universality observables $R_{K^{(*)}}$ and then show the implication on the branching ratios of some rare semileptonic $B \to (K^{(*)}, \phi)+$ missing energy, processes.

Primary author: SAHOO, Suchismita (Central University of karnataka)

Co-authors: Prof. MOHANTA, Rukmani (University of Hyderabad); Dr SINGIRALA, Shivaramakrishna (University of Hyderabad)

Presenter: SAHOO, Suchismita (Central University of karnataka)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **23** Type: **Oral**

Searching for WIMPs and Other New Physics with LZ

Wednesday, May 15, 2024 2:25 PM (25 minutes)

LUX-ZEPLIN(LZ) is a direct detection dark matter experiment located nearly a mile underground at the Sanford Underground Research Facility (SURF) in Lead, South Dakota, USA. Employing a dual-phase Time Projection Chamber (TPC) containing 7 tonnes of active xenon surrounded by veto systems, LZ presents a world-leading sensitivity in detecting Weakly Interacting Massive Particles (WIMPs), a highly motivated dark matter candidate. Beyond the quest for WIMPs, the LZ experiment explores diverse new physics phenomena. This presentation will provide an update on the current status of LZ and its latest results.

Primary author: XIA, Shilo (LBNL)

Presenter: XIA, Shilo (LBNL)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **24** Type: **Oral**

Baryon Number Violation Searches Using the DUNE Far Detector

Wednesday, May 15, 2024 2:30 PM (30 minutes)

The DUNE experiment will have a rich set of physics topics, including neutrino oscillation and Beyond Standard Model (BSM) physics. Of great importance to the latter of these goals in baryon number violation (BNV), especially including proton decay (PDK), neutron-antineutron transformations, and dinucleon decay. All suffer from atmospheric neutrino backgrounds, which at times mimic these rare events' unique topologies. In this talk, we will review recent results in this vein using the DUNE Far Detector, and look forward to some upcoming analyses.

Primary authors: BARROW, Josh (UMN, Fermilab visitor); WAN, Linyan; STOKES, Tyler (Louisiana State University); Dr TSAI, Yun-Tse (SLAC)

Presenter: BARROW, Josh (UMN, Fermilab visitor)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

Contribution ID: **25** Type: **Oral**

Urban Mining of e-scrap –Biohydrometallurgy is the future

Tuesday, May 14, 2024 4:40 PM (20 minutes)

Voluminous generation of electronic waste (e-waste) is a global trend, with 53.6 Mt of generation in 2019; it is further expected to reach 74.9 Mt by 2030 world-wide. This waste is a secondary source of various valuable metals including critical and rare metals, and processes of recovering these metals has been seen with the concept of urban mining. While pyrometallurgical and hydrometallurgical methods are most commonly utilized, but these are coupled with energy intensiveness and the generation of hazardous wastewater, respectively. Biohydrometallurgy is an emerging technique that has the potential to mitigate these limitations by utilizing microorganisms. For the past twelve years, our research group has been using cyanogenic bacterial strains including Chromobacterium violaceum, Pseudomonas fluorescens, Pseudomonas balearica, and Bacillus sporothermodurans for the recovery of various metals from Waste Computer Printed Circuit Boards (WCPBs). The WCPBs are a cause of great environmental concern, accounting for nearly 3-6% wt. of total electronic waste. Thus, we are harnessing the metabolic activities of microorganisms to facilitate the extraction, and transformation of metals from WCPBs. To overcome the specificity limitations of this green technology, we devised sequential leaching approach through chemo-biohydrometallurgy process. Pretreatment with Ferric chloride led to the maximum recovery of Cu metal prior to biocyanidation process. Consequently, the leaching efficiency for other valuable metals such as Ag, Au, and Pt improved to 57%, 67% and 60%, respectively by novel Bacillus strain (i.e., Bacillus sporothermoduran). We reported this new Bacillus strain as potential bacteria with toxicity tolerance to EC50 = 450 g L-1 of pulp density (crushed WCPBs with particle size <150μm). Thus utilizing these promising microbial strains, biohydrometallurgical processes can be implemented on a large-scale to achieve the agenda of the Sustainable Development Goals under the strategies of urban mining.

Primary authors: Dr KUMAR, Anil (School of Chemical and Metallurgical Engineering, University of the Witwatersrand, Johannesburg, South Africa); Dr PRADHAN, Jatindra Kumar (Department of Zoology, Government Autonomous College, Phulbani, Kandhamal, Odisha-762001, India); Dr THAKUR, Pooja (Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh 173234); Dr KUMAR, Sudhir (Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh 173234)

Presenter: Dr KUMAR, Sudhir (Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat, Solan, Himachal Pradesh 173234)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **26** Type: **Oral**

The SuperCDMS SNOLAB experiment

Wednesday, May 15, 2024 5:00 PM (20 minutes)

The low mass (< 10 GeV/c^2) dark matter parameter space presents several candidates of interest, but requires devices with excellent energy resolution operated in ultra-low background environments to perform meaningful searches. SuperCDMS SNOLAB is a broadband direct dark matter search experiment projected to achieve world-leading sensitivity under 5 GeV/c^2 mass for nucleon-coupled dark matter candidates and probe previously unexplored regions in the sub-GeV mass range. As the experiment marches towards its commissioning phase, this talk will present an overview of the science, a brief status report and highlight results to anticipate in the near future.

Primary author: PRADEEP, Aditi (University of British Columbia)

Presenter: PRADEEP, Aditi (University of British Columbia)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **27** Type: **Oral**

Latest results of the PandaX-4T experiment

Wednesday, May 15, 2024 2:00 PM (25 minutes)

PandaX-4T is a deep-underground experiment that searches for rare events using a dual-phase liquid xenon time projection chamber. The detector has an active volume containing 4 tons of liquid xenon. Recently, PandaX-4T has completed the first two runs of data collection. In this talk, the latest search results on dark matter, B8 and pp solar neutrinos, as well as neutrinoless double beta decay of xenon isotopes will be presented.

Primary author: QIAN, Zhicheng (上海交通大学)

Presenter: QIAN, Zhicheng (上海交通大学)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **34** Type: **Oral**

Electron Lifetime Measurements in the LUX-ZEPLIN (LZ) Dark Matter Experiment

Wednesday, May 15, 2024 2:50 PM (25 minutes)

The LZ experiment is a dual-phase liquid xenon Time Projection Chamber (TPC) located at the Sanford Underground Research Facility (SURF) to detect Weakly Interacting Massive Particles (WIMPs). Dual-phase TPCs are designed to observe interactions that either excite or ionize a medium via a prompt scintillation (S1) at the interaction site and a delayed amplified signal (S2) in the extraction region at the gas-liquid interface near the top of the detector. The prompt S1 signal is created by de-excitation and recombination of xenon atoms, while the delayed S2 signal is created after transporting the freed electrons from the interaction site to undergo electroluminescence in gaseous xenon via a strong electric field. Using the S1 and S2 signals, we can perform a three-dimensional reconstruction of an interaction. Calibrating and understanding how the detector response varies as a function of position and time is critical for event identification to distinguish background from signal. One aspect that can affect our S2 signal is electron lifetime, which reflects how many signal electrons are lost over time due to impurities in liquid xenon. Electron lifetime depends both on the purity of the medium and the strength of the drift electric field, both of which can vary over time and position in the TPC. This presentation will describe the results of LZ's electron lifetime analysis to understand the drift of electrons in the LZ detector, which plays a crucial role for event reconstruction.

Primary author: GENOVESI, Jack (SDSMT)

Presenter: GENOVESI, Jack (SDSMT)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **35** Type: **Oral**

Radiopure flexible cables for rare-event physics detectors

Thursday, May 16, 2024 4:40 PM (20 minutes)

Readout cables for signal sensors are a fundamental component of rare event searches for dark matter and neutrinoless double beta decay. While they possess unique electrical and mechanical properties, polyimide-based flexible cables can be a significant contributor to the total detector background, due to their relatively high content of long-lived primordial radionuclides like 238U and 232Th and their progeny, as well as 40K. Commercially-available flexible cables have 232Th and 238U measured in the mBq/kg range, making them incompatible with the stringent levels required for ultralow background next-generation rare event detectors.
In previous work, we investigated and successfully sourced low-background (μBq/kg) copper-polyimide laminates which serve as the starting material for flexible cable manufacturing. However, even when starting with low-background materials, cable manufacturing processes result in finished cables several orders of magnitude higher in radioactivity (mBq/kg range) due to contamination during processing. In collaboration with a commercial cable manufacturer, we completed a systematic investigation of the manufacturing process and alternative materials. We then developed a cleaning method that reduced the radioactivity levels of the final cables from mBq/kg to nearly that of the starting laminate –a few tens of μBq/kg. In this work, we have rigorously tested our cleaning method and are incorporating the method on a commercial scale. In addition, we are investigating multi-layer impedance-controlled cables and superconducting cables in our quest for the highest functioning and most radiopure cables commercially available.

Primary author: ROCCO, Nicole (Pacific Northwest National Laboratory)

Co-authors: ARNQUIST, Isaac (Pacific Northwest National Laboratory); DI VACRI, Maria Laura (Pacific Northwest National Laboratory); SALDANHA, Richard (Pacific Northwest National Laboratory); SCHLIEDER, Tyler (Pacific Northwest National Laboratory)

Presenter: ROCCO, Nicole (Pacific Northwest National Laboratory)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **36** Type: **Oral**

Nuclear Astrophysics Underground –Status of CASPAR

Thursday, May 16, 2024 11:00 AM (30 minutes)

The closer accelerator-based experiments get to the burning regime of interest for stellar nucleosynthesis, the lower the reaction probability becomes. With this exponential drop off in cross-section the issue of background interference in signals becomes more problematic even with modern detection techniques. Aboveground experiments suffer from background interactions from cosmic ray interference at a typically greater rate than expected reaction signatures. To eliminate this cosmic interference the CASPAR accelerator laboratory is located at Sanford Underground Research Facility, studying nuclear reactions of astrophysical interest specifically (p,γ), (α,γ) and (a,n) reactions. The accelerator system has been in a 2-year hibernation and is currently ramping up into production mode again. This talk will highlight recent measurements at CASPAR, and the future timeline for new experimental campaigns.

Primary authors: ROBERTSON, Daniel (University of Notre Dame); COUDER, Manoel (University of Notre Dame); GOERRES, Joachim (University of Notre Dame); HANHARDT, Mark (SDSTA/SURF); SIMON-ROBERTSON, Anna (University of Notre Dame); STRIEDER, Frank (South Dakota School of Mines & Technology); WIESCHER, Michael (University of Notre Dame)

Presenter: ROBERTSON, Daniel (University of Notre Dame)

Session Classification: Plenary: Nuclear Astrophysics, Biology, DUNE Phase II

Track Classification: Nuclear Physics

Contribution ID: **37** Type: **Oral**

Enhancement of methane oxidation in methanotrophs

Tuesday, May 14, 2024 3:20 PM (20 minutes)

Methane, a potent greenhouse gas, has garnered significant attention due to its environmental impact and economic potential. Enhancing methane catalysis poses challenges in both chemical and biological sectors. Biological methane conversion offers advantages such as higher conversion rates, improved selectivity, self-renewal properties, and economically feasible upstream processing. The complete genome of Methylosinus trichosporium OB3b was sequenced using Nanopore technology, identifying 4,877 genes on the chromosome. The integrated metabolomic profile revealed 63 metabolites, out of which 14 are screened down with regard to their commercial relevance. Bifunctional aldehyde dehydrogenase and phospholipase were annotated in the ethanolamine pathway, while fatty acid desaturase was identified as a one-step enzyme enabling the direct conversion of precursor R-decanoyl-[acp] into R-decenoic acids in the R-decenoic acid pathway. A pan-genomic study of 75 Type II methanotrophs spanning different genera revealed 256 exact core gene families. Among the 22 observed hypothetical proteins in the core genes, the functionality of 12 were identified. Notable findings included Methylocella tundrae, which possessed three copies of sMMO components, setting it apart from other methanotrophs. Despite of all observed strains had essential genes for the serine pathway, Methylooceanibacter marginalis lacked serine hydroxymethyltransferase (SHMT), Methylobacterium variabile had both isozymes of SHMT, and Methylobrevis sp. displayed a unique serine-glyoxylate transaminase isozyme. Only nine strains contained anaplerotic enzymes, indicating their utilization of the glyoxylate pathway, whereas the remaining strains followed the enoylmalonyl-CoA (EMC) pathway. Methylovirgula sp. 4MZ18 possessed genes from both pathways, and Methylocapsa sp. S129 possessed the A-form of malate synthase, distinguishing it from other strains with the G-form. The study also uncovered phylogenetic relationships and distinct clustering patterns among Type II methylotrophs, leading to the proposal of a separate genus for Methylovirgula sp. 4M-Z18 and Methylocapsa sp. S129. With an effort to enhance methane oxidation rates in OB3b, macromolecular modeling and docking were employed revealing an unexplored active site within the particulate form (pMMO). Additionally, we identified five potential mutants (B:Leu31Ser, B:Phe96Gly, B:Phe92Thr, B:Trp106Ala, and B:Tyr110Phe) that show promise in improving methane oxidation rates. The regulation of the Cu switch was observed within a narrow range of Cu concentrations, specifically between 3 and 5 μM. Notably, this regulation resulted in a significant increase in methane consumption rates, rising from 3.09 to 3.85 μM.day-1 on the 6th day. The upregulation of Mbn synthesis genes (mbnABC) and the Ton-B siderophore receptor gene (mbnT) at above 5μM Cu may be responsible for the enhanced Mbn synthesis leading to increased Cu consumption. To distinguish between cells expressing the soluble form of MMO (sMMO) and the pMMO, we developed a quantitative assay based on the Naphthalene-Molisch principle. Overall, this dissertation provided valuable insights into the genetic diversity of methylotrophs, effective strategies for enhancing methane oxidation rates, and the regulatory role of copper in MMOs.

Primary author: Dr SAMANTA, Dipayan (South Dakota School of Mines and Technology)

Co-author: Prof. SANI, Rajesh (South Dakota School of Mines and Technology)

Presenter: Dr SAMANTA, Dipayan (South Dakota School of Mines and Technology)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **38** Type: **Oral**

Application of machine learning for anomaly detection and background discrimination in LZ data

Wednesday, May 15, 2024 5:10 PM (25 minutes)

LUX-ZEPLIN (LZ) is a dark matter direct detection experiment using a dual-phase xenon time projection chamber with a 7-ton active volume, which recently set a world leading limit for spin-independent scattering at 36 GeV/c2, rejecting cross sections above 9.2×10−48 cm2 at the 90% confidence level. Machine learning techniques have been explored at various stages of data analysis, for identifying anomalous events and background discrimination. Anomalies are expected in data, especially in the early stages of the experiment, such as from misclassification of pulses and interaction types, as well as detector pathologies. In this talk I will discuss about an unsupervised dimensional reduction approach that can effectively identify anomalous events in early LZ data. Additionally, I will present on application of machine learning tools in LZ analysis to discriminate problematic backgrounds.

Primary author: ARTHURS, Maris (Postdoctoral associate)

Presenter: ARTHURS, Maris (Postdoctoral associate)

Session Classification: Advanced Data Analysis

Track Classification: Advanced Data Analysis

Contribution ID: **39** Type: **Poster**

Synergistic Microbial Solutions for Sustainable Agriculture

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Global nutrient demand, economic pressures, and declining crop prices drive fertilizer demand, necessitating sustainable solutions to safeguard soil, crop, and environmental health. To address these concerns, we aim to develop a microbial-based bio-fertilizer for the agricultural industry, mitigating chemical fertilizer's environmental and socio-economic impacts. The objective of the research is to bio-assemble synergistic interactions between microbial communities with complementary metabolic capabilities to replenish essential nutrients in agricultural soils and act as a carbon sink. The current ongoing work involves screening microbial populations with nitrogen fixation, carbon fixation, and phosphorus solubilization abilities from the agricultural fields. After confirming the metabolic capabilities via biochemical assays of the isolates, compatible microbial strains will be identified through cross-streaking assays. The next steps in the experiment would involve greenhouse trials to assess the effectiveness of the microbial fertilizer, and monitoring plant growth, soil health, and related ecotoxicity. This work, therefore, holds the potential to improve soil health, increase crop yields, and boost agricultural productivity through microbial fertilizers. Adoption can lead to higher revenues for farmers, stimulate economic activity in rural communities, and create new opportunities for agricultural biotechnology companies, driving innovation and job creation.

Keywords: Agricultural Biotechnology, Microbial Biofertilizers, Soil Health

Primary author: KAUR, Navdeep

Co-authors: Dr DIWAKAR, Prasoon K; Dr SANI, Rajesh; Dr GOVIL, Tanvi

Presenter: KAUR, Navdeep

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **40** Type: **Oral**

Mitigating Plastic Pollution in Agriculture through Biodegradable Mulch Films

Tuesday, May 14, 2024 4:20 PM (20 minutes)

Antonia Gibbs (1) and Jasmeet Kaur (2), Chirag Abrol (2), Tanvi Govil (1), Heidi Sierveding (3), and Rajesh K. Sani (1,2)
1 Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota Mines, Rapid City, SD, USA
2 Department of Chemistry, Biology, and Health Sciences, South Dakota Mines, Rapid City, SD, USA
3 Civil and Environmental Engineering (CEE), South Dakota Mines, Rapid City, SD, USA

Plastic mulch films are currently used in the agricultural industry to aid crop growth by enhancing water retention and suppressing weed growth. These films can have adverse effects on the local environment due to fragmenting through physical, biological, and chemical means throughout the product's lifetime, leaving behind microplastics. One way to mitigate this problem is by replacing the petroleum-based, non-biodegradable plastic films currently in use with biodegradable bioplastic films that may benefit soil and plant health. One such biodegradable bioplastic that could be used in this application is polyhydroxyalkanoate (PHA), a polymer readily made and degraded by many species of bacteria. The focus of this study on PHA is to determine the effects of biodegradation on plant health. In this study, three pots each of soybeans with PHA or Viaflex films, and two each with PHA powder, or no additives, were planted in a climate-controlled growth chamber. Ongoing monitoring of plant health parameters is being performed, including measuring plant height and timing of life cycle development milestones. One each of the PHA and Viaflex films is taken from a pot every thirty days to monitor their relative degradation rates, measure changes in their physical and mechanical properties, and observe microbial growth on the surface of the films.
Keywords: Biodegradation, Climate Change, Greenhouse Gases, Polyhydroxyalkanoates

Primary authors: Mrs GIBBS, Antonia (South Dakota Mines - Department of Chemical and Biological Engineering); KAUR, Jasmeet (South Dakota Mines - Department of Chemistry, Biology, and Health Sciences)

Presenters: Mrs GIBBS, Antonia (South Dakota Mines - Department of Chemical and Biological Engineering); KAUR, Jasmeet (South Dakota Mines - Department of Chemistry, Biology, and Health Sciences)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **41** Type: **Poster**

Utilizing Signaling Molecules for Sustainable Crop Management in Agriculture

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Jasmeet Kaur1, Antonia Gibbs2, Tanvi Govil2, and Rajesh K. Sani1,2
1 Department of Chemistry, Biology, and Health Sciences, South Dakota Mines, Rapid City, SD, USA
2 Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota Mines, Rapid City, SD, USA

Sustainable agriculture holds immense promise in meeting the food demands of our ever-expanding global population. The integration of signaling molecules in agriculture represents a promising approach for sustainable and eco-friendly crop management. Identifying these signaling molecules and harnessing them to improve the interaction between beneficial microbes and plant roots can improve resource availability and use efficiency. The introduction of signaling molecules such as flavonoids can stimulate biofilm formation in soil diazotrophic bacteria, promote bacterial colonization of plant tissues, and improve biological nitrogen fixation (BNF) with increased grain yield. Whereas molecules like lectin acid can act as an adhesion molecule between root and nitrogen-fixing bacteria.
Under the NSF EPSCoR RII-T2 BioWRAP project, our research focuses on the biomanufacturing of flavonoids through microbial route. By exploring these compounds as potential agricultural amendments, we aim to stimulate the proliferation of nitrogen-fixing microbiota in agricultural fields, thereby mitigating the reliance on synthetic nitrogen fertilizers. The initial investigation encompasses various methodologies and optimization strategies for flavonoid extraction. This involves investigating both chemical and microbial routes to determine their efficacy and scalability. By utilizing microbial routes, we aim to demonstrate the scalable production of bioactive flavonoids. Furthermore, research extends to evaluating the impact of flavonoids on plant and soil health.
Keywords: Sustainable agriculture, Flavonoids, Biomanufacturing

Primary author: KAUR, Jasmeet (SDSMT)

Presenter: KAUR, Jasmeet (SDSMT)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **42** Type: **Poster**

Bio-Mediated Soil Stabilization for Enhanced Infrastructure Resilience

Tuesday, May 14, 2024 3:45 PM (35 minutes)

In the United States, addressing the detrimental effects of freeze-thaw phenomena on highway infrastructure alone costs approximately $2 billion annually. Frost-heave and thaw-weakening pose significant challenges to civil infrastructure in cold regions. Psychrophiles have evolved a range of adaptations to cope with the stresses imposed by freeze-thaw cycles. This research project presents the application of extracellular polymeric substances (EPS) secreted by a psychrophilic bacterium to stabilize frost-susceptible (FS) soil. EPS has been acknowledged in literature to display antifreeze properties, including water retention, nutrient and ion sequestration, and osmoregulation, thus enabling bacteria to prevent ice crystal formation in soils. Therefore, we propose that these properties of EPS could also stop frost-susceptible soil from freezing if enough EPS is present to regulate the soil's moisture. For this purpose, EPS was extracted from a psychrophilic bacterium, grown at different temperatures and growth media for 30 days. The extracted EPS is combined with FS Soil to examine it for antifreeze properties under a microscope. The thermal properties like freezing, thawing, and thermal hysteresis of the control and treated soils are evaluated using a thermoelectric cooling system. Indeed, by employing EPS for soil stabilization in the Sanford Underground Research Facility (SURF), we can mitigate frost-heave and thaw-weakening risks underground, ensuring the integrity of underground structures for research.
Keywords: Bio-mediated soil stabilization; Extracellular polymeric substances (EPS); Psychrophilic bacteria

Primary authors: GARG, Ishika (South Dakota School of Mines and Technology); Ms SHARMA, Rimjhim (South Dakota School of Mines and Technology)

Co-authors: Dr LINGWALL, Bret (South Dakota School of Mines and Technology); Dr SANI, Rajesh (South Dakota School of Mines and Technology); Mr RAHMAN, Rashed (University of Arizona); Dr GOVIL, Tanvi (South Dakota School of Mines and Technology); Dr BHEEMASETTI, Tejo (University of Arizona)

Presenters: GARG, Ishika (South Dakota School of Mines and Technology); Ms SHARMA, Rimjhim (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **43** Type: **Oral**

Advances in High Purity Germanium Single Crystals: Characterization and Progress at the USD

Tuesday, May 14, 2024 3:20 PM (20 minutes)

This presentation provides an overview of the recent advancements in High Purity Germanium (HPGe) crystals at the University of South Dakota (USD). The focus of this research lies in the meticulous characterization of HPGe crystals, addressing critical parameters such as impurity concentration, dislocation density, and diameter control during crystal growth.

Our goal is to improve the efficiency and performance of HPGe detectors, driven by the requirements of the research and development involved in rare event searches. In order to investigate elusive events such as neutrinoless double- beta decay and dark matter interactions, these detectors are essential that demand unprecedented sensitivity and precision. Such detectors can only be fabricated if good quality of crystals can be grown with homogenous net impurity concentration of ˜5x10ˆ{9} to 3x10ˆ{10}/cm3.

This work is supported by NSF OISE 1743790, NSF PHYS 2310027, DOE DE-SC0024519, DE-SC0004768.

Primary author: BHATTARAI, Sanjay (University of South Dakota)

Co-authors: Dr MEI, Dongming (University of South Dakota); Mr DONG, Kungming (University of South Dakota); Mr WARREN, Austin (University of South Dakota); Mr BUDHATHOKI, Narayan (University of South Dakota)

Presenter: BHATTARAI, Sanjay (University of South Dakota)

Session Classification: Double Beta Decay

Track Classification: Double Beta Decay

Contribution ID: **44** Type: **Poster**

Modification of Biopolymers from Geobacillus sp. strain EP1 for 3D printing Biofertilizer Encapsulation

Tuesday, May 14, 2024 3:45 PM (35 minutes)

1 Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota Mines, Rapid City, SD, USA
2 Department of Chemistry, Biology, and Health Sciences, South Dakota Mines, Rapid City, SD, USA

Sustainable production of biofertilizers offers an environmentally friendly alternative to chemical fertilizers, mitigating runoff and reducing industrial production. Here, we propose a method utilizing a consortium of microbes directly placed in soil, facilitated by hydrophobic, heat-resistant, and biodegradable capsules. Previous research highlights the thermophilic bacterium Geobacillus sp. strain WSUCF1's capacity to sustainably produce exopolysaccharides (EPSs), rich in glucomannan and mannan, with high thermal stability and low crystallinity. An adapted version of strain WSUCF1, the Geobacillus sp. strain EP1, tailored for growth on corn stover, yields abundant biopolymers. By elucidating the structure and bonds of these biopolymers, sustainable methods for enhancing crystallinity and hydrophobicity can be explored. These modified biopolymers show promise as 3D printing materials for biofertilizer capsules, offering innovative solutions for sustainable agriculture.
Keywords: Biopolymer, Biofertilizer, Exopolysaccharides, Sustainability

Primary authors: SUTKO, Kelly (South Dakota School of Mines and Technology); SANI, RAJESH (SD School of Mines and Technology); GOVIL, Tanvi

Presenter: SUTKO, Kelly (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **45** Type: **Poster**

Advancing Sustainable Biopolymer Production through Cell Free Biomanufacturing

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Kritika Thakur1, Chirag Abrol2, David R. Salem1, and Rajesh K. Sani1,2, Tanvi Govil1
1 Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota Mines, Rapid City, SD, USA
2 Department of Chemistry, Biology, and Health Sciences, South Dakota Mines, Rapid City, SD, USA

In the quest for sustainable biopolymers, Polyhydroxyalkanoates (PHAs) stand out for their inherent biodegradability. However, their industrial production faces challenges, including high production costs and complex downstream processes. To surmount these obstacles, our approach involves leveraging cell-free systems to streamline PHA synthesis and polymerization. Our ongoing work focuses on deciphering the metabolic pathways of cnambio1 and designing a chain elongation pathway using acetyl CoA compounds derived from the sugar pathway. The sugar feedstock is sourced from valorized Corn Stover using a novel consolidated bioprocessing (CBP) system, eliminating the need for pretreatments. We are also exploring innovative purification methods tailored to the unique characteristics of cell-free-produced PHAs, ensuring the isolation of pure and homogeneous biopolymer products. By accelerating the shift towards a sustainable biopolymer industry, our efforts contribute to global initiatives aimed at curbing the projected accumulation of 12 billion metric tons of plastic waste in landfills by 2050. Through strategic manipulation of synthetic multi-enzyme pathways, our work paves the way for the establishment of "Bio-Precursor Industries" worldwide, marking a significant step towards a more environmentally conscious future.
Keywords: Bio-Precursor industries; Cell-free biomanufacturing; Consolidated bioprocessing (CBP) Polyhydroxyalkanoates (PHAs)

Primary authors: Mr ABROL, Chirag (SDSMT); Ms THAKUR, Kritika (SDSMT)

Presenters: Mr ABROL, Chirag (SDSMT); Ms THAKUR, Kritika (SDSMT)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **46** Type: **Oral**

Enhancing XENONnT's Sensitivity to Neutrinoless Double-beta Decay with TextCNN

Tuesday, May 14, 2024 3:00 PM (20 minutes)

XENONnT employs a large target mass and dual-phase TPC to achieve unparalleled sensitivity in rare event searches. The neutrinoless double-beta ($0\nu\beta\beta$) decay searches at XENONnT encounters limitations due to gamma-rays emitted by the detector material. Therefore, a TextCNN (convolutional neural network for text) model with waveform augmentation is designed to extract maximum information from the detector data. It demonstrates remarkable capability, achieving over 60% background rejection while maintaining a 90% signal acceptance. It significantly improved the background rejection for $0\nu\beta\beta$ searches at XENONnT, which can potentially improve the sensitivity of the $0\nu\beta\beta$ search for ^{136}Xe by over 30%. This highlights the potential for utilizing ^{136}Xe enriched xenon to achieve heightened sensitivity to $0\nu\beta\beta$ decay in future dark matter experiments such as XLZD.

Primary author: ZHONG, Min (University of California, San Diego)

Presenter: ZHONG, Min (University of California, San Diego)

Session Classification: Double Beta Decay

Track Classification: Double Beta Decay

Contribution ID: **47** Type: **Oral**

Effect of bioavailable copper on Oleidesulfovibrio alaskensis G20 biofilm formation

Tuesday, May 14, 2024 5:00 PM (20 minutes)

Copper is known to have inhibitory effects on bacterial growth. However, sulfate-reducing bacteria (SRB) have demonstrated the ability to grow in the presence of toxic levels of metal ions. This study aimed to evaluate the influence of Cu(II) ions on biofilm formation by the SRB strain Oleidesulfovibrio alaskensis G20 (OA-G20) in a lactate-based medium supplemented with varying concentrations of Cu(II). When exposed to media containing high levels of Cu(II) (30μM), OA-G20 exhibited inhibited growth in its planktonic (free-floating) state. Conversely, under the same experimental conditions with elevated Cu(II) concentrations (e.g., 30-100μM??), OA-G20 displayed enhanced biofilm formation on glass surfaces. Microscopic observations revealed that the Cu-induced biofilms exhibited changes in cellular morphology and increased accumulation of carbohydrates and proteins compared to Cu(II)-free biofilms. Consistent with these findings, gene expression analysis using qPCR showed a significant upregulation of genes involved in sulfur and energy metabolism, EPS production, and stress response in the copper-induced biofilms. In contrast, genes related to cellular division (ftsZ, ftsA, ftsQ) were negatively regulated compared to the control. These results suggest that the presence of Cu(II) ions triggers alterations in the cellular morphology and gene expression levels of OA-G20, impacting its ability to adhere to surfaces and produce EPS. This adaptation, characterized by enhanced biofilm formation, represents a crucial strategy employed by OA-G20 to resist and cope with metal ion stress.

Primary author: Ms THAKUR, Payal

Co-author: Prof. SANI, Rajesh K

Presenter: Ms THAKUR, Payal

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **48** Type: **Oral**

Development of Germanium (Ge) Ring Contact Detectors for Ge-based Neutrinoless Double-Beta Decay Experiment

Tuesday, May 14, 2024 2:40 PM (20 minutes)

The next generation neutrinoless double beta (0νββ) decay experiments aim to achieve sensitive to a decay with a half-life of ˜1028 years. A germanium-76 (Ge-76)-based experiment can achieve the discovery potential for this rare decay process due to its excellent energy resolution and ability to reject scattered gamma-ray events. LEGEND-1000 prefers large-size detectors (>3 kg per detector) to further reduce backgrounds, complexity, and cost. This talk will explore large-size Ge fabricated in a novel ring contact (GeRC) geometry using high-purity Ge crystals grown at USD. The GeRC detector, a collaborative effort between ORNL, UNC, TAMU, and USD, has undergone significant improvements since its inception. Last year, an initial GeRC detector has been successfully fabricated at TAMU and subsequently tested at UNC. Regrettably, this first iteration did not meet our expectations. However, this presents an opportunity to enhance our research capabilities. By establishing an upgraded workshop at USD, we are now better equipped to study GeRC detectors comprehensively. Leveraging the invaluable experience gained from TAMU, we are poised to re-fabricate the first detector at USD. In this presentation, we will present some preliminary results obtained from the GeRC detector fabricated at USD, utilizing crystals grown exclusively at USD.

Primary authors: BOS, Brady (University of North Carolina); Dr RADFORD, David (Oak Ridge National Laboratory); MEI, Dongming (University of South Dakota); Dr WILKERSON, John (University of North Carolina); DONG, Kunming (University of South Dakota); Dr HARRIS, Rusty (Texas A&M University); Dr WEI, Wenzhao (University of South Dakota)

Presenter: DONG, Kunming (University of South Dakota)

Session Classification: Double Beta Decay

Track Classification: Double Beta Decay

Contribution ID: **49** Type: **Oral**

Synthesis and antibacterial efficacy of chitosan-stabilized calcium peroxide nanomaterials

Presently, there is a significant focus on synthesizing antibacterial nanomaterials for various antibacterial applications, necessitating modifications to the chemical processes involved. In this study, we present the synthesis of chitosan-stabilized calcium peroxide (CCP) nanomaterials (NMs) using a facile precipitation technique with varying reaction temperatures. The crystalline structure and composition formation of the synthesized NMs were confirmed through X-ray diffraction studies, Fourier Transform Infrared spectroscopy, and Energy-dispersive X-ray spectroscopy. Additionally, the shape and size of the NMs synthesized at different temperatures were analyzed using scanning electron microscopy (SEM), nanoIR3 and transmission electron microscopy (TEM). Finally, the prepared CCP NMs exhibited antibacterial activity, as assessed by the inhibition zone method against both Gram-negative and Gram-positive bacteria. The antimicrobial results demonstrated a higher inhibition zone for the CCP NMs, suggesting their potential utility in antibacterial and antibacterial-based coating applications.

Primary author: Dr TIPPABATTINI, Jayaramudu (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States)

Co-authors: Prof. SANI, Rajesh K (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States); Dr GOVIL, Tanvi (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States)

Presenter: Dr TIPPABATTINI, Jayaramudu (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **50** Type: **Oral**

NOvA+T2K Joint Analysis Results

Tuesday, May 14, 2024 2:00 PM (25 minutes)

NOvA and T2k are long-baseline accelerator neutrino experiments that are sensitive to oscillation phenomenon governed by the atmospheric mass-squared splitting. In particular, both experiments are sensitive to the CP-violating phase in the neutrino sector. Although both experiments measure the same oscillation process, their measurements are complementary and record data over different energy scales and baselines. This talk will report on the recent joint oscillation measurement from these two experiments.

Primary author: PAWLOSKI, Gregory (University of Minnesota)

Presenter: PAWLOSKI, Gregory (University of Minnesota)

Session Classification: Neutrino Oscilltaion

Track Classification: Neutrino Oscillations

Contribution ID: **52** Type: **Poster**

Unveiling pH-Dependent metabolic flexibility and homeostasis mechanisms in Oleidesulfovibrio alaskensis G20

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Sulfate Reducing Bacteria (SRB) demonstrate remarkable metabolic adaptability spanning various environments, including marine sediments, wastewater systems, and oil reservoirs, highlighting their substantial metabolic flexibility influenced by the variability in pH conditions. Nevertheless, the precise molecular mechanisms underlying their adaptation strategy remain elusive. Investigating the adaptation strategies of Oleidesulfovibrio alaskensis G20 to varying pH conditions, we found notable pH-dependent variations in growth rates, with pH 7 yielding the highest specific growth rate (μmax, 0.030 hr-1), followed by pH 6 (0.032 hr-1), while pH 8 exhibited a lower μmax of 0.024 hr-1. Additionally, pH 8 converged to pH 7 by day 2, while pH 6 reached pH 7 on day 3. Lactate consumption rates were highest at pH 7 (0.35 mM lactate.hr-1) and lowest at pH 8 (0.09 mM lactate.hr-1). Noteworthy hydrogen production was observed under acidic and alkaline conditions, while neutral pH showed no hydrogen production. Differential gene expression was confirmed via RTPCR analysis at mid-exponential (day 2) and stationary (day 4) phases, encompassing genes related to hydrogenase, F0-F1 ATPase, sulfate reduction, lactate dehydrogenase, amino acid synthesis, and carbon/energy metabolism. The study revealed significant upregulation of genes related to hydrogenases, lactate dehydrogenase, and sulfur metabolism during the mid-exponential phase, while genes associated with carbon and energy metabolism were downregulated in both acidic and alkaline conditions, indicating pH homeostasis regulation. This mechanism involves ATPases as proton pumps, hydrogenases facilitating reversible conversion of protons to hydrogen, and sulfate and energy metabolism confined to electron donors (lactate) and acceptors (sulfate), alongside amino acid synthesis for generating basic and acidic amino acids to counter pH and maintain homeostasis

Primary author: Ms SAXENA, Priya (South Dakota School of Mines and Technology)

Co-authors: Dr SAMANTA, Dipayan (South Dakota School of Mines and Technology); Ms THAKUR, Payal; Prof. SANI, Rajesh (South Dakota School of Mines and Technology)

Presenter: Dr SAMANTA, Dipayan (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **53** Type: **Oral**

Metagenome Assembled Genomes (MAGs): Extreme Habitat of Deception Island

Tuesday, May 14, 2024 5:20 PM (20 minutes)

Deception Island is an active volcano area in the southern Antarctic and forms a very unique ecological niche for extremophilic organisms, especially microbes, that survive and thrive in such habitat. A total of 7 samples were collected in an expedition in 2022 at sites of Fumarole Bay, Kronar Lake, Whaler's Bay, Pendulum Cove, Crater 70, Telephone Bay, and Obisidiana. Multiple extractions were performed for gDNA and the final 7 pooled gDNA samples were processed for metagenome library and sequencing using Rapid barcoding SQK-RBK114.24 kit from Oxford Nanopore. The sequencing generated 3.84 GB of raw data with N50 of 1.5 Kb. All the reads were processed for quality trimming using super-quality parameters using Guppy v6.7.0. Taxonomic analysis of reads using the NCBI-nr database resulted in 62 bacterial genera from all the samples. Sample MetaFum recovered only 1 read and was identified as Sulfitobacter. Sample MetaKronr recovered 2 reads and both were identified as Photobacterium leiognathi. Sample MetaPenCor also obtained 2 reads, and identified as Pseudomonas aeruginosa and as Photobacterium leiognathi. Sample MetaWhalbay, obtained 58 reads and found similarity with 27 bacterial genera where Streptomyces was predominant. Sample MetaCrat70 achieved a metagenome assembly of 20 contigs, where 10 contigs were identified as Photobacterium leiognathi, 6 as chloroplast from Orchophyta and 4 contigs did not find any match in the database. Sample MetaTelBay obtained 1204 reads reads were identified as Photobacterium leiognathi, followed by Salmonella, and Salmonella. We also have found a few reads matched with viruses such as uncultured marine virus and bacteriophage Pelagibacter phage Skadi-8. Sample MetaObis, obtained only 623 reads and got similarity with Photobacterium leiognathi, Olleya sp. Mesoflavibacter sp., Uncultured flavobacterium, Flaviramulus, Kineobactrum salinum, Sulfuriminas autotrophica, Polaribacter, Lutibacter, Pseuoalteromonas artica, and Mesorhizobium terrae. These results indicate that Photobacterium followed by Streptomyces and Salmonella are the dominant genera present in Deception Island but there were other unique genera present that could be novel for taxonomy and contribute novel metabolic functions as well. This study is brief and preliminary and warrants a more detailed sampling and metagenome sequencing for MAGs assembly and analysis to unveil the microbial treasure of Deception Island.
Keywords: Deception Island, Extreme environments, Long-read sequencing, Metagenome, Metagenome Assembled Genomes

Primary author: Dr SINGH, Ram (SD Mines)

Co-authors: Ms SHAH, Richa (SD Mines); Ms KAUR, Jasmeet (SD Mines); Dr GOVIL, Tanvi (SD Mines); Dr BANERJEE, Aparna (Instituto de Ciencias Aplicadas); Dr SANI, Rajesh (SD Mines)

Presenter: Dr SINGH, Ram (SD Mines)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **54** Type: **Poster**

The Accelerator Neutrino Neutron Interaction Experiment: New Developments in Neutrino Detection

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Abstract: The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a 26-ton water Cherenkov neutrino detector along the Booster Neutrino Beam (BNB) at Fermilab. Its primary physics goals are the measurement of final-state neutron yield of neutrino interactions and of charged-current cross section of muon neutrinos. ANNIE is also a prime staging ground for up-and-coming technologies in neutrino detectors. One such technology is Water-based Liquid Scintillator (WbLS), a novel detector medium aimed at combining the advantages of Cherenkov and scintillation detectors. ANNIE has recently deployed a target 366L vessel of WbLS in its tank. This talk will detail the experiment and its recent activity, up to and including this deployment.

Primary author: LEMMONS, Franklin (South Dakota School of Mines and Technology)

Presenter: LEMMONS, Franklin (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: DUNE Phase II

Contribution ID: **55** Type: **Oral**

The Impact of Oxygen Concentration on Methane-Oxidizing Bacteria and the Characterization of Novel Bacteria from SURF

Tuesday, May 14, 2024 3:00 PM (20 minutes)

Methane-oxidizing bacteria (MOB) play a crucial role in the global methane cycle, serving as significant actors in biogeochemical cycling. However, their physiological response to changing oxygen concentrations remains incompletely understood. This study, in part, demonstrates how two MOB species, *Methylosinus trichosporium* OB3b and *Methylomonas* sp. WSC-7, respond to changing oxygen concentrations and the addition of catalase, a hydrogen peroxide scavenger, in growth media. Through transcriptomics analysis, we showed that under high oxygen conditions, *M. trichosporium* OB3b upregulates genes involved in reactive oxygen species (ROS) defense, including cytochrome c peroxidase and superoxide dismutase, suggesting a need to deal with elevated ROS levels. Conversely, *Methylomonas* sp. WSC-7 exhibits cell clustering behavior, potentially as a defense mechanism against ROS toxicity. Differential expression of flagellar biosynthesis genes and chemotaxis response genes further supports this adaptive response. Addionally, rates of methane oxidation for both strains are impacted by the concentration of oxygen and amending the growth media with catalase. Our findings underscore the importance of oxygen concentration in modulating MOB physiology and suggest potential strategies for optimizing their growth conditions, especially for the effective isolation of novel MOB. This work also describes the characterization of two novel strains of MOB, SURF-1 and SURF-2. The strains were isolated from a microbial mat and submerged sediments, respectively, inside a tunnel at the Sanford Underground Research Facility. Specifically, they were isolated from the "17 Ledge"mining area approximately 4,850 ft below the surface. Analysis of the strains using phylogenetic and chemotaxonomic analyses coupled with analysis using genome-wide estimates of similarity indicate the strains are novel members of the genus *Methylomonas*.

Primary author: Dr GARNER, Christopher (University of Oklahoma)

Presenter: Dr GARNER, Christopher (University of Oklahoma)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **56** Type: **Oral**

Unusual Dielectric Behavior at Low Temperatures: Neutrality Induction and Excited Dipole States in Germanium Detectors for MeV-Scale Dark Matter Detection

Thursday, May 16, 2024 5:20 PM (20 minutes)

This work explores a fascinating oddity in semiconductor dielectric behavior at very low temperatures, with a particular focus on germanium detectors operating at helium temperatures. The relative capacitance rapidly decreases below 11 K and stabilizes at 6.5 K, which is similar to the fully depleted state that was measured at 77.8 K under ambient circumstances. Interestingly, this neutralization process happens without reference to bias voltage, suggesting that it is an inherent feature. This trend is confirmed by consistent observations, which show that neutrality is induced below 6.5 K. The neutralization of the intrinsic charge of the semiconductor is mostly attributed to excited dipole states. This unusual finding casts doubt on long-held beliefs and offers new information about the physics of semiconductors at extremely low temperatures.
Furthermore, by taking advantage of the low binding energy of these dipole states, this work not only advances theoretical understanding but also presents a novel idea of using germanium detectors at helium temperatures for MeV-scale dark matter detection. A detailed examination clarifies the fundamental processes behind this unique dielectric behavior and the ensuing induction of neutrality. In addition to its theoretical importance, this study opens up new possibilities for the development of low-temperature semiconductor device design and optimization.

Primary author: BUDHATHOKI, Narayan (University of South Dakota)

Presenter: BUDHATHOKI, Narayan (University of South Dakota)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **57** Type: **Oral**

Searching for MeV-scale Dark Matter at TESSERACT

Wednesday, May 15, 2024 5:40 PM (20 minutes)

The TESSERACT experiment will perform direct-detection searches for MeV-scale dark matter using transition-edge sensors (TESs) and multiple cryogenic target materials. The target materials (superfluid helium-4, gallium arsenide, and polar sapphire) are complementary to dark matter searches in the MeV range, and each produces photon and quasiparticle signals. Comparing these signals will allow us to discriminate between electron and nuclear recoils. Finally, we will use multiple channels and other techniques to identify and mitigate low-energy-excess (LEE) events known to plague low-mass dark matter searches. I will describe the goals and objectives of the TESSERACT experiment, before discussing SPICE and HeRALD, and the above-ground R&D efforts being undertaken toward the goal of running dark matter searches with TESSERACT underground.

Primary author: MATAVA, William (University of California at Berkeley)

Presenter: MATAVA, William (University of California at Berkeley)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **58** Type: **Poster**

Power Over Fiber for the DUNE Vertical Drift Photon Detection System

Tuesday, May 14, 2024 3:45 PM (35 minutes)

The Deep Underground Neutrino Experiment (DUNE) is a long-baseline neutrino experiment that will send an intense beam of neutrinos through two particle detectors: a near detector located at Fermilab (Chicago), and far detector located at ˜1.5 km underground at Sanford Underground Research Facility (SURF) in South Dakota.

The first far detector module (FD1) will employ Horizontal Drift (HD) technology, and the second module will have the Vertical Drift (VD) technology. The second module (FD2) will vertically drift the ionized electrons from the cathode plane suspended at the mid-height of the active volume of the cryostat, dividing it into two vertically separated volumes. For the first time, photon detectors called X-ARAPUCAS will be installed in the cathode plane to increase the photon detection coverage in FD2. Because the cathode is biased with a high voltage (˜300 kV) it is not possible to power the photon detectors with conventional copper cables. Power-over-Fiber (PoF) technology has been proposed to power the photon detection system (PDS) based on optical power transmission over optical fibers. The PoF technology has not been applied before in a particle physics experiment operating at cryogenic temperatures. This poster will present preliminary results on the different PoF components, their QA/QC, and their installation to supply electrical power to the PDS of the ProtoDUNE Vertical Drift (Module-0) located on the cathode plane.

Primary author: LEON SILVERIO, Diana (South Dakota School of Mines)

Presenter: LEON SILVERIO, Diana (South Dakota School of Mines)

Session Classification: Poster Session

Track Classification: Neutrino Oscillations

Contribution ID: **62** Type: **Oral**

Recent Neutrino Parameters Impact on the Effective Majorana Neutrino Mass in $0\nu\beta\beta$ Decay

Tuesday, May 14, 2024 2:20 PM (20 minutes)

We explore the impact of recent updates to neutrino oscillation parameters and the sum of neutrino masses on the sensitivity of neutrinoless double-beta ($0\nu\beta\beta$) decay experiments. By incorporating the latest cosmological constraints on the sum of neutrino masses and laboratory measurements on oscillations, we constrain the sum of neutrino masses for both the normal hierarchy (NH) and the inverted hierarchy (IH). Our analysis reveals a narrow range for the sum of neutrino masses, approximately 0.06 eV/c^2 for NH and 0.102 eV/c^2 for IH. Using these constraints, we compute the effective Majorana masses for both NH and IH scenarios and establish the corresponding allowed regions. Notably, we find that the minimum neutrino mass is non-zero, as constrained by the current oscillation parameters. Furthermore, we estimate the half-life of $0\nu\beta\beta$ decay using these effective Majorana masses for both NH and IH. Our findings indicate that upcoming ton-scale experiments will comprehensively explore the IH scenario, while 100-ton-scale experiments will effectively probe the parameter space for the NH scenario.

Primary author: MEI, Dongming

Presenter: MEI, Dongming

Session Classification: Double Beta Decay

Track Classification: Double Beta Decay

Contribution ID: **63** Type: **Oral**

Predictive Impurity Profiling in Germanium Crystals through Machine Learning and Hall Effect Measurements

Wednesday, May 15, 2024 4:45 PM (25 minutes)

This abstract introduces Hall effect measurements for evaluating Germanium crystal properties and proposes using machine learning to improve accuracy amidst challenges like equipment failures and sample fluctuations. It focuses on high-purity Germanium for rare event detection. Traditional methods for assessing impurity levels are limited, prompting the exploration of machine learning. The study aims to optimize predictive models using parameters like mobility, resistivity, and impurity concentration, evaluating various machine learning models. It suggests future research directions for enhancing predictive capabilities.

Primary author: ACHARYA, Pramod (The University of South Dakota)

Presenter: ACHARYA, Pramod (The University of South Dakota)

Session Classification: Advanced Data Analysis

Track Classification: Advanced Data Analysis

Contribution ID: **64** Type: **Poster**

Insight into Biofilm Dynamics: Integrating Experimental Curing, Advanced Imaging, and Machine Learning

Tuesday, May 14, 2024 3:45 PM (35 minutes)

A biofilm is a layer of microbial cells associated with a surface enclosed in an extracellular polymeric matrix. Research in biofilms is associated with the benefits and drawbacks of its growth, which include roles in bioremediation and wastewater treatment as the pros and influence on human health as the cons. We have initially grown biofilms on a glass surface and subsequently obtained its images via optical imaging techniques. We are further in the process of detecting antimicrobial producing capabilities of our microorganism and how this ability can be benefitted by the formation of biofilms by bacteria. This study is being conducted to transform biofilm growth control, with the Intelligent System autonomously adjusting environmental parameters, thus enabling precise growth regulation. Objectives of this study are multi-fold: Generation of a dataset correlating biofilm growth with influential factors, analysing the strengths of different growth drivers and developing a smart framework to regulate biofilm formation effectively. The organism of choice is a non-pathogenic microbe Pseudomonas stutzeri, known for its biofilm forming ability. 3D confocal images would be utilized to derive qualitative and quantitative data using BiofilmQ. Machine-learning based models created by applying this data would enforce future adaptability and integration of advanced modules over time, eventually building a model for real-time interpretation and autonomous control of biofilm growth. Ultimately, this project would encourage further research and inclusion of the evolving field of computational biology, potentially creating a substantial societal and scientific impact through its contribution to diverse areas.

Primary author: Ms KALIA, Sirina (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States)

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Presenter: Ms KALIA, Sirina (Karen M. Swindler Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD, United States)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **65** Type: **Oral**

Neutrinoless Double Beta Decay Experiments

Wednesday, May 15, 2024 9:30 AM (30 minutes)

The search for neutrinoless double beta decay is currently the most sensitive tool to study the possible identity of neutrinos and anti-neutrinos and with-it new physics beyond the Standard Model of particle physics. A world-wide effort is under way to mount a new generation of experiments, utilizing ton-amounts of decaying substance, deployed in detectors with unprecedented background. The goal is to explore multiple nuclides with different technologies to provide unambiguous evidence for an observation, should the parameters of Nature allow a discovery. In this presentation I will survey ongoing and planned experiments.

Primary author: Dr PIEPKE, Andreas (University of Alabama)

Presenter: Dr PIEPKE, Andreas (University of Alabama)

Session Classification: Plenary: Undiscovered Decays

Track Classification: Double Beta Decay

Contribution ID: **67** Type: **Oral**

Overview of the DUNE Phase-II Program

Thursday, May 16, 2024 10:30 AM (30 minutes)

The Deep Underground Neutrino Experiment (DUNE) is the next-generation long-baseline experiment aimed at measuring Charge-Parity Violation (CPV) in the neutrino sector along with unambiguously resolving the neutrino mass hierarchy. In addition, DUNE can also search for physics Beyond the Standard Model (BSM), nucleon decay, supernova and solar neutrinos. DUNE will consist of a near detector at Fermilab and a second, much larger, far detector (FD), a mile underground at the Sanford Underground Research Facility (SURF) in South Dakota 800 miles away. DUNE has developed a two-phase strategy toward the implementation of this mega science project. With Phase-I construction well underway, DUNE is now planning for Phase-II, as envisaged by the recommendations of Particle Physics Project Prioritization Panel (P5) and the European Strategy for Particle Physics. The Phase-II far and near detector components, and the increased beam power, will enable a new era of precision and discovery in neutrino physics. This talk will give an overview of the DUNE Phase-II program and technology options currently being explored for near and far detectors. The expanded science opportunities offered by DUNE Phase-II along with a status of current R&D activities underway across the globe will also be described.

Primary author: Dr GOLLAPINNI, Sowjanya (Los Alamos National Laboratory)

Presenter: Dr GOLLAPINNI, Sowjanya (Los Alamos National Laboratory)

Session Classification: Plenary: Nuclear Astrophysics, Biology, DUNE Phase II

Track Classification: DUNE Phase II

Contribution ID: **69** Type: **not specified**

Recent results from MicroBooNE and status of the Short-Baseline Neutrino program

Thursday, May 16, 2024 9:30 AM (30 minutes)

The MicroBooNE liquid argon time projection chamber (LArTPC) operated in the BNB and NuMI neutrino beamlines as part of the short baseline neutrino (SBN) program at Fermilab from 2015-2021. The experiment collected the world's largest neutrino-argon scattering data set, which it has used to publish over 60 results covering its primary physics goals: (1) investigate the MiniBooNE low-energy excess and search for beyond-standard-model physics, (2) study neutrino-argon interactions, and (3) develop novel hardware and software for LArTPCs. This talk provides an overview of recent results from the MicroBooNE experiment, including a search for sterile neutrinos under a 3+1 oscillation model, heavy neutral lepton and dark-trident searches, and several inclusive and exclusive neutrino-argon cross section measurements. The talk concludes with an update on the status of the ICARUS and SBND detectors in the SBN program.

Presenter: Dr EBERLY, Brandon (University of Southern Maine)

Session Classification: Plenary: Advanced Materials, Geology, Advanced Data Analysis

Track Classification: Neutrino Oscillations

Contribution ID: **70** Type: **Oral**

Overview of neutrinoless double beta decay

Wednesday, May 15, 2024 9:00 AM (30 minutes)

The Standard Model, as it currently stands, is not able to explain some of the most important questions about our universe such as what was the mechanism that led to the observed antimatter-matter asymmetry. Answers to these fundamental questions may come from neutrinos, which are one of the least understood particles. One of the most interesting possibilities is that neutrinos could be their own antiparticle, i.e. a Majorana fermion, which would inherently violate lepton number – a crucial ingredient in theories such as leptogenesis. In addition, this opens the possibility that the Standard Model is a low-energy effective field theory and alternative mass-generating mechanisms beyond the usual Higgs mechanism. Neutrinoless double beta decay is the most feasible method of determining if the neutrino is a Majorana fermion and in this talk, I will give an overview of the theoretical aspects of this ultra-rare process.

Primary author: Dr MISTRY, Krishan (University of Texas at Arlington)

Presenter: Dr MISTRY, Krishan (University of Texas at Arlington)

Session Classification: Plenary: Undiscovered Decays

Track Classification: Double Beta Decay

Contribution ID: **71** Type: **Oral**

Pushing Rare Event Search to the Limit with Machine Learning Algorithms

Tuesday, May 14, 2024 11:30 AM (30 minutes)

Rare event searches allow us to search for new physics inaccessible with other means by leveraging specialized radiation detectors. Machine learning provides a new tool to maximize the information provided by these detectors. The information is sparse, which forces these algorithms to start from the lowest level data and design customized models to produce results. The focus of this seminar will be on two main areas within rare event search experiments: neutrinoless double beta decay and dark matter. We will delve into the sophisticated mechanisms of radiation detectors that are specifically designed to detect these extraordinarily rare events. Moreover, the seminar will shed light on the development and application of specialized machine learning algorithms, integrating domain knowledge from fields such as spatiotemporal analysis, geometric deep learning, and time series analysis. In the latter part of the presentation, we will discuss the potential of next-generation AI/ML tools that are being developed to fully realize the discovery capabilities of rare event search experiments.

Primary author: LI, Aobo (University of California San Diego)

Presenter: LI, Aobo (University of California San Diego)

Session Classification: Plenary: Neutrinos

Track Classification: Advanced Data Analysis

Contribution ID: **72** Type: **Oral**

The Deep Underground Neutrino Experiment DUNE: Prospective Physics Program and Status

Tuesday, May 14, 2024 10:30 AM (30 minutes)

The Deep Underground Neutrino Experiment (DUNE) is the future flagship particle physics experiment of the US HEP program. It will measure the mass ordering within a few years, will make precision measurements of various neutrino oscillation parameters, and has the potential to make measurements of CP-violation in the neutrino sector with >5 (>3) sigma significance for 50% (>75%) of the parameter space. These measurements will be enabled by DUNE's 800 mile baseline, tens of kilotons of liquid argon target a mile underground at SURF, wideband neutrino beam in the few GeV range of unprecedented intensity, and highly performant near detector complex. This talk will review the primary science program of DUNE in light of the current generation of experiments, i.e. T2K and NOvA, and provide an overview of prototyping and construction efforts underway towards realizing this ambitious experiment.

Primary author: Dr WOOD, Kevin (Lawrence Berkeley National Laboratory)

Presenter: Dr WOOD, Kevin (Lawrence Berkeley National Laboratory)

Session Classification: Plenary: Neutrinos

Track Classification: Neutrino Oscillations

Contribution ID: **73** Type: **Oral**

The Theia Detector

Tuesday, May 14, 2024 5:00 PM (20 minutes)

Theia is a proposed large-scale neutrino detector designed to discriminate between Cherenkov and scintillation signals in order to facilitate a rich program of precision and rare-event physics. The baseline design consists of a tank filled with a novel scintillator, such as water-based liquid scintillator (WbLS), along with fast, spectrally-sensitive photon detection, in order to leverage both the Cherenkov signal's direction sensitivity and the remarkable energy resolution and low threshold of a scintillator detector. This talk will present the physics reach of a 25 kTon Theia detector deployed at the far detector site in the LBNF neutrino beam, as well as its complementarity to the DUNE LArTPC program. This includes sensitivity to CP violation and neutrino mass ordering, as well as a broad program of other physics topics, such as the measurement of solar, geo-, supernova burst, and diffuse supernova background neutrinos alongside the potential to search for neutrinoless double-beta decay, with a sensitivity reaching the normal ordering regime of neutrino mass phase space. The rapid progress already made in the R&D required to realize Theia will be presented.

Primary author: Dr PICKARD, Leon (UC Berkley)

Presenter: Dr PICKARD, Leon (UC Berkley)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II

Contribution ID: **74** Type: **Oral**

The future of the DarkSide-20k Dark Matter Search

Wednesday, May 15, 2024 3:15 PM (25 minutes)

The DarkSide-20k liquid-argon dark-matter detector is a two phase TPC currently under construction at Laboratori Nazionali del Gran Sasso (LNGS) in Italy. It is the next phase in the Global Argon dark Matter Collaboration's efforts and will start operations in 2026. The 50-tonne (20-tonne fiducial) mass of low radioactivity underground argon will comprise a two-phase time projection chamber (TPC), instrumented with Silicon Photomultipliers (SiPMs). Underground argon (UAr) is extracted and separated at the Urania natural gas well plant in Colorado, U.S., and purified by cryogenic distillation at the Aria plant in Sardinia. Radiopurity assay of the UAr will be performed with DArT in the ArDM facility at Canfranc. The design of the TPC is inspired by the 50 kg DarkSide-50 experiment, which pioneered the use of UAr and demonstrated world-leading sensitivity to Dark Matter candidates with mass below 3.6 GeV/cˆ2. DarkSide-20k will be essentially free from all non-neutrino backgrounds for exposures up to and beyond 100 tonnes x year, with a foreseen sensitivity reaching 7.4 x 10ˆ{-48} cmˆ2 for a WIMP mass of 1 TeV/cˆ2 in a 200 t yr run. Furthermore, thanks to the two-phase operation to the light argon mass, DarkSide-20k will have a unique sensitivity to core-collapse supernova neutrinos. This talk will focus on the detector design, photosensor development, the underground argon facilities and the physics program for the experiment.

Primary author: Dr LAI, Michela (UC Riverside)

Presenter: Dr LAI, Michela (UC Riverside)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **75** Type: **Oral**

Dark Matter Searches with Noble Liquids

Wednesday, May 15, 2024 11:00 AM (30 minutes)

Dark matter experiments using liquid xenon and liquid argon targets have demonstrated exceptional sensitivities to medium- to high-mass dark matter candidates. Therefore, these two technologies are strong contenders for the G3 dark matter project and may explore WIMP parameter spaces down to the irreducible neutrino background. Meanwhile, new developments in noble liquid detector design and signal readout open the possibilities for such detectors to detect low-mass and ultra-low-mass dark matter particles. This talk will review the status of noble liquid experiments and discuss their future potentials.

Primary author: Dr XU, Jingke (LLNL)

Presenter: Dr XU, Jingke (LLNL)

Session Classification: Plenary: Dark Matter

Track Classification: Dark Matter

Contribution ID: **76** Type: **Oral**

Overview of Nucleon Decay

Wednesday, May 15, 2024 8:30 AM (30 minutes)

Baryon number is not necessarily an exact symmetry in Nature, and its violation is deeply connected to topics such as the grand unification theories, the supersymmetry, and the baryon asymetry in our universe.So far, baryon number violation has yet to be detected. This talk discusses recent experimental approaches and future prospects towards baryon number violation processes including nucleon decay and neutron-antineutron oscillation.

Primary author: Dr WAN, Linyan (Fermilab)

Presenter: Dr WAN, Linyan (Fermilab)

Session Classification: Plenary: Undiscovered Decays

Track Classification: Proton Decay

Contribution ID: **77** Type: **Oral**

Neutrino theory overview

Tuesday, May 14, 2024 9:30 AM (30 minutes)

The observation of neutrino oscillations has shown that neutrinos are massive and hence that the Standard Model of particle physics has to be extended. In this talk I will discuss recent theory developments in neutrino oscillation and scattering physics, and in neutrino mass models which can be used to guide experimental explorations of the neutrino sector.

Primary author: Dr GEHRLEIN, Julia (Colorado State University)

Presenter: Dr GEHRLEIN, Julia (Colorado State University)

Session Classification: Plenary: Underground Science & Native American Heritage

Track Classification: Neutrino Oscillations

Contribution ID: **78** Type: **Oral**

Light dark matter: wimpier than the WIMP

Wednesday, May 15, 2024 11:30 AM (30 minutes)

We know dark matter exists and we have been trying to directly detect it for almost 40 years. Experiments searching for the heavily-favored candidate, the GeV-scale WIMP, have thus far yielded null results. Recently, the field has pushed towards a new class of "hidden sector"particles, with masses below the proton. To observe this type of "light"dark matter, new, extremely sensitive technologies that generate measurable electronic-recoil signals are required. In this talk, we will report on efforts using semiconductor devices to discover dark matter at various underground laboratories.

Primary author: Dr NORCINI, Danielle (Johns Hopkins University)

Presenter: Dr NORCINI, Danielle (Johns Hopkins University)

Session Classification: Plenary: Dark Matter

Track Classification: Dark Matter

Contribution ID: **79** Type: **Oral**

Automated industrial platform for fuel bioethanol using Clostridium with co-production of high-value peptides via clostridial IVTT

Thursday, May 16, 2024 11:30 AM (30 minutes)

Demand for plasmid DNA has increased tremendously with growth in cell and gene therapies and surged following the outbreak of the Covid-19 pandemic. Scaling up manufacturing capacity for production of high-quality plasmid DNA to meet demand will require automated solutions using industrial automation components that are more durable, dynamic, and powerful than lab instruments. This plasmid platform will be integrated with other platforms to provide a large-scale high-throughput automated system for all aspects of DNA production. Hyper scheduling of the modular units will allow for parallel operations using SCARA and 4,5,6 axis robots and continuous 24/7/365 operations. Such a platform is proposed for ethanol biofuel production from Clostridium, such as Clostridium autoethanogenum that can utilize xylose (main component of cellulosic biomass), grown on carbon dioxide or carbon monoxide using the resulting S30 fraction from the bacterial extract in industrial IVTT to make high-value peptides (such as natural sweetener brazzein) and proteins in kg quantities. The platform will be described in detail.

Primary author: Dr HUGHES, Stephen (CTO, Integrated Biorefining Corporation)

Presenter: Dr HUGHES, Stephen (CTO, Integrated Biorefining Corporation)

Session Classification: Plenary: Nuclear Astrophysics, Biology, DUNE Phase II

Track Classification: Biology

Contribution ID: **80** Type: **Oral**

Innovative Purification Techniques for Producing High-Quality Germanium Detectors for Low-Mass Dark Matter Searches

Thursday, May 16, 2024 5:00 PM (20 minutes)

Achieving detector-grade germanium crystals necessitates employing advanced purification methods to eliminate impurities from standard-grade materials. At the University of South Dakota, we specialize in a meticulous zone refining process tailored to ensure exceptional purity and quality. In this presentation, we delve into the nuances of semiconductor types and provide an overview of how specific impurities and doping influence semiconductor properties. Moreover, we offer insights into our laboratory's purification procedure, emphasizing our commitment to achieving consistent and high-quality results. Additionally, we discuss the preparatory steps preceding zone refining and detail our post-refinement analysis methods to validate the efficacy of our purification process. Join us as we explore the intricacies of advanced purification techniques vital for producing germanium detectors optimized for low-mass dark matter detection.

Primary author: WARREN, Austin (University of South Dakota)

Presenter: WARREN, Austin (University of South Dakota)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **81** Type: **Oral**

Machine learning-based waveform analysis for pile-up events

Wednesday, May 15, 2024 4:20 PM (25 minutes)

Machine learning (ML) techniques are increasingly being used in the analysis of data in particle physics as well as in neutrinoless double-decay experiments. ML approach is often suitable to discriminate between signal and background events in cases where signal and background spectrum are well-known and when the spectra can be fed into ML algorithms for training. Also, various ML-based pulse shape discrimination techniques can also be used for event classification. In this study, we use the ML technique, specifically using the Recurrent Neural Networks to distinguish between single and pileup waveforms of physical events. We also discuss the regression analysis that can be used to find the signature of isomeric transitions during the gamma cascade following the decay of the nucleus.

Primary author: PAUDEL, Laxman Sharma (University of South Dakota)

Presenter: PAUDEL, Laxman Sharma (University of South Dakota)

Session Classification: Advanced Data Analysis

Track Classification: Advanced Data Analysis

Contribution ID: **82** Type: **Oral**

The New JUNO Reactor Neutrino Experiment with Summary on Daya Bay/Double Chooz/RENO

Tuesday, May 14, 2024 2:25 PM (25 minutes)

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator detector under construction 650 m underground in China. JUNO will feature a rich physics portfolio with neutrinos from many sources including nuclear reactors, supernovae, cosmic-ray interactions in the atmosphere, the Sun, and the Earth. The primary neutrino target will consist of a 35.4 m diameter acrylic sphere filled with liquid scintillator surrounded by 17,612 20" photomultiplier tubes (PMTs) and 25,600 3" PMTs providing around 78% photocoverage. JUNO is expected to achieve a 3% energy resolution at 1 MeV, allowing to determine the neutrino mass ordering to 3σ with ˜6 years of data-taking and measure $\sin^2\theta_{12}$, Δm^2_{21}, and Δm^2_{32} to better than sub-percent precision. After a brief review of the legacy from the Daya Bay, Double Chooz and RENO experiments, this talk will provide a broad overview of the status and prospects of JUNO.

Primary author: MANDUJANO, Roberto (University of California Irvine)

Presenter: MANDUJANO, Roberto (University of California Irvine)

Session Classification: Neutrino Oscilltaion

Track Classification: Neutrino Oscillations

Contribution ID: **83** Type: **Oral**

DUNE Low Energy Physics with Solar and Supernova Neutrinos

Thursday, May 16, 2024 4:20 PM (20 minutes)

The Deep Underground Neutrino Experiment (DUNE) is a project that includes four 17.5-kton modules with liquid argon that will be located about a mile underground at the Sanford Underground Research Facility in Lead, South Dakota. One of its primary goals is to observe and characterize neutrinos coming from a supernova burst in the Milky Way and surrounding galaxies. In the case of a successful measurement, the resulting energy spectrum and time distribution of neutrinos would provide important information for supernova modeling and black hole formation. DUNE may also be able to detect supernova-burst neutrinos before the light signal reaches the Earth, serving as an early warning system, as well as point to the supernova. Additionally, dependent on achieved backgrounds mitigation during production and underground installation, DUNE may measure B-8 neutrinos coming from the Sun and use them to improve our understanding of neutrino interactions and oscillations. This could include potential non-standard neutrino interactions and resolving the metallicity content in the Sun. Finally, DUNE will be able to detect the more rare but higher energetic hep solar neutrinos, and possibly diffuse supernova burst neutrinos, both of which have never been observed before.

Primary author: SINEV, Gleb (South Dakota School of Mines and Technology)

Presenter: SINEV, Gleb (South Dakota School of Mines and Technology)

Session Classification: Supernova & Solar Neutrinos

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **86** Type: **Oral**

The Sanford Underground Research Facility

Tuesday, May 14, 2024 8:50 AM (40 minutes)

The Sanford Underground Research Facility (SURF) has been operating for 17 years as an international facility dedicated to advancing compelling multidisciplinary underground scientific research, including physics, biology, geology, and engineering. Seven primary underground levels at SURF offer a unique environment that allows researchers the opportunity to explore an array of important questions regarding the origin of life and its diversity, mechanisms associated with geologic processes as well as engineering topics such as mining innovations and technology developments. SURF laboratory facilities include a Surface Campus as well as campuses at the 4850-foot level (1490 m, 4300 m.w.e.) that host a range of significant physics experiments, including the LUX-ZEPLIN (LZ) dark matter experiment and the MAJORANA DEMONSTRATOR rare-decay experiment. The CASPAR nuclear astrophysics accelerator completed the first phase of operation at the Ross Campus and is planning for the second phase beginning in 2024. SURF is also home to the Long-Baseline Neutrino Facility (LBNF) that will host the international Deep Underground Neutrino Experiment (DUNE). SURF offers world-class service, including an ultra-low background environment, low-background assay capabilities, and electroformed copper is produced at the facility. The initial phase of laboratory expansion is underway on the 4850L (1485 m, 4100 m.w.e.) for new large caverns (nominally 100m L x 20m W x 24m H) on the timeframe of next-generation dark matter and neutrino experiments (˜2030). As some experiment activities are completing and as SURF is preparing to increase underground laboratory space, a call has been issued to the underground science community for letters of interest.

Primary author: HEISE, Jaret (SDSTA/SURF)

Presenter: HEISE, Jaret (SDSTA/SURF)

Session Classification: Plenary: Underground Science & Native American Heritage

Track Classification: Plenary

Contribution ID: **87** Type: **Oral**

The Value of Underground Field Laboratories for Advancing Geothermal Energy

Thursday, May 16, 2024 9:00 AM (30 minutes)

As we seek to meet global decarbonization goals there is an urgent need to reduce greenhouse gas emissions by transitioning to clean sources of energy and increasing total energy efficiency. The crystalline rocks that make up the primary constituents of the earth's continental crust have a high specific heat, making them efficient reservoirs for storing thermal energy. Where these rocks are naturally heated by the earth's deep subsurface these rock formations form a vast and mostly untapped source of heat that can be harnessed in enhanced geothermal systems (EGS) for low-emission, always-on energy. It is estimated that through improvements in technology geothermal energy could supply 60 gigawatts of electricity to the US grid, which amounts to 8.5% of all electricity generation and emissions reductions equivalent to removal of 6 million cars per year. Lower temperature resources could supply heating and cooling to 28 million households over this same time frame. Where these rocks are not naturally heated, they have the potential to store large quantities of thermal energy seasonally. This holds the potential to significantly reduce and decarbonize roughly half of global energy consumption that is used for heating and cooling. The easily accessible highly stressed crystalline rocks and the supporting experimental infrastructure at the Sanford Underground Research Facility make it a particularly attractive location to test and advance the technology to help realize the full potential of geothermal energy. The Development, Monitoring, and Control of Fracture Thermal Energy Storage in Crystalline Rock Formations (DEMO-FTES) project is an international collaboration seeking to demonstrate the ability to efficiently store and retrieve thermal energy seasonally. The Center for Understanding Subsurface Signals and Permeability (CUSSP) is a DOE Energy Earthshot Research Center seeking to advance the scientific understanding of the mechanisms controlling fracture network permeability for EGS and detecting changes by remote geophysical imaging. Both projects have sought out the Yates amphibolite formation on the 4100 level of SURF to conduct experiments to advance geothermal technology. Tests at underground facilities in sedimentary formations were a crucial part of the technological developments that enabled the unlocking of US unconventional petroleum reserves. It is envisioned that the experiments conducted by the DEMO-FTES and CUSSP projects can have a similar catalyzing role in unlocking the vast potential of geothermal energy.

Primary authors: Dr BURGHARDT, Jeffrey (Pacific Northwest National Laboratory); Dr ROSSO, Kevin (Pacific Northwest National Laboratory)

Presenter: Dr BURGHARDT, Jeffrey (Pacific Northwest National Laboratory)

Session Classification: Plenary: Advanced Materials, Geology, Advanced Data Analysis

Track Classification: Geology

Contribution ID: **88** Type: **Oral**

Theory of Dark Matter

Wednesday, May 15, 2024 10:30 AM (30 minutes)

Neutrino experiments will have leading sensitivity to several dark matter and dark sector models. I discuss signals from a range of different dark sector models, from induced nucleon decay in mesogenesis models to production, scattering, and decay of dark sector states in neutrino beams. I present simulation tools for boosted dark matter and induced nucleon decay signals. I discuss some challenges with developing simulation and analyses to achieve a comprehensive program at the SBN and DUNE experiments.

Primary author: BERGER, Joshua (Colorado State University)

Presenter: BERGER, Joshua (Colorado State University)

Session Classification: Plenary: Dark Matter

Track Classification: Dark Matter

Contribution ID: **89** Type: **Oral**

The CYGNO/INITIUM project for directional Dark Matter searches

Thursday, May 16, 2024 4:20 PM (20 minutes)

We are going to present the CYGNO/INITIUM project for the development of a high precision optical readout gaseous Time Projection Chamber (TPC) for directional Dark Matter search and solar neutrino spectroscopy, to be hosted at Laboratori Nazionali del Gran Sasso (LNGS). CYGNO peculiar features are the use of sCMOS cameras and PMTs coupled to a multiple GEM amplification structure to readout a TPC filled with an helium-fluorine based gas mixture at atmospheric pressure. With such characteristics, we aim to achieve 3D tracking with head tail capability and background rejection down to O(keV) energy, to boost sensitivity to low WIMP masses for both Spin Independent and Spin Dependent coupling. We will illustrate the staged shielded underground operation of the 50 L prototype LIME (the largest developed so far by the collaboration) and the analysis of the data collected with such setup. We will outline the design and prospects for the development of the already funded O(1) m3 demonstrator to be hosted in Hall F of LNGS and illustrate the physics reach of a possible future O(30) m3 experiment stemming from these developments. We will furthermore discuss the R&D results obtained by the collaboration towards the maximisation of the CYGNO potentialities, and in particular the recent demonstration of negative ion drift operation at atmospheric pressure with optical readout obtained in synergy with the ERC Consolidator Grant project INITIUM.

Primary author: Prof. BARACCHINI, Elisabetta (Gran Sasso Science Institute)

Presenter: Prof. BARACCHINI, Elisabetta (Gran Sasso Science Institute)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **90** Type: **Oral**

Latest Results and Future Directions of CRESST

Wednesday, May 15, 2024 4:40 PM (20 minutes)

The CRESST experiment (Cryogenic Rare Event Search with Superconducting Thermometers) focuses on detecting dark matter particles scatter off nuclei in cryogenic detectors using different materials such as $CaWO_4$, Al_2O_3, $LiAlO_2$, and Si. Capable of identifying nuclear recoils with detection thresholds as low as 10 eV, CRESST is highly effective in the pursuit of low mass dark matter particles. The latest results from CRESST-III in the dark matter search are presented in this talk. It also addresses the observation of an unexplained event population at very low energy levels, known as the "low energy excess,"which compromises the sensitivity of many low mass dark matter detection experiments. Additionally, the talk outlines future directions for the CRESST experiment.

Primary author: Dr MANCUSO, Michele (Max Planck Institute for Physics)

Presenter: Dr MANCUSO, Michele (Max Planck Institute for Physics)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **92** Type: **Poster**

Probing the Solar Neutrino Day/Night Effect

Tuesday, May 14, 2024 3:45 PM (35 minutes)

Hints of neutrino oscillations were first apparent in the solar electron neutrino deficit observed by the Davis Solar Neutrino experiment in the Homestake Mine (Lead, SD). Subsequent experiments showed that neutrinos oscillate - proving they are massive. This, paired with the Mikheyev-Smirnov-Wolfenstein (MSW) effect explaining how matter alters oscillations, allows for a full explanation of the observed solar electron neutrino flux.
The MSW effect depends on electron density, so it is present in the Sun as well as the Earth. Super-Kamiokande has shown this results in a measurable non zero difference between nighttime and daytime flux. This asymmetry is the Solar Neutrino Day/Night Effect. We are doing an analysis of this using a simplified model which estimates the asymmetry at different times of night. Initially, we have done so using energy scaling appropriate for experiments with existing data (e.g. Super-Kamiokande). By then changing the energy scaling, we see how visible this asymmetry will be to DUNE. Additionally, we are considering how further enhancements to DUNE, such as a low backgrounds module, may aid in probing this effect.

Primary author: FODROCI, Michael (South Dakota School of Mines and Technology)

Co-author: REICHENBACHER, Juergen (South Dakota School of Mines and Technology)

Presenter: FODROCI, Michael (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **93** Type: **Oral**

Radiological Backgrounds in DUNE Far Detectors

Thursday, May 16, 2024 4:40 PM (20 minutes)

The Deep Underground Neutron Experiment (DUNE) uses a neutrino beam and near detectors at Fermilab and four 10 kilotonne liquid argon Far Detector modules at SURF in South Dakota in order to measure fundamental neutrino properties and to search for supernova neutrinos, nucleon decay, and a plethora of other physics topics. While DUNE's far detectors are powerful tools for studying a wide variety of signals, radiological backgrounds may degrade resolution and event reconstruction, thereby posing an obstacle to DUNE realizing its widest possible potential, they may impair detection and reconstruction of hadronic interactions, and they may impede sensitivity to low-energy signals such as supernova and solar neutrinos. Radiological backgrounds arise from the natural contamination of radioactive isotopes in detector materials and the surrounding cavern, as well as from cosmogenic sources still present underground. This talk will provide an overview of radiological backgrounds relevant for DUNE's far detectors, discuss challenges associated with them, and review techniques for modeling and mitigating them.

Primary author: Dr WESTERDALE, Shawn (University of California Riverside)

Co-author: REICHENBACHER, Juergen (South Dakota School of Mines and Technology)

Presenter: Dr WESTERDALE, Shawn (University of California Riverside)

Session Classification: Supernova & Solar Neutrinos

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **94** Type: **Oral**

From undergorund to space: How extremophiles can be developed for consumer product goods

Tuesday, May 14, 2024 2:20 PM (20 minutes)

Abstract: The use of biology in consumer product goods has been a common practice for many years. However, only recently have consumers started to appreciate and intentionally look for products that feature novel biological compound. Extremophiles are a relatively untapped resource for the health and wellness product space. Delavie Sciences has leveraged extremophiles for the creation of functional ingredients for skincare products. Bacillus Lysate, a novel sunscreen ingredient, was developed from an extremophile studied aboard the international space station. Hydrolytic Enzyme Complex, an extract of hydrolytic enzymes, was developed from a novel thermophilic fungus. The story of discovery, scale-up, and commercialization may help spark new ideas and possible avenues for future research and development.

Primary author: Dr LANDRY, Kyle (Delavie Sciences)

Presenter: Dr LANDRY, Kyle (Delavie Sciences)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **95** Type: **Oral**

Biology research at SURF

Tuesday, May 14, 2024 2:40 PM (20 minutes)

Abstract: The Sanford Underground Research Facility (SURF) with its vast underground footprint provides opportunities for research activities beyond astroparticle physics, rare event searches and neutrino physics. SURF is hosting biology research focusing on microorganisms in extreme environments, biofilms, as wells as astrobiology and in-situ cultivation. A brief overview of the research currently performed at SURF will be presented. The facility's unique characteristics present a number of opportunities, and applications from new experiments and groups are welcome.

Primary author: Dr HORN, Markus (Sanford Underground Research Facility)

Presenter: Dr HORN, Markus (Sanford Underground Research Facility)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **96** Type: **Oral**

LEGEND: Searching for 0νββ in 76-Ge

Tuesday, May 14, 2024 2:00 PM (20 minutes)

Despite being the most abundant particle in the universe with mass, several key characteristics of the neutrino remain unknown. A theorized decay process called neutrinoless double beta decay (0νββ) offers a unique method to probe properties of the mysterious neutrino, including its quantum nature and mass. The Large Enriched Germanium Experiment for Neutrinoless double-beta Decay (LEGEND) is utilizing the benefits of High Purity Germanium (HPGe) detectors to investigate 0νββ in the 76Ge isotope. Building on the successes of the Majorana Demonstrator (MJD) and Gerda experiments, LEGEND is using a phased approach to achieve a 1 tonne array of HPGe detectors enriched to > 90% in 76Ge with a goal to be sensitive to a 0νββ half-life of > 1028 years. The first phase, LEGEND-200, has been actively taking data with 142 kg of HPGe detectors at the Laboratori Nazionale del Gran Sasso (LNGS) since March of 2023.
The full tonne scale experiment, LEGEND-1000, will begin construction soon at LNGS. This talk will cover the extensive efforts of the LEGEND collaboration and the utilization of technologies from the MJD and GERDA experiments. This work is supported by the U.S. DOE and the NSF, the LANL, ORNL and LBNL LDRD programs; the European ERC and Horizon programs; the German DFG, BMBF, and MPG; the Italian INFN; the Polish NCN and MNiSW; the Czech MEYS; the Slovak SRDA; the Swiss SNF; the UK STFC; the Russian RFBR; the Canadian NSERC and CFI; the LNGS, SNOLAB, and SURF facilities.

Primary author: BOS, Brady (THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL)

Presenter: BOS, Brady (THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL)

Session Classification: Double Beta Decay

Track Classification: Double Beta Decay

Contribution ID: **97** Type: **Oral**

First demonstration for a LArTPC-based search for intranuclear neutron-antineutron transitions and annihilation in 40Ar using the MicroBooNE detector

Wednesday, May 15, 2024 2:00 PM (30 minutes)

Massive and deep underground detectors such as the future Deep Underground Neutrino Experiment (DUNE) will offer a great opportunity to search for rare, beyond-the-Standard-Model (BSM) physics signals including baryon number violating (BNV) processes. One such BNV process is nucleus-bound neutron-antineutron transition, followed by antineutron annihilation on a nearby neutron/proton that produces multiple final state pions, characterized by a unique, star-like topological signature. This signature should be easily recognizable within a fully active liquid argon time projection chamber (LArTPC) detector. While the future DUNE LArTPC can search for this signature with high sensitivity, existing data from the much-smaller MicroBooNE LArTPC can be used to demonstrate and validate the methodologies applicable in the DUNE search. This talk presents a deep learning-based analysis of MicroBooNE data, making use of a sparse convolutional neural network (CNN) and event topology information to search for argon-bound neutron-antineutron transition-like signals in MicroBooNE. This analysis demonstrates LArTPCs'capability, combined with deep-learning techniques, to search for such rare processes with high signal efficiency and strong background rejection.

Presenter: Dr KALRA, Daisy (Columbia University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

Contribution ID: **98** Type: **Oral**

The Deep Underground Neutrino Experiment (DUNE): ND-LAr and the 2x2 Demonstrator

Tuesday, May 14, 2024 2:50 PM (25 minutes)

In order to make precision measurements of Neutrino oscillation parameters, the Deep Underground Neutrino Experiment (DUNE) will improve both statistical and systematic uncertainties that current generation experiments are susceptible to. DUNE's neutrino beam of unparalleled intensity and 17 kton/module target mass will serve to mitigate statistical uncertainties to a level where systematic uncertainties of today's experiments would dominate the error budget. In order to fulfill its science program, DUNE will need to constrain such systematics from the ˜10%-level of today's measurements to the few-percent level. The near detector complex will be the primary tool used to mitigate systematic uncertainties in neutrino-Argon interaction modeling, neutrino flux generation, and detector response. A novel liquid argon (LAr) time projection chamber (TPC) called ND-LAr is at the heart of DUNE's near detector complex. ND-LAr will feature a modular design with 70 optically segmented TPCs and a pixelated charge readout system to help cope with the high rate environment. This presentation will provide an overview of the ND-LAr design and present the status of the 2x2 Demonstrator, which is a prototype of ND-LAr that is set to operate in the NuMI neutrino beamline at Fermilab imminently.

Primary author: WOOD, Kevin (Lawrence Berkeley National Laboratory)

Presenter: WOOD, Kevin (Lawrence Berkeley National Laboratory)

Session Classification: Neutrino Oscilltaion

Track Classification: Neutrino Oscillations

Contribution ID: **99** Type: **Oral**

Exploration of subsurface microorganisms with single cell techniques

Tuesday, May 14, 2024 2:00 PM (20 minutes)

Abstract: I will review recent work performed by my group on the genome and phenome analyses of individual microbial cells in their natural environment. I will introduce the key concepts, rationale and instrumentation behind these technologies, along with examples of their application. Next, I will focus on results from deep subsurface microbiome studies, including SURF. Together, these examples showcase new insights and opportunities offered by studies of individual microbial cells.

Primary author: Dr STEPANAUSKAS, Ramunas (Bigelow Laboratory for Ocean Sciences)

Presenter: Dr STEPANAUSKAS, Ramunas (Bigelow Laboratory for Ocean Sciences)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **100** Type: **Oral**

Extremophilic processes and microbiome: Companion for marching towards net zero

Tuesday, May 14, 2024 5:40 PM (20 minutes)

Abstract: The microbiome is a community of microbes living together in a specific habitat. Microbiome is the all-rounder player in nature that participates in dual functions in natural processes. They are the producers of green-house gases, and consumers too. The bioenergy and environmental processes to produce the fuels, chemicals and materials with net zero emissions are mandatory to achieve the net zero. Through scientific literature survey, it is felt to have specific biocatalysts like enzymes, whole cells, and crude mixtures to make these processes efficient. Multistep conversions also need a complex set of new-generation catalysts. The use of multimember consortia as catalysts for the processes in the holobiome approach offers the potential to provide biological solutions to complex climate issues. The evolving concept of integrated biorefineries, if integrated with microbiome and computational biology, can offer the potential for alternative biological paths to coproduce and cater to the material, fuel and chemical sectors. This may further offer the decarbonization of the industrial as well as transportation sectors, a step to net zero. Keywords: Microbiome; Netzero, Climate change

Primary author: Dr SINGH, Balendra (Department of Biotechnology, India)

Presenter: Dr SINGH, Balendra (Department of Biotechnology, India)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **101** Type: **Oral**

The search for light dark matter with DAMIC-M

Wednesday, May 15, 2024 5:20 PM (20 minutes)

The DAMIC-M (DArk Matter In CCDs at Modane) experiment will use skipper CCDs to search for low mass (sub-GeV) dark matter underground at the Laboratoire Souterrain de Modane (LSM). With a kg-scale silicon target mass and sub-electron energy resolution, the detector will surpass the exposure and threshold of previous experiments. Thus, DAMIC-M will have world-leading sensitivity to a variety of "hidden sector"candidates. In this talk, we will report on science results from a prototype detector and the status of the detector construction.

Primary author: NORCINI, Danielle (Johns Hopkins University)

Presenter: NORCINI, Danielle (Johns Hopkins University)

Session Classification: Dark Matter

Track Classification: Dark Matter

Contribution ID: **102** Type: **Oral**

Nucleon Decay Searches in JUNO

Wednesday, May 15, 2024 3:00 PM (30 minutes)

The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton multipurpose underground liquid scintillator (LS) detector currently under construction in China, with a 650-meter rock overburden (1800 m.w.e.) for shielding against cosmic rays. One of the capabilities of JUNO detector is to search for the baryon number violation processes, which would be a crucial step towards testing the Grand Unified Theories and explaining the matter-antimatter asymmetry of the Universe. The nucleon decay provides
a direct observation of baryon number violation and has been the focus of many experiments over the past several decades. The JUNO LS target consists of about 88% 12C and 12% 1H. The large LS detector of JUNO has a distinct advantage in detecting nucleon decay, with high energy resolution 3% and an excellent energy threshold of 0.7 MeV. For proton decay, the mode $p \longrightarrow \nu K$ is one of two dominant decay
modes predicted by a majority of GUTs, with expected sensitivity at τ /B($p \longrightarrow \nu K^{-}$ +) > 9.6 × 1033 yr after 10 years of data taking. Meanwhile, neutron invisible decay has two modes, $n \longrightarrow$ inv and $nn \longrightarrow$ inv, prevalent in some new physics models. After 10 years of data taking, the JUNO expected sensitivities at a 90% confidence level are τ /B($n \longrightarrow$ inv) > 5.0 × 1031 yr and τ /B($nn \longrightarrow$ inv) > 1.4 × 1032 yr. Both decays will exceed the corresponding current best limits.

Presenter: JIANG, Cailian (Nanjing University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

Contribution ID: **103** Type: **Poster**

A Novel Neutron-Based Calibration System for DUNE

Tuesday, May 14, 2024 3:45 PM (35 minutes)

The Deep Underground Neutrino Experiment (DUNE) is a next-generation long baseline neutrino experiment, which will measure the oscillation probabilities of neutrinos and antineutrinos at unprecedented precision to quantify the Charge-Parity (CP) violation in the leptonic sector. These measurements require a precision detector calibration that constrains the uncertainties from relevant detector response parameters. However, traditional calibration methods have limitations due to the lower cosmic ray muon flux at the deep underground location. As such, new strategies are needed to meet DUNE's stringent calibration needs. One of the main energy scale and resolution calibration systems being developed for DUNE includes the Pulsed Neutron Source (PNS). This is a device which can inject neutrons into the detector modules, where their capture signatures can be used as a standard candle for energy scale and resolution calibration. To show the effectiveness of such a calibration for a DUNE Prototype detector (ProtoDUNE) we have produced simulations using the Liquid Argon Simulation Software (LArSoft) framework. We have determined through simulation that the most effective calibration technique for a surface detector will rely on identifying energy deposits from one of the highest intensity gammas released in neutron capture on argon. By carefully selecting these events we analyze a spectrum which includes two prominent features: the Compton edge, and the double escape peak.

Primary authors: Dr WANG, Jingbo (South Dakota School of Mines and Technology); JOHNSON, Walker (South Dakota School of Mines and Technology)

Presenter: JOHNSON, Walker (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Neutrino Oscillations

Contribution ID: **104** Type: **Oral**

Probing Astro- and Particle Physics with Supernova and Solar Neutrinos at SURF

Tuesday, May 14, 2024 11:00 AM (30 minutes)

Many mysteries still surround the neutrino. Despite being the most common massive particle in the universe, its basic properties, such as their mass, are still unknown, as they interact very rarely with matter. They are produced copiously during the life cycles of stars. Measuring neutrinos from the sun, pioneered by the Davis experiment at SURF, has confirmed the nuclear fusion processes responsible for providing the energy that sustains life on Earth. Further, these experiments found the first confirmed physics beyond the standard model – neutrino oscillations which gave the first indication of neutrino mass. Though neutrinos only interact very rarely with other constituents of matter, they fuel some of the most violent explosions in the universe: core-collapse supernovae. In the dying moments of the most massive stars, a change in the nuclear state of the star's core produces an enormous flux of neutrinos, blowing away the outer envelopes of stellar plasma while forming a neutron star or black hole. Though the light signal of supernovae has been studied for millennia, we can now explore the neutrino signals in large, underground particle detectors. These experiments directly observe the inner workings of the collapse, the formation of black holes and neutron stars, and many properties of neutrinos.Several experiments, including the DUNE and LZ experiments at SURF, are dedicated to understanding these stellar processes. In the talk, we will discuss the history and future of studying solar and supernova neutrinos, emphasizing the major efforts at SURF

Primary author: PERSHEY, Daniel (Florida State University)

Presenter: PERSHEY, Daniel (Florida State University)

Session Classification: Plenary: Neutrinos

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **105** Type: **Poster**

Quality Assurance for Potential Supernova Neutrino Detections with DUNE at SURF

Tuesday, May 14, 2024 3:45 PM (35 minutes)

When completed, the far detector of the Deep Underground Neutrino Experiment (DUNE), which will be located nearly a mile underground at the Sanford Underground Research Facility (SURF) in Lead, SD, will be the world's largest and most advanced liquid argon time projection chamber-based neutrino detector. DUNE's goal is to answer open questions on neutrino properties and to explore potential topics beyond it, such as detecting supernova neutrinos. These neutrinos can be produced and released as a near-light speed isotropic burst during a supernova event. Information encoded in such neutrino bursts can improve our understanding of the supernova process, including how neutron stars and black holes are formed during these events, as well as illuminate new characteristics of neutrino flavor oscillations and mass ordering. Moreover, the far detector will serve as an early warning supernova detection system, as neutrino bursts can arrive several hours before the photon component. For DUNE to be able to detect supernova burst neutrinos, it is crucial that the radiological backgrounds (from the detector components, surrounding cavern and the argon itself) are small enough and that we understand the response of the detector for such faint low energy signals by developing appropriate calibration methods. We will present ongoing radiological assay work and on the development of a unique 9 MeV gamma-ray calibration source gauging the detector response near DUNE's threshold for supernova neutrino detection.

Primary author: RATH, Tyler (South Dakota School of Mines and Technology)

Co-authors: GARCIA, Guillem (South Dakota School of Mines and Technology); REICHENBACHER, Juergen (South Dakota School of Mines and Technology); GARCIA, Shane (South Dakota School of Mines and Technology)

Presenter: RATH, Tyler (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **106** Type: **Oral**

Diffuse Supernova Neutrino Background Search

Thursday, May 16, 2024 5:20 PM (20 minutes)

Core-collapse supernovae produce neutrinos across all flavors in the range of a few tens of MeV. The integrated flux of these neutrinos forms the diffuse supernova neutrino background (DSNB) or supernova relic neutrinos (SRNs). Their flux, flavor composition, and energy spectrum provide insights into supernova dynamics and star formation. This talk gives a short summary of recent DSNB searches at KamLAND, SK, and SK-Gd.

Primary author: WAN, Linyan (Fermilab)

Presenter: WAN, Linyan (Fermilab)

Session Classification: Supernova & Solar Neutrinos

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **107** Type: **Oral**

Calibrating DUNE LArTPC Detectors Using Low-Energy Radioactive Decays

Thursday, May 16, 2024 5:00 PM (20 minutes)

The Deep Underground Neutrino Experiment (DUNE) at the Long-Baseline Neutrino Facility (LBNF) is an international project that will be the largest particle physics experiment ever built in North America. The DUNE project will use massive liquid argon time projection chambers (LArTPCs) to provide insight on fundamental questions such as the origin of the matter/antimatter asymmetry in the universe, the nature of astrophysical sources of neutrinos (e.g. stellar core-collapse supernovae), and the prospective occurrence of baryon number violation. In order to answer such questions, DUNE will make measurements that probe the nature of neutrino oscillation with unprecedented precision. DUNE relies on precise measurements of neutrino-argon interactions, necessitating an extensive calibration program for the LArTPC detectors recording these interactions. Given the detectors will be located underground with significant overburden, the low cosmic ray rate greatly limits calibration capabilities using cosmogenic activity. Low-energy decays of radioactive isotopes naturally present in the (atmospheric) argon can provide a handle on calibrations that complements what can be done with limited statistics of cosmogenic activity in the detectors. Such decays can also provide a unique calibration source for astrophysical neutrino interactions in the detector. In this talk, the prospect of calibrating DUNE's LArTPC detectors using low-energy radioactive decays is presented, including preliminary results obtained using data from DUNE's prototype detectors.

Primary author: Dr MOONEY, Michael (Colorado State University)

Presenter: Dr MOONEY, Michael (Colorado State University)

Session Classification: Supernova & Solar Neutrinos

Track Classification: Neutrino Oscillations

Contribution ID: **108** Type: **Oral**

Laying the groundwork for trust in dark matter results

Wednesday, May 15, 2024 5:35 PM (25 minutes)

As new dark matter detectors turn on, it's useful to think about what dark matter discovery will look like.

This talk will discuss two aspects of building trust in dark matter results: (1) data blinding through adding "salt,"or fake signal, and (2) the possibilities in combining underground detector information to further constrain backgrounds.

Several dark matter experiments (this talk will focus on CDMS and LUX) have used salt in their analyses. For CDMS, creating salt was time-consuming enough that salting is not currently a viable blinding method for first results. If we could generate salt more quickly, this would be a great blinding method for first results as it allows analyzers to look at the entire data set! I will discuss our efforts at using Generative Adversarial Networks, a type of deep machine learning, to quickly generate salt. Our software library is open source and will soon be publicly available on pypi.

I will also discuss the current state of a collaboration between SuperCDMS and the National Science Data Fabric, an NSF-funded organization that specializes in helping scientists do more science through easier data access. Together with a project aimed at making custom binary data more accessible without requiring changing format, PONDD, it's possible to imagine combining data across underground detectors, which could create a wide veto array and potentially further constrain environmental radiation.

Primary author: ROBERTS, Amy (University of Colorado Denver)

Presenter: ROBERTS, Amy (University of Colorado Denver)

Session Classification: Advanced Data Analysis

Track Classification: Advanced Data Analysis

Contribution ID: **109** Type: **Oral**

Results, Status and Future of the KATRIN experiment and Outlook on Project 8, ECHo, and HOLMES

Tuesday, May 14, 2024 3:15 PM (25 minutes)

Massive neutrinos impart an experimental signature in the endpoint region of beta-decay spectra. The KArlsruhe TRitium Neutrino (KATRIN) experiment uses a high-activity tritium source and a high-resolution spectrometer to place the most stringent upper limit on the effective neutrino mass of 0.8 eV/cˆ2 (90% CL). Experimental improvements and further data taking will bring KATRIN towards its final design goal of a sensitivity of 0.2 eV/cˆ2 (90% CL). Next generation experiments aim to use novel differential detectors and alternative beta-decay sources to push the sensitivity limit below the 0.1 eV/cˆ2 threshold.

Primary author: GAVIN, Andrew (University on North Carolina)

Presenter: GAVIN, Andrew (University on North Carolina)

Session Classification: Neutrino Oscilltaion

Track Classification: Neutrino Oscillations

Contribution ID: **110** Type: **Oral**

A SURF Low Background Module (SloMo)

Tuesday, May 14, 2024 5:20 PM (20 minutes)

With radiopurity controls and targeted design modifications a kton-scale liquid argon time projection chamber similar to DUNE could be used for enhanced low energy physics searches. This includes improved sensitivity to supernova and solar neutrinos, and other rare event searches. This talk will present simulation studies to evaluate physics sensitivities of such a module. It will also discuss R&D to develop large-scale radiopurity controls necessary to construct such a detector.

Primary author: JACKSON, Christopher (Pacific Northwest National Laboratory)

Presenter: JACKSON, Christopher (Pacific Northwest National Laboratory)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II

Contribution ID: **111** Type: **not specified**

APEX Design and VD Technology for DUNE FD3

Primary author: CAVANNA, Flavio (Fermilab)

Presenter: CAVANNA, Flavio (Fermilab)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II

Contribution ID: **112** Type: **not specified**

ARIADNE Design and Technology for DUNE

Primary author: MAVROKORIDIS, Kostas (University of Liverpool)

Presenter: MAVROKORIDIS, Kostas (University of Liverpool)

Session Classification: DUNE Phase 2 - Parallel

Contribution ID: **113** Type: **Oral**

APEX Design and VD Technology for DUNE FD3

Tuesday, May 14, 2024 4:20 PM (20 minutes)

DUNE needs 40 kilotons of LAr fiducial mass to achieve its core CPV physics goal specified in the 2014 P5 report. To complete the fiducial mass, the DUNE phase 2 program requires two more FD modules in addition to FD1 and FD2. The construction of phase II FD3 is endorsed in every budget scenario in the 2023 P5 report. DUNE envision its phase II FD3 with a much more capable photon detection system than its phase I FD. The most reliable path towards this vision is to optimize the existing technologies in FD2 (VD). In this talk, we present the APEX (Aluminum Profiles with Embedded X-arapucas) design where we will instrument the Phase II DUNE FD3 with large-area X-arapuca photodetectors on the entire LArTPC field cage. The photon detectors will cover four vertical walls of the LArTPC volume, with an optical area coverage up to 2000mˆ2. This offers DUNE improved event reconstruction, better timing and energy resolution, enhanced background rejection capability, and improved physics reach across GeV and MeV energy region. Furthermore, this light detection system can be combined with all proposed phase 2 charge readout concepts.
The PoF (power over fiber) and SoF (signal over fiber) technologies developed and successfully demonstrated in DUNE VD make detector and electronics deployment on high voltage field cage surface possible. Despite this, the scaling up of the photodetectors to thousands of square meters as well as integrating with the LArTPC field cage structure poses challenges to mechanics and electronics. One particular challenge is understanding how the instrumented PD modules interplay with the LArTPC E field. To address this, we performed a material charge-up test in a small TPC system at the surface environment. The PoF and SoF require multiple optical fibers to supply detector power and read out signals. The routing of hundreds-of-kilometers-long fibers throughout the entire field cage structure also requires new designs of the profile and field cage. The large area detector also puts higher requirements on detector production cost and efficiency, and prompt us to optimize detector design while maintaining comparable detection efficiency as phase I FD.

The scaling up of the photon detectors also drastically increases the number of readout channels. This brings challenges to the power consumption of cold electronics and signal readout bandwidth. In response to these challenges, we proposed a new PoF design that can supply the high SiPM bias for many PD modules sitting on equipotential FC profiles. This solution will mitigate both cold readout power consumption challenges and noise problems. A wavelength-division multiplexing solution in combination with a novel ring resonator modulation technology that offers hundreds of GB/s readout ability is proposed and being pursued to address the signal readout bandwidth problem. The signal amplification and digitization with in-house designed ASICs are also proposed to reduce the cost and power consumption. Staged prototype plans to address these development goals will be presented at the end of the talk.

Primary author: SHI, Wei (Stony Brook University)

Presenter: SHI, Wei (Stony Brook University)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II

Contribution ID: **114** Type: **Oral**

SoLAr: a novel approach to multipurpose LArTPCs for neutrino physics

Tuesday, May 14, 2024 4:40 PM (20 minutes)

Liquid Argon Time Projection Chambers (LArTPCs) are set to be one of the main detector technologies for the next generation of neutrino experiments. While LArTPCs have already been proven to be exceptional detectors for GeV-scale physics, their sensitivity to the MeV scale is still limited by backgrounds and non-optimal energy resolution.

SoLAr is a R&D project aiming to boost the performance of LArTPCs at the energy scale of low-energy astrophysical neutrinos (>5 MeV) such as Supernova neutrinos and solar neutrinos produced by the ^{8}B and the still unobserved hep reaction. SoLAr's innovative approach combines the light and charge readout of LArTPCs onto a combined dual readout anode plane, allowing for better positional resolution in light detection and combined light and charge calorimetry. Two small-scale prototype detectors were built and operated at the University of Bern in 2022 and 2023. Furthermore, simulations studies are underway to design an effective shielding against radiological background and to establish the experiment sensitivity under different assumptions on the detector design. This contribution will cover the SoLAr detector concept, preliminary results from the two prototype detectors, and some initial considerations on the expected experiment performance.

Primary author: GUFFANTI, Daniele (University & INFN Milano-Bicocca)

Presenter: GUFFANTI, Daniele (University & INFN Milano-Bicocca)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II

Contribution ID: **115** Type: **Poster**

Constraining Non-Standard Neutrino Interactions with Solar Neutrinos in Existing and Future Neutrino and Dark-Matter Experiments

In the standard model of particle physics (SM), the neutrino is an elementary particle that is significantly lighter than other massive particles and can exist in one of three flavor or mass states. Because of this, neutrinos can change states as they undergo a process called neutrino oscillations. Neutrino-oscillation parameters have been measured in many experiments and are mostly consistent with SM. Neutrino oscillations are also modified by matter, an effect that can be further altered by the presence of non-standard neutrino interactions (NSI). NSI are interactions that are not predicted by SM and can change existing reactions or result in new ones. In this work, we propose to use neutrinos that originate in the Sun to study NSI, as the core of the Sun is a dense medium that produces a high flux of neutrinos and where matter oscillations are significant. Additionally, a discrepancy exists between neutrino-oscillation measurements conducted with solar neutrinos and neutrinos generated by nuclear reactors. One of the potential explanations for this discrepancy is NSI with certain couplings. We consider existing and future neutrino and dark-matter experiments where solar neutrinos could be observed as an opportunity to improve our knowledge of neutrino interactions and constrain NSI.

Primary author: SINEV, Gleb (South Dakota School of Mines and Technology)

Co-author: REICHENBACHER, Juergen (South Dakota School of Mines and Technology)

Presenter: SINEV, Gleb (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **116** Type: **Oral**

Optical readout of large scale dual-phase liquid Argon TPCs with the ARIADNE technology

Tuesday, May 14, 2024 5:40 PM (20 minutes)

Optical readout of large scale dual-phase liquid Argon TPCs is an attractive and cost effective alternative to charge readout. Following the successful demonstration of 3D optical readout with the ARIADNE 1-ton detector, the ARIADNE+ experiment was deployed using the protoDUNE "cold box"at the CERN neutrino platform imaging a much larger active region of 2mx2m. ARIADNE+ uses 4 Timepix3 cameras imaging the S2 light produced by 16 novel glass THGEMs. ARIADNE+ takes advantage of the raw Timepix3 data coming natively 3D and zero suppressed with a 1.6 ns timing resolution. Cosmic muon events were recorded successfully at stable conditions providing the first demonstration for its use in kton scale experiments such as DUNE. Following these successful results, a proposal to instrument NP02 ProtoDUNE cryostat is in preparation and the design is advancing.

Primary author: MAVROKORIDIS, Kostas (University of Liverpool)

Presenter: MAVROKORIDIS, Kostas (University of Liverpool)

Session Classification: DUNE Phase 2 - Parallel

Track Classification: DUNE Phase II