Conference on Science at the Sanford Underground Research Facility

Report of Contributions

Contribution ID: **1** Type: **Oral**

Latest results from the CUORE experiment

Wednesday, May 11, 2022 2:30 PM (30 minutes)

The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for 0νββ decay that has been able to reach the one-tonne mass scale. The detector, located at the LNGS in Italy, consists of an array of 988 TeO2 crystals arranged in a compact cylindrical structure of 19 towers. CUORE began its first physics data run in 2017 at a base temperature of about 10 mK and in April 2021 released its 3rd result of the search for 0νββ, corresponding to a tonne-year of TeO2 exposure. This is the largest amount of data ever acquired with a solid state detector and the most sensitive measurement of 0νββ decay in 130Te ever conducted, with a median exclusion sensitivity of 2.8×10^25 yr. We find no evidence of 0νββ decay and set a lower bound of 2.2 ×10^25 yr at a 90% credibility interval on the 130Te half-life for this process. In this talk, we present the current status of CUORE search for 0νββ with the updated statistics of one tonne-yr. We finally give an update of the CUORE background model and the measurement of the 130Te 2νββ decay half-life, study performed using an exposure of 300.7 kg·yr.

Co-author: CUORE COLL.

Presenter: Dr SURUKUCHI, Pranava (Yale University)

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

Contribution ID: **2** Type: **Poster**

A Novel Isolate Methylocystis sp. NLS7 as a promising candidate for industrial production of PHA from methane

Wednesday, May 11, 2022 3:52 PM (1 minute)

Recent interest in the mitigation of greenhouse gases has contributed to an increased amount of research in the field of methanotrophy. Studies have demonstrated that methane-oxidizing bacteria have the ability to utilize methane as their sole carbon and energy source to produce polyhydroxyalkanoates, or PHAs, which can be modified to produce renewable plastics. Methylosinus trichosporium OB3b and Methylocystis parvus OBBP have been presented as the most feasible bacteria to be used as industrial workhorses for polyhydroxyalkanoate production from methane. We have shown that a novel isolate Methylocystis sp. NLS7 has robust growth on methane, comparable to that of the OB3b and OBBP previously published. In addition, FTIR has confirmed the presence of polyhydroxyalkanoate purified from the biomass of NLS7. DSC studies show PHA from NLS7 has melting temperature similar to industrial PHA. Once the yield of PHA from NLS7 is further optimized, the methanotroph will become a promising candidate for the large-scale industrial production of polyhydroxyalkanoates. Genetic engineering studies are ongoing to maximize the yield and properties of the PHA produced.

Primary author: MOUTSOGLOU, Eleni

Co-authors: SANI, RAJESH (SD School of Mines and Technology); Dr SALEM, David (South Dakota School of Mines and Technology)

Presenter: MOUTSOGLOU, Eleni

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **3** Type: **Oral**

Searching for Beyond the Standard Model Physics with MicroBooNE

Thursday, May 12, 2022 3:20 PM (20 minutes)

MicroBooNE is an 85-tonne active mass liquid argon time projection chamber (LArTPC) at Fermilab. It has excellent calorimetric, spatial and energy resolution and is exposed to two neutrino beams, which make it a powerful detector not just for neutrino physics, but also for Beyond the Standard Model (BSM) physics. The experiment has competitive sensitivity to heavy neutral leptons possibly present in the leptonic decay modes of kaons, and also to scalar bosons that could be produced in kaon decays in association with pions. In addition, MicroBooNE serves as a platform for prototyping searches for rare events in the future Deep Underground Neutrino Experiment (DUNE). This talk will explore the capabilities of LArTPCs for BSM physics and highlight some recent results from MicroBooNE.

Presenter: Dr KALRA, Daisy (Columbia University)

Session Classification: Dark Matter - Parallel I

Track Classification: Dark Matter

Contribution ID: **4** Type: **Poster**

Limitations of Direct Microbial Transformation of Carbon Dioxide to Biofuels

Wednesday, May 11, 2022 3:57 PM (1 minute)

Fixation of carbon dioxide via direct biocatalytic conversion to liquid fuel presents a possible solution to reduce greenhouse gas emissions and produce a valuable product. Studies have been conducted on reducing carbon dioxide electrochemically and enzymatically; however, scale up of these methods is for the most part, nonexistent. Cultivation of microorganisms capable of fixing carbon dioxide is another point of interest. Using a continuous feedstock of syngas, microbes like Clostridium ljungdahlii and Clostridium autoethanogenum are capable of carbon dioxide reduction and production of acetate, ethanol, and other compounds via the Wood-Ljungdahl pathway. With this, many limitations arise namely the production of invaluable products that make the process economically unviable for long term success. Introduction of a dynamic co-culture could produce compounds of more value, but with-it different limitations exist. In this, we go into these limitations that arise with direct microbial transformation of carbon dioxide to biofuels currently keeping the movement at bay and possibly delaying further innovation and industrialization.

Primary authors: ZAUG, Jacob (South Dakota School of Mines); SANI, RAJESH (SD School of Mines and Technology)

Presenter: ZAUG, Jacob (South Dakota School of Mines)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **5** Type: **Poster**

Small bugs for big problems: Enriching microbes to degrade plastics

Wednesday, May 11, 2022 3:53 PM (1 minute)

Plastics have revolutionized many industries, but their desirable properties also bring disposal challenges. Importantly, plastics are recalcitrant to biological degradation and have negative impacts on the ecosystems in which they accumulate. This research seeks to develop a methodology to depolymerize and convert plastic waste into a commodity. Currently, plastic-rich samples have been collected from the Rapid City Water Reclamation Facility and Rapid City Landfill and are being enriched to isolate microbes in purity and consortia with the ability to degrade various plastics. Additionally, degradation testing protocols are being refined, and once the microbes are isolated, metatranscriptomic analysis will begin in order to understand what genes are responsible for degradation and how they might be engineered to improve efficiency. In the future, we will create a 'consortium' of engineered microbes to valorize plastic waste, and model microbial isolates will be used to transform degradation products into valuable bioproducts and green chemicals.
Keywords: Degrade, Enrichment, Plastic, Microbes, Synthetic.

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Presenter: Ms GOVIL , Tanvi (Department of Chemical and Biological Engineering & CNAM-Bio Center, South Dakota School of Mines and Technology, Rapid City, SD, USA)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **6** Type: **Poster**

Accelerated carbon sequestration from extremophilic microbes

Wednesday, May 11, 2022 3:54 PM (1 minute)

Greenhouse gases, such as carbon dioxide, are a major contributor to climate change and this creates a need for capture of such gases. Current solutions involve pumping captured carbon dioxide into depleted oil and gas fields. However, this runs the risk of potential leaks allowing the carbon dioxide to escape and enter the atmosphere. Fortunately, in the presence of water carbon dioxide dissociates into carbonate ions which then reacts with calcium ions to form stable calcium carbonate. It is thought that process can be accelerated through the use of microbes specifically ones that produce the enzyme carbonic anhydrase. The Sanford Underground Research Facility (SURF) provides a unique environment to investigate and isolate extremophilic microorganisms that could be used in this biomineralization process. DNA and RNA isolation were performed on core samples taken from for SURF genomic and transcriptomic analysis to determine the native flora on this environment as well as metabolic activity. Samples were also placed in enrichment media to select and isolate any microorganisms capable of carbonic anhydrase production. In addition, a thermophilic bacterium, Geobacillus sp. WSUCF1, was investigated for it biomineralization capabilities.

Primary author: VAUGHN, Magan

Co-authors: KAUR, Jasmeet; Dr LINGWALL, Bret; GOVIL, TANVI (SDSMT); SANI, Rajesh (Department of Chemical and Biological Engineering & CNAM-Bio Center, South Dakota School of Mines and Technology, Rapid City, SD, USA)

Presenter: VAUGHN, Magan

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **7** Type: **Oral**

Latest Results of NOvA and T2K

Wednesday, May 11, 2022 2:00 PM (20 minutes)

Long-baseline neutrino oscillation experiments present some of the most compelling paths towards beyond-the-standard-model physics. They do this by utilising intense, well controlled muon neutrino beams along with near detectors to constrain neutrino flux, cross sections, and backgrounds whilst measuring electron neutrino appearance and muon neutrino disappearance. By observing these neutrino oscillations along with their antineutrino counterparts, experiments are able to probe outstanding questions in neutrino physics including the neutrino mass ordering, leptonic CP violation, and measuring the atmospheric neutrino mass splitting and the large mixing angle. Resolving these questions could lead to an understanding of the nature of neutrino mass and explaining the observed excess of matter over antimatter in our Universe. In this talk, we will review recent results from two World-leading long-baseline neutrino experiments, NOvA and T2K.

Primary author: WARBURTON, Karl (Iowa State University)

Presenter: WARBURTON, Karl (Iowa State University)

Session Classification: Neutrino Oscillations - Parallel

Track Classification: Neutrino Oscillations

Contribution ID: **8** Type: **Poster**

Does surface energy have effect on SRB biofilm formation?

Wednesday, May 11, 2022 3:56 PM (1 minute)

Sulfate-reducing bacteria (SRB) have a unique ability to grow under anaerobic conditions using sulfate as a terminal electron acceptor, reducing it to hydrogen sulfide. SRB thrives in many natural environments, deep subsurface environments, and processing facilities in an industrial setting. considering to their ability to alter the physicochemical properties of underlying metals, SRB can induce fouling, corrosion, and pipeline clogging challenges. The biocorrosion cost a loss of about 3Billion USD to every year to USA. To effectively combat the challenges posed by SRB, it is essential to understand their molecular mechanisms of biofilm formation and corresponding biocorrosion. Identification of processes and mechanisms working in biofilm will lead us to design a next-generation metal which will not allow biofilm formation and ultimately save the resources. We hypothesize that variation in atomic lattice orientation and physical grains and grains boundaries corresponds to different surface energy and that may have effect on bacterial attachment for biofilm formation. To understand the interaction between metal surface and bacteria during initial attachment and biofilm formation. We have designed an experiment with three different type of surfaces viz; Annealed copper, Glass and Carbon steel and a SRB strain Desulfovibrio alaskensis G20. Anaerobic bioreactor (CDC-Bioreactor) was used for setup and incubated for 7 days in an anaerobic chamber at 30 ℃. Biofilm was harvested and analyzed for Confocal laser microscopy and qPCR to observe the effect on biofilm and regulatory mechanisms of biofilm formation respectively. Results of first observance confirm that carbon steel surface has good biofilm followed by annealed copper and glass surface has least biofilm. The same was also validated with confocal laser microscopy. qPCr analysis also support the hypothesis and resulted in higher expression of regulatory gene (σ54 Factor), periplasmic transporter gene (LuxP) and energy metabolic gene (dsrA). With these positive results we could conclude that surfaces with high energy have better biofilm growth and may have higher biocorrosion. The study need to be further performed extensively with many more combination of metal surfaces and different types of same metal to make a concrete conclusion.

Primary author: Dr SINGH, Ram (Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology)

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Presenter: Dr SINGH, Ram (Department of Chemical and Biological Engineering, South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **9** Type: **Oral**

AMoRE searching for the neutrinoless double beta decay of 100Mo

Wednesday, May 11, 2022 3:00 PM (30 minutes)

AMoRE (Advanced Mo-based Rare process Experiment) is an international collaboration searching for the neutrinoless double-beta decay of 100Mo using molybdate scintillating crystal with metallic magnetic calorimeters as low-temperature sensors. AMoRE-I, as the second phase experiment, has been installed at the Yangyang underground laboratory (Y2L) and accumulates the data under radon reduced environment. In the final phase experiment, AMoRE-II will be installed at the Yemi underground laboratory (Yemilab), which is being constructed newly for deeper (1 km overburden) and larger space for future experiments. Here, we present the current status of the AMoRE-I, the preparation of the AMoRE-II, and the physics approaches using the AMoRE detector.

Primary authors: SO, Jungho (Insitute for Basic Science); COLLABORATION, AMoRE

Presenter: SO, Jungho (Insitute for Basic Science)

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

Contribution ID: **10** Type: **Poster**

Analysis of bacterial carbonic anhydrase for accelerated carbon sequestration

Wednesday, May 11, 2022 3:58 PM (1 minute)

The growing population and industrialization have led to the emission of greenhouse gases, amongst which carbon dioxide is the most persistent in the environment. This gas causes an elevation in the earth's temperature with serious effects on health as well. The most convenient solution to this problem is carbon capture, utilization, and storage (CCUS). Carbon dioxide sequestration in the form of a stable, environmentally safe solid carbonate has obvious potential for long-term carbon dioxide storage. Microbial carbonic anhydrase (CA) catalyzes reversible carbon dioxide hydration and produces Ca/Mg carbonates that resemble weathering/carbonation in nature and are gaining merit for CCUS. The produced carbonates are environmentally stable. As a result, the variety and specificity of CAs from various microbes may be investigated for CCUS. To enable this, the present study enriched several different rock samples for bacterial growth to explore CAs for mineral carbonation. DNA and RNA are isolated to proceed with
metagenomics, meta-transcriptomics, and targeted CA sequencing. Further, universal primers are currently being designed for CAs to amplify from the isolated DNA.

Primary author: Ms KAUR, Jasmeet

Co-authors: LINGWALL, Bret; SANI, Rajesh (Department of Chemical and Biological Engineering & CNAM-Bio Center, South Dakota School of Mines and Technology, Rapid City, SD, USA); Ms GOVIL, Tanvi; Ms VAUGHN, Magan

Presenter: Ms KAUR, Jasmeet

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **11** Type: **Poster**

Biometallurgy of Rare Earth Elements using Methylotrophs

Wednesday, May 11, 2022 3:59 PM (1 minute)

Rare Earth Elements (REEs, lanthanides) are a category of 15 metallic elements in the periodic table that have similar physical and chemical properties. These lanthanides are used in a variety of products, including nuclear reactor components, cell phones, magnets, camera lenses, and batteries, and as such are fundamental to industrialized cultures around the world. Lanthanides were supposed to be unrelated to biological processes until they were discovered in the active site of the XoxF-type methanol dehydrogenase of the methylotrophic bacteria. When lanthanides are present, this methanol dehydrogenase (XoxF) allows methylotrophs grow on one-carbon molecules. When lanthanides are not supplied, these methylotrophs utilizes the Ca-dependent methanol dehydrogenase i.e. MxaFI. In the presence of XoxF, REEs are transported into the periplasm and shuttled into the cytoplasm, where they are stored in crystalline deposits. Here we present, isolation and characterization of extremophiles from rocks collected from SURF, and lanthanides chelation using selected extremophiles. We also present genetic, phenotypic, and biochemical characterization of a gene cluster that enables growth of extremophiles on insoluble REEs. Investigation of the gene cluster will not only further our understanding of lanthanides biochemistry but will also generate sustainable methods for REEs recovery.

Primary author: VATWANI, Sarita (South Dakota school of mines and technology)

Co-author: Dr SANI, Rajesh (South Dakota school of mines and technology)

Presenter: VATWANI, Sarita (South Dakota school of mines and technology)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **12** Type: **Poster**

Deciphering the Genome to Phenome relationship in Pseudomonas citronellolis at varying methane concentrations

Wednesday, May 11, 2022 4:05 PM (1 minute)

The environment and conditions present around an organism govern how the organism responds to adapt and survive in its environment. These responses are predetermined based on the expression of specific genes under various conditions, and hence, such genes determine the phenotypic response of the bacteria. Methane, a naturally and anthropogenically produced simple and abundant C1 gas is capable of being utilised by methanotrophic and heterotrophic organisms as a cheap and effective carbon source, instead of being released into the environment where it accelerates greenhouse effect. Utilisation of an effective mediator of this concept –Pseudomonas citronelollis, known for its ability to accumulate PHA under stress (Polyhydroxyalkanoate –poly-(R)-3-hydroxybutyrate), a natural biodegradable biopolymer with the capability to replace petroplastics, would result, not only in methane bio-remediated, but accumulation of a value-added product of paramount industrial importance, allowing us to harness its true potential. A precise Genome-to-Phenome correlation allows us to modulate the response of Pseudomonas citronellolis to various concentrations of methane, in order to enhance the accumulation of PHA. Additionally, methane uptake and assimilation rate enhancement by optimising methane monooxygenase (MMO) activity as well as optimised stress induction can facilitate increased biomass and PHA accumulation respectively. Advanced imaging techniques, namely –Scanning Electron Microscopy, Atomic Force Microscopy and Brunaeur-Emmett-Teller –Surface area analysis would be used for the determination of phenotypic characters respective to efficient methane assimilation which would be correlated with the transcriptome analysis for the determination of genome-phenome responses of the bacteria to the varying methane environment. Similarly, response to other similar carbon sources as electron donors could be extrapolated, thereby allowing use of other cheap and abundant carbon sources to facilitate PHA accumulation.

Primary author: SHARMA, Yash

Co-author: Ms SHARMA, Wageesha

Presenter: SHARMA, Yash

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **13** Type: **Poster**

The Snowball Chamber: Supercooled Water for Dark Matter and General Radiation Detection

Wednesday, May 11, 2022 3:40 PM (1 minute)

The snowball chamber is analogous to the bubble and cloud chambers in that it relies on a phase transition, but it is new to high-energy particle physics. The concept of the snowball chamber relies on supercooled water, which can remain metastable for long time periods in a sufficiently clean and smooth container (on the level of the critical radius for nucleation). The results gleaned from the first prototype setup (20 grams) will be reviewed, as well as plans for the future, with an eye to future deployment of a larger (kg-scale) device underground for direct detection of dark matter WIMPs, with a special focus on low-mass (GeV-scale) WIMPs, capitalizing on the presence of H, which could potentially also lead to world-leading sensitivity to spin-dependent-proton interactions for O(1 GeV/c^2)-mass WIMPs. Supercooled water also has the potential advantage of a sub-keV energy threshold for nuclear recoils, although this remains a prediction from atmospheric chemistry that must still be verified with careful measurements.

Primary author: SZYDAGIS, Matthew (UAlbany SUNY)

Presenter: SZYDAGIS, Matthew (UAlbany SUNY)

Session Classification: Poster Session

Track Classification: Dark Matter

Contribution ID: **14** Type: **Oral**

Current status and the upgrade of COSINE-100 and DM-Ice experiments

Thursday, May 12, 2022 5:20 PM (20 minutes)

COSINE-100 is the joint effort between KIMS and DM-Ice. It is a direct-detection dark matter search experiment with the goal of testing DAMA/LIBRA's claim of an annual modulation, using the same NaI(Tl) target. COSINE-100 experiment has been collecting physics data since September 2016 at the Yangyang underground laboratory, South Korea. It consists of ~106 kg of low background NaI(Tl) detectors submerged in a 2 tons liquid scintillator veto counter. DM-Ice17 consists of two prototype NaI(Tl) detectors deployed in the Southern hemisphere under Antarctic ice and operating continuously since June 2011. In this talk, I present the status of COSINE-100, including the recent results on WIMP and annual modulation search, and prospects for the next phase, COSINE-200. In addition, I will review ongoing R&D projects for, and the future phases of the DM-Ice experiment at the south pole.

Primary author: Dr ADHIKARI, Govinda (Yale University)

Presenter: Dr ADHIKARI, Govinda (Yale University)

Session Classification: Dark Matter - Parallel II

Track Classification: Dark Matter

Contribution ID: **15** Type: **Oral**

DarkSide-20k and the Liquid Argon Dark Matter Program

Thursday, May 12, 2022 2:20 PM (20 minutes)

The DarkSide program already produced world-class results for both the low mass ($M_{WIMP} < 10GeV/c^2$) and high mass ($M_{WIMP} > 100GeV/c^2$) direct detection search for dark matter with its primary DarkSide-50 detector. Operating since late 2013, it is a 50-kg-active-mass dual-phase Liquid Argon Time Projection Chamber (TPC), filled with low radioactivity argon from an underground source. The next step of DarkSide program consists of a new generation experiment involving collaboration within Global Argon Program for Dark Matter that engages all the current Argon-based experiments. DarkSide-20k is designed as a 20-tonne fiducial mass dual-phase Liquid Argon TPC with SiPM based cryogenic photosensors with high detection efficiency. TPC will be installed inside a cryostat containing more than 700 t of liquid argon and be surrounded by an active neutron veto. The detector will be housed at the INFN Gran Sasso (LNGS) underground laboratory, just like his predecessor, and should be free of any instrumental background for exposure of >100 tonne x year. DarkSide-20k is expected to attain a WIMP-nucleon cross-section exclusion sensitivity of $7.4 \times 10^{-48}\ cm^2$ for a WIMP mass of $1TeV/c^2$ in a 200 t yr run. The talk will highlight the latest updates on the ongoing R\&D activities toward large-scale argon detectors and their capabilities.

Primary authors: DARKSIDE-20K; WOJACZYŃSKI, Rafał (AstroCeNT CAMK)

Presenter: WOJACZYŃSKI, Rafał (AstroCeNT CAMK)

Session Classification: Dark Matter - Parallel I

Track Classification: Dark Matter

Contribution ID: **16** Type: **Oral**

Recent results from PandaX-4T experiment

Thursday, May 12, 2022 2:00 PM (20 minutes)

The PandaX-4T experiment located at China Jinping Underground Laboratory is a dual-phase xenon direct dark matter detection experiment, with 4-ton scale liquid xenon as target material in the sensitive volume. Recently, PandaX-4T has completed the detector construction and the subsequent commissioning run. In this talk, I will provide an overview on the performance of PandaX-4T detector and talk about the recent results from commissioning run.

Primary author: WANG, Qiuhong (Fudan University)

Presenter: WANG, Qiuhong (Fudan University)

Session Classification: Dark Matter - Parallel I

Track Classification: Dark Matter

Contribution ID: **17** Type: **Oral**

Search for 0νββ with the Complete EXO-200 Dataset

Thursday, May 12, 2022 4:20 PM (25 minutes)

The EXO-200 Collaboration searched for neutrinoless double beta decay ($0\nu\beta\beta$) using a liquid xenon time projection chamber filled with ~150 kg of enriched ^{136}Xe from September 2011 to December 2018. The use of a multi-dimensional analysis including calorimetric, spatial and topological information for the events allowed EXO-200 to perform one of the most sensitive searches for ($0\nu\beta\beta$) to date. For the final analysis, advanced techniques such as a Deep Neural Network were deployed to maximize the topological discrimination between signal and gamma backgrounds. This talk will present the analysis of the full dataset from EXO-200, including the final 0nbb result and other physics searches.

Primary author: JAMIL, Ako (Yale University)

Presenter: JAMIL, Ako (Yale University)

Session Classification: Double Beta Decay - Parallel II

Track Classification: Double Beta Decay

Contribution ID: **18** Type: **Oral**

Searching for 0vbb Decay with High Pressure Xenon Gas Time Projection Chambers

Thursday, May 12, 2022 4:45 PM (25 minutes)

Finding evidence of neutrinoless double beta decay would reveal the Majorana nature of the neutrino and give insight into the origins of the matter-antimatter asymmetry in the universe, the smallness of neutrino mass, and the symmetry structure of the Standard Model. The NEXT collaboration is developing a sequence of high pressure xenon gas time projection chambers with the aim of creating a ton-scale, very low background neutrinoless double beta decay search. In this talk, we will highlight the strengths of this program, including recent results from the NEXT-White demonstrator, status of NEXT-100, and prospects for ton-scale and beyond R&D and experiments.

Primary author: ROGERS, Leslie (argonne national laboratory)

Presenter: ROGERS, Leslie (argonne national laboratory)

Session Classification: Double Beta Decay - Parallel II

Track Classification: Double Beta Decay

Contribution ID: **19** Type: **Oral**

Dark Matter search with the CRESST-III experiment

Thursday, May 12, 2022 4:20 PM (20 minutes)

The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment, installed at the Laboratori Nazionali del Gran Sasso (LNGS), is suited for direct detection of dark matter particles via elastic scattering off nuclei.
CRESST uses an array of crystals operated as cryogenic calorimeters, each equipped with a cryogenic light detector.
An interaction in the crystal produces a phonon and a light signal: the phonon signal allows a precise energy measurement, the light signal is used to discriminate the expected dark matter signal (nuclear recoil) from the dominant background (electron/gamma and alpha). In early 2018, CRESST completed an initial data taking campaign reaching a nuclear recoil threshold of 30.1 eV on $CaWO_4$ crystals. This unprecedented low threshold allows to probe dark matter particle masses down to 160 MeV/c^2.
Currently the sensitivity is limited by the presence of events of unknown origin that rise from a few hundreds of eV down to threshold.
Dedicated measurements with different target materials are currently on going at LNGS to investigate the nature of this low energy excess.
Most recent results are presented. The current stage and the perspectives for the next phase of the experiment will be also discussed.

Primary author: Dr DI LORENZO, Stefano

Presenter: Dr DI LORENZO, Stefano

Session Classification: Dark Matter - Parallel II

Track Classification: Dark Matter

Contribution ID: **20** Type: **Oral**

Low-Energy Neutrino Interactions in the LZ Experiment

Thursday, May 12, 2022 3:20 PM (20 minutes)

The LUX-ZEPLIN (LZ) experiment is sensitive not only to dark matter Weakly Interacting Massive Particle (WIMP) interactions, but also to those of low-energy neutrinos. In particular, 8B (Boron-8) solar neutrinos from natural nuclear fusion processes in our Sun should lead to dozens of events above threshold over the lifetime of LZ, appearing in the same region of event-type parameter space as a low-mass (few-GeV/c^2) WIMP would. While this background will impact the sensitivity of LZ in that particular WIMP mass range, it is also a boon for neutrino physics. In this talk we will discuss how LZ will be able to see Coherent Elastic Neutrino-Nucleus Scattering (CEvNS), recently first observed by COHERENT using neutrinos generated by the Spallation Neutron Source at Oak Ridge National Laboratory, but in this case using 8B solar neutrinos. Potentially, LZ may be able to determine if deviations exist from the Standard Model CEvNS cross-section, and separately perform tests of the solar model. At the same time, the use of 8B neutrinos should allow for fresh studies of the uncertainties in the light and charge yields from low-energy nuclear recoils, of critical importance to detection of WIMPs, at any mass. Lastly, neutrinos from other sources such as Core-Collapse Supernovae (CCSNs) should also be detectable within LZ, in an energy regime orders of magnitude lower than for instance in DUNE, allowing for complementary measurements.

Primary author: SZYDAGIS, Matthew (UAlbany SUNY)

Presenter: SZYDAGIS, Matthew (UAlbany SUNY)

Session Classification: Supernova & Solar Neutrinos - Parallel

Track Classification: Supernova & Solar Neutrinos

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

Status of the LUX-ZEPLIN (LZ) Experiment

Friday, May 13, 2022 11:40 AM (30 minutes)

LUX-ZEPLIN (LZ) is a direct detection dark matter experiment located at the Sanford Underground Research Facility in Lead, South Dakota. It features a two-phase xenon time projection chamber, surrounded by an instrumented xenon "skin"and liquid scintillator active vetoes. The active region of the xenon TPC contains 7 tonnes of liquid xenon with a 5.6 tonne fiducial volume, allowing us to reach a WIMP-nucleon spin-independent cross section sensitivity of 1.4 x 10^-48 cm^2 for a 40 GeV/c^2 mass in 1000 live days. This talk will provide an overview of the experiment and report on its status.

Primary author: CARMONA-BENITEZ, Carmen (Pennsylvania State University)

Presenter: CARMONA-BENITEZ, Carmen (Pennsylvania State University)

Session Classification: Plenary - Dark Matter

Track Classification: Dark Matter

Contribution ID: **22** Type: **Oral**

The Machine Learning Epochs of Neutrinoless Double Beta Decay

Thursday, May 12, 2022 5:20 PM (20 minutes)

Neutrinoless Double Beta Decay ($0\nu\beta\beta$) is one of the primary research interests in particle and nuclear physics. As we enter the era of artificial intelligence, machine learning has grown exponentially in almost all types of $0\nu\beta\beta$ detectors. Thanks to its end-to-end nature, machine learning algorithms can easily surpass traditional algorithms by maximally extracting information from detectors. Furthermore, a well-interpreted machine learning analysis can reciprocally benefit the traditional analysis. However, the power of machine learning will not be fully unleashed unless we appropriately design and interpret the model. In this talk, I will discuss three critical components of a comprehensive machine learning analysis: model design, machine interpretability, and learning from the machine. The KamLAND-Zen and Majorana Demonstrator experiments demonstrate that these components will work reciprocally to improve the search sensitivity of $0\nu\beta\beta$.

Primary author: LI, Aobo (UNC Chapel Hill)

Presenter: LI, Aobo (UNC Chapel Hill)

Session Classification: Advanced Data Analysis - Parallel

Track Classification: Advanced Data Analysis

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

First Search for Majorana Neutrino at the Inverted Mass Ordering Region with KamLAND-Zen

Wednesday, May 11, 2022 2:00 PM (30 minutes)

The discovery of neutrinoless double beta decay (0νββ) would shed light on the persistent puzzle surrounding the origin of neutrino mass and help explain the matter-dominated universe. As one of the leading experiments searching for 0νββ, the KamLAND-Zen experiment has provided a stringent constraint on the neutrinoless double-beta(0νββ) decay half-life in 136Xe using a xenon-loaded liquid scintillator. We report an improved search using an upgraded detector with almost double the amount of xenon and an ultra-low radioactivity container, corresponding to an exposure of 979kg·yr of 136Xe. We have not observed 0νββ yet, but this search makes use of novel algorithms to perform beta-gamma separation using machine learning and tag spallation products on order day time scales. As a result, we obtain a lower limit for the 0νββ decay half-life of T > 2.29×10^26 yr at 90% C.L., corresponding to upper limits on the effective Majorana neutrino mass of 36 –156 meV using commonly adopted nuclear matrix element calculations. Our improved sensitivity provides a limit that reaches below 50 meV for the first time and is the first search for 0νββ in the inverted mass ordering region.

Primary author: LI, Aobo (UNC Chapel Hill)

Presenter: LI, Aobo (UNC Chapel Hill)

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

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

The SuperCDMS Experiment Overview

Thursday, May 12, 2022 4:40 PM (20 minutes)

The SuperCDMS SNOLAB experiment, which will search for dark matter particles with masses ≤ 10 GeV, is currently under construction 2 km underground in SNOLAB, Canada. The 24 detector payload contains cryogenic germanium and silicon detectors that allow the detection of sub-keV energy depositions from dark matter particle interactions. Two different types of detector designs are employed, denoted as the High Voltage detectors (HV) and the interleaved Z-dependent Ionization and Phonon detector (iZIP). HV detectors have a low threshold and excellent energy resolution, while iZIP detectors discriminate between electron and nuclear recoils, which is necessary for understanding backgrounds. The SuperCDMS experiment, its status, and the projected sensitivity will be discussed in this talk.

Primary authors: PODVIIANIUK, Ruslan (USD); SUPERCDMS COLLABORATION

Presenter: PODVIIANIUK, Ruslan (USD)

Session Classification: Dark Matter - Parallel II

Track Classification: Dark Matter

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

The CYGNUS Directional Recoil Observatory

Thursday, May 12, 2022 5:40 PM (20 minutes)

Gas Time Projection Chambers (TPCs) with highly segmented readouts based on micropattern gaseous detectors (MPGDs) are capable of measuring the detailed topology and direction of low-energy nuclear recoils and electron recoils, in real time. This unique capability enables new measurements, and is also highly desirable for probing below the neutrino floor by distinguishing between dark matter (DM) and neutrino scattering. The CYGNUS collaboration aims to deploy a modular network of detectors in multiple underground labs (including in the southern hemisphere), which will be expanded over time. I will outline the physics program enabled by this scheme in the next two decades. Current and near-term, m^3-scale detectors can be used for precision studies of final state topology, such as measurements of the Migdal effect, and searches for beyond the Standard Model (BSM) physics at beam dumps and neutrino beams. Next generation, 10 m^3 detectors should allow measurements of CNO solar neutrinos via coherent elastic scattering, and produce improved limits on spin-dependent DM scattering. A ton-scale observatory would probe unexplored DM parameter space, including below the neutrino floor, and can be used to confirm the galactic origin of a dark matter signal. I will discuss recent developments in the CYGNUS collaboration, including construction of new detectors, gas and performance optimization studies, and novel algorithm development in support of the physics program.

Primary author: VAHSEN, Sven (University of Hawaii)

Presenter: VAHSEN, Sven (University of Hawaii)

Session Classification: Dark Matter - Parallel II

Track Classification: Dark Matter

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

Investigating the novel ISS Methylobacterium species for PHA biosynthesis

Wednesday, May 11, 2022 3:00 PM (20 minutes)

Polyhydroxyalkanoates (PHAs) are gaining attention in the family of polyesters polymers due to its biodegradability and biocompatibility. The polymer molecular structure is decided by the biosynthetic pathways of microbes employed for PHA synthesis which is influenced by the bacterial species, substrate utilized, and the culturing conditions provided. There are more than100 PHA polymer monomeric units and the composition of these sub-units in polymer structure determines their physical and thermo-mechanical features. This variability has produced PHAs with drastically different polymer properties. In this context, it is of interest to explore PHA producers with properties having desirable functionality. In this study, we investigate novel Methylobacterium species isolated from the International Space Station for the potential PHA synthesis. The research focuses on comprehensive in-silico analysis of the whole genome sequences and metabolic pathways entailed in methanol to PHA production. Cell biomass production was assessed, and the DNA extracted from these strains were used in molecular targeting of the essential genes for PHA synthesis. PHA extraction protocol is optimized and confirmation of PHA in the extract was ensured by biophysical techniques. The physical and thermal properties of the extracted PHA polymers are reported. The findings further elucidate the relationship between carbon substrate, and the biochemical pathways resulting in polymer characteristics.

Primary author: SHARMA, Wageesha (South Dakota Mines)

Co-authors: Prof. SANI, RAJESH (SOUTH DAKOTA MINES); Prof. SALEM, David (South Dakota Mines); Dr VENKATESWARAN, Kasthuri (NASA Jet Propulsion Laboratory); Dr SINGH, Nitin (NASA Jet Propulsion Laboratory)

Presenter: SHARMA, Wageesha (South Dakota Mines)

Session Classification: Biology - Parallel

Track Classification: Biology

Contribution ID: **28** Type: **Poster**

CYGNUS studies of Angular Resolution of Electron Recoils in Gas

Wednesday, May 11, 2022 3:48 PM (1 minute)

The CYGNUS collaboration is composed of several directional recoil detection research groups that are proposing a large-scale experiment with a network of directional detectors dispersed globally. This experiment is attractive in the context of dark matter searches because it can penetrate the neutrino floor and has a practical way of confirming the galactic origin of a detected nuclear recoil signal. Recently, there has been a realization that directional recoil detectors also offer a unique ability to do neutrino physics; a particularly interesting example is the possibility of obtaining a firm measurement of the Sun's CNO neutrino flux. Given the direction to the Sun and the combined measurement of recoil energy and direction, event-by-event reconstruction of the neutrino energy spectrum is possible. The electron recoil channel is particularly promising because the kinematics result in higher recoil energies at a given neutrino energy. Evaluating and optimizing the CYGNUS sensitivity to neutrinos requires a good understanding of the detector's energy resolution and the angular resolution of electron recoils. However, electron recoils have complex trajectories and the angular resolution that can be achieved is not well understood. We discuss a general method for approximating and optimizing the angular resolution of electron recoils in gas time projection chambers. We will also show specific examples of the expected directional performance in CYGNUS detectors, including the CYGNO optical readout detector currently being commissioned underground at Gran Sasso.

Primary author: GHREAR, Majd (University of Hawaii)

Presenter: GHREAR, Majd (University of Hawaii)

Session Classification: Poster Session

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **29** Type: **Poster**

Identification of hyperactive AFPs, their production, purification, characterization, and testing their antifreeze properties.

Wednesday, May 11, 2022 4:01 PM (1 minute)

Psychrophiles produce antifreeze proteins which acts as a survival strategy for them in very low temperature especially in ice. Antifreeze protein (AFPs) inhibit ice crystal growth and lower the freezing point of water in a process that results in stabilizing ice crystals and inhibiting ice recrystallization. Moreover it is still unclear how Antarctic bacterial AFPs interact with ice, so more research needs to be conducted to determine how these proteins behave at the water/ice interface. It is thought that pore water phase changes in a seasonally frozen ground are interconnected with a variety of regional and global problem, including damages to payments and foundations due to frost-heave and thawing. Using a biomimetic and bio-mediated approach, we propose a more sustainable way to control phase changes in pore fluids of seasonally frozen ground in order to mitigate these impacts and enhance the resiliency of civil infrastructure in cold regions. Research on this topic is focused on developing a freeze thaw resistant bio-mediated ground improvement technique that uses minimal energy and no chemicals, different types of AFPs control frost susceptibility by inhibiting the formation of ice and thus, controlling the volume change in soils. By enhancing the moisture storage in subsurface media and implementing this technique, this technique can be used to improve foundations for buildings, towers, pavements and many more structures as well as to promote sustainable next-generation foundation techniques.

Primary authors: TIKU, Aditya; Dr SANI, Rajesh

Presenter: TIKU, Aditya

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **30** Type: **Poster**

Radiogenic Neutrons and External Gamma-ray Backgrounds at LEGEND-1000

Neutrinoless double beta decay ($0\nu\beta\beta$) is a rare decay process and is considered as the most promising way to prove the Majorana nature of neutrinos, that is neutrinos are their own antiparticles. The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) aims to build a phased ^{76}Ge-based $0\nu\beta\beta$ decay experimental program with the discovery potential of a half-life beyond 10^{28} years. The first (second) phase of LEGEND will deploy 200 (1000) kg of high purity germanium detectors made from germanium enriched to at least 90\% in ^{76}Ge. In order to achieve an unprecedented background goal of 1×10^{-5} cts/keV kg yr at the Q-value of 2039 keV, backgrounds are being carefully investigated in LEGEND-1000. Both ambient neutrons from the laboratory room and neutrons generated by (α, n) reactions and fissions in apparatus materials are important backgrounds. Similarly, gamma rays from far-way components such as the stainless-steel cryostat are also important. In this poster, we will discuss our Monte-Carlo (MC) simulation study of these neutrons and gamma rays at LEGEND-1000.

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

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

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

Contribution ID: **31** Type: **Oral**

Low Background kTon-Scale Liquid Argon Time Projection Chambers

Wednesday, May 11, 2022 5:10 PM (20 minutes)

We find that it is possible to increase sensitivity to MeV or lower-energy physics in a third or fourth DUNE-like module with careful controls over radiopurity and some modifications to a detector similar to the DUNE Far Detector design. In particular, sensitivity to supernovae and solar neutrinos can be enhanced with these changes and an improved photon detection system. A neutrino-less double beta decay search with ^{136}Xe loading appears feasible. Furthermore, sensitivity to Weakly Interacting Massive Particle (WIMP) Dark Matter (DM) becomes competitive with the planned world program in such a detector, and potentially offers a unique seasonal variation detection that is characteristic for the nature of WIMPs.

Primary author: CHURCH, Eric (PNNL)

Presenter: CHURCH, Eric (PNNL)

Session Classification: DUNE Module of Opportunity - Parallel

Track Classification: DUNE Module of Opportunity

Contribution ID: **32** Type: **Poster**

Epigenetics of Sulfate Reducing Bacteria Under Copper Stress

Wednesday, May 11, 2022 4:03 PM (1 minute)

Epigenetics is a mechanism of gene regulation without changing the DNA sequence, which is heritable in nature. Epigenetic regulation is poorly studied in prokaryotes and is associated with DNA methylation that regulates the DNA-protein interaction in bacteria which often plays a role in phenotypic variations. Our study focuses on biofilm-forming Desulfovibrio alaskensis G20 (DA G20), which are sulfate-reducing bacteria (SRB), thereby producing hydrogen sulfide as an end product. Hydrogen sulfide is responsible for metal corrosion which is directly proportional to the biofilms formation by the SRB on metal surfaces. Preliminary experiments were performed on the planktonic DA G20 cells grown under variable bioavailable copper conditions (0, 5, 15, and 30μM) in anaerobic serum bottles. DA G20 cell density decreased with an increase in copper ion concentration. The DNA from copper stress and non-stress cells of DA G20 were extracted, followed by epigenetics analyses. The samples were subjected to Whole-Genome Bisulfite Sequencing for epigenetic profiling. The sequencing data were processed using the Galaxy platform, wherein Bismark workflow was set up to map the m5C base modifications. Our results suggest that more than 20% methylation changes were present in the genes responsible for biofilm formation across CpG, CHG and CHH islands. The data is crucial to investigate the role of epigenetics in the biocorrosion of a metal surface by SRB biofilms.

Primary author: THAKUR, Payal

Presenter: THAKUR, Payal

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **33** Type: **Poster**

Purity Monitoring System for the SingleCube Detector at CSU

Wednesday, May 11, 2022 3:42 PM (1 minute)

SingleCube is a cubic-foot pixelated liquid argon (LAr) time-projection chamber (LArTPC) that is a small-scale prototype of the DUNE near detector. It operates in the physics department at Colorado State University (CSU) and it is used to test new technologies and techniques for the Deep Underground Neutrino Experiment (DUNE). When charged particles pass through LAr in the detector, they ionize argon atoms and produce scintillation light. In a TPC, ionization electrons drift in an electric field to the anode plane to be detected, and scintillation light is detected using light detectors. This information is used to reconstruct particle trajectories in the detector. The reduction of this charge and scintillation light due to electronegative impurities is detrimental to the successful reconstruction of particle trajectories and interactions. A purity monitor and corresponding electronics system has been developed at CSU to monitor the impurity level in SingleCube. In the purity monitor, free electrons are produced from a piece of gold at the cathode by the impingement of light from a UV light source. The electrons drift through the LAr in an applied electric field to the anode, however, some are absorbed by impurities in the argon along the way. The difference in charge measured between the cathode and the anode provides a measurement of electron lifetime, which gives valuable insight into the impurity level. In this talk, I will discuss the SingleCube purity monitoring system at CSU and developments that have been made.

Primary author: FOGARTY, Samuel (Colorado State University)

Presenter: FOGARTY, Samuel (Colorado State University)

Session Classification: Poster Session

Track Classification: Neutrino Oscillations

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

A search for argon-bound neutron-antineutron oscillation with the MicroBooNE LArTPC

Thursday, May 12, 2022 2:00 PM (20 minutes)

Massive and deep underground detectors such as the future Deep Underground Neutrino Experiment (DUNE) will offer a unique opportunity to search for rare, beyond-Standard Model (BSM) physics signals. One such BSM process is nucleus-bound neutron-antineutron oscillation—a baryon number violating process that produces a unique, star-like topological signature that 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 MicroBooNE data can be used to demonstrate and validate the methodologies that are used as part of the DUNE search. This talk presents a deep learning (DL)-based analysis of MicroBooNE off-beam data, making use of a sparse convolutional neural network (CNN) to search for neutron-antineutron oscillation-like signals in MicroBooNE. This search represents the first-ever search for neutron-antineutron oscillation in a LArTPC.

Primary author: Dr KALRA, Daisy (Columbia University)

Presenter: Dr KALRA, Daisy (Columbia University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

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

Nucleon Decay Studies at Super-Kamiokande

Thursday, May 12, 2022 2:20 PM (20 minutes)

Searching for proton decay and other baryon number violation processes is an essential and high priority goal of particle physics, closely related to fundamental topics such as baryon asymmetry of the universe, grand unified theories (GUT), and new physics below the GUT scale. With more than 20 years of data-taking and a large fiducial volume, Super-Kamiokande (SK) has presented leading constraints in the key benchmark modes as well as many other modes to cover many possible sources of baryon number violation. In this talk, I will give a summary of nucleon decay searches at SK so far, introduce recent efforts to expand the fiducial volume and to use neutron tagging for background reduction, and discuss the prospects of these analyses at SK-Gd and Hyper-Kamiokande.

Primary author: WAN, Linyan

Presenter: WAN, Linyan

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

Contribution ID: **36** Type: **Poster**

Investigating Short-Baseline Neutrino Anomalies with ICARUS

Wednesday, May 11, 2022 3:43 PM (1 minute)

The ICARUS T600 LArTPC detector successfully ran for three years at the underground LNGS laboratories, providing a first sensitive search for LSND-like anomalous electron neutrino appearance in the CNGS beam. After a significant overhauling at CERN, the T600 detector has been placed in its experimental hall at Fermilab, filled with liquid argon, raised to the nominal drift high voltage, and the first events observed with full TPC readout. Commissioning has since been underway with regular data taking beginning in May 2021 and the first neutrino events from the Booster Neutrino Beam (BNB) and the Neutrinos at the Main Injector (NUMI) off-axis beam have been observed. Searches for sterile neutrinos will soon begin in the framework of the Short Baseline Neutrino (SBN) Program, devoted to clarifying the open questions of previously observed short-baseline neutrino anomalies. This talk will provide an overview of ICARUS and its role in the SBN Program.

Primary author: MUELLER, Justin (Colorado State University)

Presenter: MUELLER, Justin (Colorado State University)

Session Classification: Poster Session

Track Classification: Neutrino Oscillations

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

Searches for baryon number violation via neutron conversions at the European Spallation Source

Thursday, May 12, 2022 3:20 PM (20 minutes)

The observation of neutrons converting to antineutrons and/or sterile neutrons would demonstrate Baryon Number Violation (BNV) for the first time. BNV is an essential condition needed to produce the matter/anti-matter asymmetry in the universe and appears in a number of theories beyond the Standard Model. Furthermore, the existence of sterile neutrons would address the dark matter problem. The HIBEAM/NNBAR project is a proposed series of experiments for the European Spallation Source (ESS) that can open up a discovery window for BNV by observing free neutrons transforming to antineutrons and/or sterile neutrons. A series of competitive searches are planned with an ultimate improvement in sensitivity of three orders of magnitude compared with the previous free neutron to anti-neutron search at Institut Laue-Langevin. This talk gives an introduction to the HIBEAM/NNBAR experiment. The motivation for the experiment and theories predicting neutron conversions are described, followed by a description of the ESS and those ESS facilities which can be exploited for the experiment. The set-ups and sensitivities of the neutron conversion searches are shown.

Primary author: YIU, Sze Chun (Fysikum, Stockholm University)

Presenter: YIU, Sze Chun (Fysikum, Stockholm University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

Contribution ID: **41** Type: **Oral**

Neutrino Theory Overview

Wednesday, May 11, 2022 10:30 AM (30 minutes)

Neutrino oscillations provide a mechanism to constrain most of the remaining known unknowns in particle physics and are becoming a powerful probe of new physics scenarios. I will discuss the impact of the oscillation parameters on other areas of physics and how we will detect them in neutrino oscillation experiments. I will also discuss some of the latest anomalies in neutrino oscillation data and speculate on what they might mean for the future.

Primary author: DENTON, Peter (Brookhaven National Laboratory)

Presenter: DENTON, Peter (Brookhaven National Laboratory)

Session Classification: Plenary - Neutrinos

Track Classification: Neutrino Oscillations

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

Report from Workshop on DUNE Module of Opportunity

Wednesday, May 11, 2022 4:20 PM (20 minutes)

This talk will review the status of DUNE detectors #3-4 and the DUNE Module of Opportunity Workshop.

Primary author: KETTELL, Steve (Brookhaven National Laboratory)

Presenter: KETTELL, Steve (Brookhaven National Laboratory)

Session Classification: DUNE Module of Opportunity - Parallel

Track Classification: DUNE Module of Opportunity

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

Enhancement of methane catalysis rates in Methylosinus trichosporium OB3b

Wednesday, May 11, 2022 4:00 PM (1 minute)

The particulate methane monooxygenase (pMMO), a membrane-bound enzyme having three-subunits (α, β, and γ) and copper-containing centers, is found in most of the methanotrophs that selectively catalyze the oxidation of methane into methanol. Active sites in pMMO of Methylosinus trichosporium OB3b were determined by docking the modeled structure with ethylbenzene, toluene, 1,3-dibutadiene, and trichloroethylene. The docking energies between the modeled pMMO structure and ethylbenzene, toluene, 1,3-dibutadiene, and trichloroethylene were -5.2, -5.7, -4.2, and -3.8 kcal/mol, respectively, suggesting the existence of more than one active site within the monomeric subunits due to the presence of multiple binding sites within the pMMO monomer. The evaluation of tunnels and cavities of the active sites and the docking results showed that each active site is specific to the radius of the substrate. To increase the catalysis rates of methane in pMMO of M. trichosporium OB3b, selected amino acid residues interacting at the binding site of ethylbenzene, toluene, 1,3-dibutadiene, and trichloroethylene were mutated. Based on screening the strain energy, docking energy, and physiochemical properties, five mutants were down selected, B:Leu31Ser, B:Phe96Gly, B:Phe92Thr, B:Trp106Ala and B:Tyr110Phe, which showed docking energies of -6.3, -6.7, -6.3, -6.5 and -6.5 kcal/mol, respectively as compared to the wild type (-5.2 kcal/mol) with ethylbenzene. These results suggest that these five mutants would likely increase methane oxidation rates compared to the wild-type pMMO.

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

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

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

Session Classification: Poster Session

Track Classification: Biology

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

Transcriptomics and functional analysis of copper stress response in the sulfate reducing bacteria Desulfovibrio alaskensis G20

Wednesday, May 11, 2022 4:04 PM (1 minute)

Copper (Cu) is an essential micronutrient required as a co-factor in the catalytic center of many enzymes in bacteria. However, excess Cu is hazardous and can generate pleiotropic effects. Cu has been the metal of choice for piping used in household water distribution systems. Due to its leaching from pipelines, Cu levels are present at elevated concentrations in ground water and in soils which is a matter of public health concern. Sulfate reducing bacteria (SRB) have been demonstrated to remove toxic levels of heavy metals including Cu. However, reports on toxicity of Cu towards SRB have primarily focused on degree of toxicity and subsequent elimination. In this study, we show in detail the Cu stress-related effects on a model sulfate reducing bacterium, Desulfovibrio alaskensis G20. Copper stress effects were measured at two different concentrations (5 μM and 15 μM) as changes in the transcriptome through RNA-Seq. In the pairwise comparison of 5 μM vs control (0 μM Cu), 61.43% of genes were found to be downregulated and 38.57% genes were upregulated. In 15 μM vs control, 49.51% genes were downregulated, and 50.5% genes were upregulated. The results indicated that the expression of inorganic ion transporters and translation machinery was massively modulated. Moreover, changes in the expression of critical biological processes such as DNA transcription and signal transduction were observed at high Cu(II) concentrations. These results will help us better understand the Cu(II) stress-response mechanism and provide avenues for future research.

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

Co-authors: Mr TRIPATHI, Abhilash (South Dakota School of Mines and Technology); Mr RAUNIYAR, Shailabh (South Dakota School of Mines and Technology); Prof. SANI, Rajesh K. (South Dakota School of Mines and Technology); Ms THAKUR, Payal (South Dakota School of Mines and Technology)

Presenter: SAXENA, Priya (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

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

Application of machine learning to find anomalous events in LZ data

Thursday, May 12, 2022 4:20 PM (20 minutes)

The LUX-ZEPLIN (LZ) experiment is a WIMP direct detection experiment using a dual-phase xenon time projection chamber with a 7 ton active volume, expecting science results in 2022. In a rare-event experiment such as LZ, it is important to identify events stemming from unexpected backgrounds, errors in reconstruction, and abnormalities in detector function. General-purpose, unsupervised anomaly finders operating on high-dimensional data can help in quickly finding these events that may otherwise be difficult to characterize. Further, anomaly finders can also increase the efficiency of identifying known but rare backgrounds with unusual topologies. In this presentation, I will discuss two approaches to anomaly finding that have been used to identify outliers in simulations and early LZ data.

Primary author: AMARASINGHE, Chami (University of Michigan)

Co-authors: KRAVITZ, Scott (Lawrence Berkeley National Lab); ARTHURS, Maris (University of Michigan)

Presenter: AMARASINGHE, Chami (University of Michigan)

Session Classification: Advanced Data Analysis - Parallel

Track Classification: Advanced Data Analysis

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

Supernova Theory: Models

Thursday, May 12, 2022 2:40 PM (20 minutes)

Over the past decade state-of-the-art computer simulations of core-collapse supernovae by multiple modeling groups have converged on a mechanism for successful explosions based upon a combination of neutrino heating and turbulence. The neutrinos, gravitational waves and electromagnetic messages that we shall detect from the next supernova in the Milky Way will allow us to test this paradigm in exquisite detail. In this talk I will give an overview of the current state of supernova modeling, how we connect the simulations to the signals we expect to observe in DUNE (and elsewhere) when the message from the next Galactic supernova finally arrives, and the nascent efforts to rise to the challenge of modeling quantum neutrino transport.

Primary author: KNELLER, Jim (NC State University)

Presenter: KNELLER, Jim (NC State University)

Session Classification: Supernova & Solar Neutrinos - Parallel

Track Classification: Supernova & Solar Neutrinos

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

New results on Neutrino Mass from the KATRIN Experiment

Wednesday, May 11, 2022 2:25 PM (20 minutes)

The Karlsruhe Tritium Neutrino (KATRIN) experiment has pushed the measurement of absolute neutrino mass scale down to the sub-eV region for the first time. The β electrons from molecular tritium decay are measured with high precision, using the magnetic adiabatic collimation with an electrostatic filter (MAC-E filter). A blind analysis for the first two scientific campaigns of KATRIN sets the most stringent upper limit of m_ν < 0.8eV/c^2 at a 90% confidence level. This new result of a direct neutrino mass measurements provides a key input to cosmological models and the theory of particle physics.

Primary author: WEIRAN FOR THE KATRIN COLLABORATION, Xu (MIT)

Presenter: WEIRAN FOR THE KATRIN COLLABORATION, Xu (MIT)

Session Classification: Neutrino Oscillations - Parallel

Track Classification: Neutrino Oscillations

Contribution ID: **49** Type: **Poster**

Seasonal Variation of Dark Matter Signals in the LZ Experiment and for a Proposed DUNE Low-Background Module at Sanford Lab

Wednesday, May 11, 2022 3:46 PM (1 minute)

Despite the lack of direct evidence, there is already an abundance of indirect evidence that points to a non-luminous new form of matter that exists in significant quantities throughout our universe. The theory of Weakly Interacting Massive Particles (WIMPs) provides an attractive new candidate particle for dark matter. It describes a relatively heavy electrically-neutral particle that only interacts through gravity and via the weak nuclear force. WIMPs would describe a halo of gaseous-like dark matter surrounding galaxies which would also solve the anomalous galactic rotation velocities of stars observed in all galaxies. Due to the rotation of our galaxy our own solar system experiences an induced "WIMP wind"if passing through such a dark matter distribution, which features a Maxwell-Boltzmann velocity distribution. We hope to either discover or refute WIMPs with the LUX-ZEPLIN (LZ) detector located at the Sanford Underground Research Facility (SURF). The LZ detector is an ultra-quiet dual-phase liquid xenon Time Projection Chamber (TPC) which will be used to acquire about three years worth of data. A potentially critical tool to differentiate WIMPs from other dark matter candidates and/or background is that due to the rotation of Earth around the Sun, there would be a seasonally changing detection rate with a unique signature for the WIMP dark matter compared to radioactive background contributions. With this in mind, a well-defined annual modulation of dark matter candidate events would provide a smoking gun in discovering WIMP dark matter. Furthermore, we show that a proposed liquid argon based low-background cryostat module for the upcoming Deep Underground Neutrino Experiment (DUNE) currently offers by far the most promising seasonal variation detection that is characteristic for the nature of WIMPs.

Primary authors: GENOVESI, Jack (South Dakota School of Mines and Technology); REICHENBACHER, Juergen (South Dakota School of Mines and Technology); SINEV, Gleb (South Dakota School of Mines and Technology)

Presenter: GENOVESI, Jack (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Dark Matter

Contribution ID: **50** Type: **Poster**

Methanotroph-heterotroph community resilience towards Cu2+/Fe2+ ratios

Wednesday, May 11, 2022 4:06 PM (1 minute)

Methane (CH4) is a greenhouse gas (GHG) with a Global Warming Potential of 28 - 36 over 100 years. Mining activities (e.g., coal mining) account for 11% of global methane emissions from anthropogenic activities, and CH4 that continues to be emitted from abandoned mines has higher CH4 content (~50 percent higher) than previously estimated. Advancement of the biological method for coal mine oxidation based on the methanotrophy combined with biopolymer (PHB - Polyhydroxybutyrate) production is a more feasible and sustainable approach for reducing CH4-associated climate change impacts. Divalent copper (Cu2+) and iron (Fe2+) play a vital role in CH4 oxidation and are critical for the expression of methane monooxygenase (pMMO or sMMO) enzymes. However, understanding their effects on methanotrophic growth and resilience is of paramount importance for improved CH4 oxidation and subsequent carbon storage as PHB. This study, as a first of its kind, therefore quantified the combined effects of variable Cu2+ and Fe2+ (5:5, 5:25 and 5:50 μM) ratios on a mixed methanotroph-heterotroph (and stable) consortium enriched from landfill top cover (LB) and compost soil (CB) over 100 days. Two identical 10 L continuous stirred tank reactors (CSTRs, Bioflo® & Celligen® 310 Fermentor/Bioreactor; John Morris Scientific, Chatswood, NSW, Australia) were used and the reactors were purged with CH4:CO2:air at the percentage ratio of 30:10:60 at the flow rate of 0.25 L min−1 (30% CH4). Specifically, we stressed the consortiums with the increasing molar concentration of Fe2+ under semi-continuous fed-batch operations and compared the microbial community shifts and PHB accumulation potentials. Cu2+/Fe2+ ratios had no significant impact on methane oxidation capacity for the first ten days of fed-batch operations, although there were significant differences in the microbial community structures in both LB and CB. Surprisingly increase in Cu2+/Fe2+ ratios favored the abundance of Sphingopyxis growth in both systems. High Fe2+ concentration also favored the growth of the type -II methanotroph population (Methylosinus sp.) in the CB-CSTR. In contrast, methanotroph abundances decreased in LB-CSTR, but increased the growth of Azospirllum. Fatty acid-profiles also changed significantly with the increasing Cu2+/Fe2+ ratios, whilst PHB content was similar in the LB- and CB-CSTR, decreasing with increasing Cu2+/Fe2+ ratios, while biomass growth was unaffected. After 13 days, methane oxidation capacities and PHB content decreased by ~50% and more in response to increasing Fe2+ concentrations. Despite similar methanotroph community structure and controlled environmental variables, increasing Cu2+/Fe2+ ratios significantly altered the microbial community distributions in the LB- and CB-CSTR, indicative of complex microbial interactions largely driven by unexplored allelopathic interactions within the mixed consortia, which might be affecting the CH4 to PHB accumulations under fed-batch operations. The dominance of certain non-methanotrophs indicates Cu2+/Fe2+ positively affected the overall resilience of community structure in both systems. Further studies will help to develop simulative community models to investigate the potential for CH4 emission abatement a priori and commercialize the PHB production.

Keywords: Methane, methanotrophs, copper, methane monooxygenase, biopolymer, CSTR

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Presenter: Dr CHIDAMBARAM PADMAVATHY, KARTHIGEYAN (Chemical and Biological Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701, USA)

Session Classification: Poster Session

Track Classification: Biology

Contribution ID: **51** Type: **Oral**

Bias Mitigation for the LUX-ZEPLIN (LZ) Experiment

Thursday, May 12, 2022 4:40 PM (20 minutes)

LUX-ZEPLIN (LZ) is a dark matter experiment located at the Sanford Underground Research Facility (SURF) in South Dakota. LZ is expected to explore new regimes of experimental sensitivity to a variety of dark matter candidates, notably Weakly Interacting Massive Particles (WIMPs). In pursuing new physics, it is important to ensure results are not influenced by biases towards achieving a predetermined outcome. Several techniques for avoiding biases have been employed in scientific experiments over the years including blinding and using hidden parameters. LZ will use a method known as salting, in which fake signal events are constructed from calibration data and covertly injected into the raw data stream during the dark matter search. These fake events are subsequently removed, but only after the data analysis is finalized. In this talk, I will discuss the motivations for this type of bias mitigation in a low-background experiment, as well as the process and tools that LZ uses to salt its data.

Primary author: WOODWARD, David (Penn State University)

Presenter: WOODWARD, David (Penn State University)

Session Classification: Advanced Data Analysis - Parallel

Track Classification: Advanced Data Analysis

Contribution ID: **52** Type: **Oral**

Calibration of a Liquid Xenon Detector for the Search for Dark Matter with the LUX-ZEPLIN (LZ) Experiment at Sanford Lab

Thursday, May 12, 2022 2:40 PM (20 minutes)

The 2nd generation direct detection dark matter experiment LZ will perform the most sensitive direct search for weakly-interacting massive particles (WIMPs). LZ is located at 4850 feet underground at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. LZ is employing a two-phase xenon detector with an active mass of 7 tonnes. WIMPs could interact in the cryogenic liquid xenon of the detector's core by scattering off xenon nuclei into a xenon nucleus, which would then recoil and produce scintillation light and electric charge. The ratio of the directly detected scintillation light S1 and the delayed charge detection S2 is characteristic for such a nuclear recoil (NR) and differs significantly from an electron recoil (ER) produced by undesired backgrounds. However, the precise knowledge of the energy dependent ratio S1/S2, for which the electron recoil dominated regime transitions into the nuclear recoil dominated regime, is key.
Calibrations with neutrons produced in DD-generators, or from AmLi, Cf-252, and Y/Be radioactive sources, are performed and analyzed to map out the NR signal region for the WIMP search. Gamma-ray sources are utilized to map out the ER region characteristic for backgrounds. In addition, a second important calibration, to be performed on a daily basis, is the determination of the lifetime of signal electrons against absorption on impurities within the liquid xenon. This is achieved through the use of internally distributed gamma-ray sources. In this talk both types of calibration will be presented, and where appropriate, compared to full detector simulations.

Primary author: SHARMA TIMALSINA, Madan (SD school of mines)

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

Presenter: SHARMA TIMALSINA, Madan (SD school of mines)

Session Classification: Dark Matter - Parallel I

Track Classification: Dark Matter

Contribution ID: **53** Type: **Poster**

Design and Simulation of a 9 MeV γ-Ray Calibration Source for the DUNE Neutrino Experiment at Sanford Lab

Wednesday, May 11, 2022 3:44 PM (1 minute)

The Deep Underground Neutrino Experiment (DUNE) is located at the Sanford Underground Research Facility (SURF) in the former Homestake Mine in Lead, SD. The DUNE detector will be comprised of four individual 10 kton liquid argon modules. The first module is scheduled to be operational in July 2026.

For DUNE it is important to understand the detector response to low low-energy neutrino events from both supernova and solar sources. The deployment of a calibration source which can mimic these low energy events is necessary to ensure that the signal response of the DUNE detector is well understood. The deployed nickel (n, γ) calibration source will be designed to emit clean 9 MeV gamma-rays induced by neutron captures on nickel to meet this task.

There are specific requirements to the deployment of a calibration source; the source must be able to endure cryogenic temperatures (87 K), it must not float, it must fit easily through the sealable flanges which have a relatively small diameter of 20 cm, and the moderator thus limited in size must still be efficient enough to thermalize neutrons so that the desired 58Ni(n, γ)59Ni reaction can occur and produce the desired 9 MeV γ-rays at a sufficient rate and purity for calibration purposes of DUNE.

Results from computer simulations utilizing the GEANT4 simulation framework are presented. Feasibility of a new compact nickel (n, γ) calibration source has been demonstrated by optimizing the configuration, location pattern and number of natural nickel rods placed inside a moderator made of high density plastic (Delrin) and by surrounding the entire assembly with a neutron absorbing boron loaded shell. Such a viable nickel (n, γ) calibration source can then simply utilize a commercially available AmLi (Americium Lithium) as internal neutron emitter. Further simulations of the calibration deployment in the DUNE detector are shown that demonstrate the clean detection signature of the optimized 9 MeV γ-ray calibration source.

Primary authors: HAISTON, James (South Dakota School of Mines and Technology, Graduate Student); STOCK, Jason (South Dakota School of Mines and Technology); Dr REICHENBACHER, Juergen (South Dakota School of Mines and Technology)

Presenter: HAISTON, James (South Dakota School of Mines and Technology, Graduate Student)

Session Classification: Poster Session

Track Classification: Supernova & Solar Neutrinos

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

Upgrading the BACoN liquid argon cryogenic system to study light yield

The study of scintillation light yield from liquid argon is interesting for many nuclear and particle physics experiments. Doping a few amounts of xenon in liquid argon could significantly shift the wavelength of scintillation light, time profile, and increase yield of the scintillation light. The measurement will be performed using BACoN system at the University of New Mexico. It consists of a stainless-steel cryostat vacuum system filled with liquid argon. The BACoN system is currently being upgraded to enhance its capability of studying Xenon doped liquid argon scintillation light. An array of silicon photomultipliers (SiPMs) will be deployed and to be complemented by a new PMT. The upgrade plan also includes the deployment of germanium detectors to mimic the setup of the LEGEND neutrinoless double beta experiment. The project is supported by LANL, LDRD. In this poster, we will describe the current progress of the BACoN upgrade efforts.

Primary author: POUDYAL, Nabin (University of South Dakota)

Co-authors: Prof. FIELDS, Douglas (University of New Mexico); Dr ELLIOTTS, Steven (Los Alamos National Lab); Prof. GOLD, Michael (University of New Mexico); Dr MASSARCZYK, Ralph (Los Alamos National Lab); Dr XU, Wenqin (University of South Dakota)

Presenter: POUDYAL, Nabin (University of South Dakota)

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

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

The Sanford Underground Research Facility

Wednesday, May 11, 2022 8:55 AM (30 minutes)

The Sanford Underground Research Facility (SURF) has been operating for 15 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. Laboratories have been developed on the surface as well as at the 4850-foot level (1500 m, 4300 m.w.e.), where several experiments are well established. SURF is also home to the Long-Baseline Neutrino Facility (LBNF) that will host the international Deep Underground Neutrino Experiment (DUNE). SURF offers an ultra-low background environment, low-background assay capabilities, and electroformed copper is produced at the facility. SURF is proposing additional underground space on the 4850L as well as a deeper site on the 7400L (2300 m, 6500 m.w.e.), and initial engineering designs for both areas have been completed. SURF has an active User Association that is leading engagement efforts with the global underground science community. SURF is a dedicated research facility with significant expansion capability, and applications from new experiments are welcome.

Primary author: HEISE, Jaret (Sanford Underground Research Facility)

Presenter: HEISE, Jaret (Sanford Underground Research Facility)

Session Classification: Plenary - Underground Science & Native American Heritage

Track Classification: Plenary

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

Baryon Number Violation Searches in DUNE

Thursday, May 12, 2022 2:40 PM (20 minutes)

The Deep Underground Neutrino Experiment (DUNE) is an international project that will study neutrinos and search for phenomena predicted by theories Beyond the Standard Model (BSM). DUNE will use a 70-kton liquid argon time projection chamber (LArTPC) located more than a kilometer underground. The excellent imaging capabilities of the LArTPC technology, in addition to the large size and underground location, allow the experiment to probe many types of rare processes. This talk will summarize DUNE's sensitivity to baryon number violating processes such as nucleon decay and neutron-antineutron oscillations.

Primary author: STOKES, Tyler (Louisiana State University)

Presenter: STOKES, Tyler (Louisiana State University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

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

Automated Neutrino Interaction Reconstruction and Particle Classification using Machine Learning in DUNE

Thursday, May 12, 2022 5:00 PM (20 minutes)

The upcoming Deep Underground Neutrino Experiment (DUNE) will provide answers to long-standing questions in neutrino physics, including the ordering of neutrino masses and the value of the CP-violating phase, δ_{CP}. Utilizing liquid argon time projection chamber (LArTPC) technology, DUNE will rely on automated reconstruction of neutrino interactions and classification of final-state particles. To this end, multiple machine learning (ML) techniques have been developed to aid in the reconstruction and classification of particle objects in both the near and far detectors and in the prototype DUNE single-phase detector (ProtoDUNE-SP). This talk presents an overview of the current status of DUNE ML efforts, including performance metrics and future avenues to pursue.

Primary author: MOGAN, Andrew (Co)

Presenter: MOGAN, Andrew (Co)

Session Classification: Advanced Data Analysis - Parallel

Track Classification: Advanced Data Analysis

Contribution ID: **58** Type: **Oral**

The Scintillating Bubble Chamber experiment a 10 kg liquid Ar bubble chamber, overview and update

Thursday, May 12, 2022 3:00 PM (20 minutes)

The Scintillating Bubble Chamber (SBC) collaboration is developing a liquid argon bubble chamber for GeV scale dark matter searches, and CEvNS searches using reactor neutrinos. Combining scintillation readout with bubble nucleation can provide significant nuclear recoil discrimination. Depending on the bubble nucleation threshold nuclear recoils will cause both a bubble to be generated and a scintillation signal, while electron recoils provide only a scintillation signal. We are currently constructing a 10 kg detector at Fermilab to explore the bubble nucleation threshold, along with calibration strategies to be able to measure nuclear recoils down to 100 eV. I will be providing an overview of the technology and an update on the progress of the detector construction, and early hardware testing.

Primary author: WHITIS, Thomas (UCSB)

Presenter: WHITIS, Thomas (UCSB)

Session Classification: Dark Matter - Parallel I

Track Classification: Dark Matter

Contribution ID: **59** Type: **Oral**

SENSEI: performance, results, and prospects for sub-GeV dark-matter searches

Thursday, May 12, 2022 5:00 PM (20 minutes)

Recently developed science-grade Skipper Charge-Coupled Devices (Skipper-CCDs) have unprecedented sensitivity to low-energy particle interactions in Silicon and are an outstanding technology to search for ultra-light dark-matter candidates. SENSEI (Sub-Electron Noise Skipper Experimental Instrument) is the first experiment to implement Skipper-CCDs for this purpose, achieving world-leading sub-GeV constraints. In this talk, we present the SENSEI experiment status and prospects. We discuss its latest results from the first year of data taking with a science-grade Skipper-CCD operated in a low-radiation environment. In the second part of this talk, we present the Oscura project, a future large-scale experiment using Skipper-CCDs for dark-matter searches.

Primary author: BOTTI, Ana Martina (Fermilab)

Presenter: BOTTI, Ana Martina (Fermilab)

Session Classification: Dark Matter - Parallel II

Track Classification: Dark Matter

Contribution ID: **60** Type: **Poster**

Measuring Non-Standard Neutrino Interactions (NSI) of Solar Neutrinos with Existing and Future Neutrino and Dark Matter Experiments

Wednesday, May 11, 2022 4:07 PM (1 minute)

Neutrinos can change flavor content on their way from their point of origin to the detector via a phenomenon known as neutrino oscillations. Neutrino oscillations have been confirmed over the past two decades in a wide range of experiments, and their measured parameters are now relatively consistent with the modified standard model (SM). However, there are hints that small deviations from SM neutrino oscillations could be caused by non-standard neutrino interactions (NSI). NSI could marginally (yet significantly) contribute to neutrino oscillations as neutrinos pass through a high-density medium. A convenient source of neutrinos that provides a high-density environment is our Sun. At its core, a high flux of neutrinos is emitted, stemming from fusion reactions, and, as these neutrinos travel to the Sun's surface, they experience a very dense matter profile that modifies their oscillation patterns. Here we study how existing and future neutrino experiments like Super-K, DUNE, Hyper-K, and a proposed low-background module for DUNE as well as dark matter experiments like LZ and XENONnT could observe effects of NSI with new precision measurements of solar neutrino oscillations. We show if and when these experiments could tap into unprobed phase space of NSI couplings, potentially discovering that the so-called 'solar neutrino anomaly' is real and caused by NSI.

Primary authors: SINEV, Gleb (South Dakota School of Mines and Technology); 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: **61** Type: **Poster**

Overview of Short-Baseline Neutrino Program

Wednesday, May 11, 2022 3:45 PM (1 minute)

Consisting of three large liquid-argon time projection chambers (LArTPCs) located along Fermilab's Booster Neutrino Beam, the Short-Baseline Neutrino (SBN) Program is a neutrino oscillation experiment that seeks to address anomalous results from the LSND and MiniBooNE experiments, where excesses of electron-like events could possibly be interpreted as originating from light sterile neutrinos. Additionally, detector R&D at SBN will benefit future long-baseline experiments, such as the Deep Underground Neutrino Experiment (DUNE), that will also utilize LArTPC technology. SBN features the 112-ton short-baseline near detector (SBND), the intermediate 89-ton MicroBooNE detector, and the 470-ton far detector (ICARUS); these detectors are located 110 m, 470 m, and 600 m from the beam source, respectively. In this presentation, the design and operational timeline of these detectors are discussed in detail, as well the role each plays in enabling SBN to fulfill its physics goals.

Primary author: KASHUR, Lane (Colorado State University)

Presenter: KASHUR, Lane (Colorado State University)

Session Classification: Poster Session

Track Classification: Neutrino Oscillations

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

Status of Proton Decay Searches

Thursday, May 12, 2022 8:15 AM (30 minutes)

Baryon number violation has been a subject of experimental and theoretical scrutiny for decades. Although it has not been detected so far, the next generation of large neutrino detectors will seek to improve upon the limits set by past and current experiments and will cover a range of lifetimes predicted by several Grand Unified Theories. In this talk, we will summarize theoretical motivations and experimental aspects of searches for baryon number violation in neutrino experiments.

Primary author: DEV, Bhupal (Washington University in St. Louis)

Presenter: DEV, Bhupal (Washington University in St. Louis)

Session Classification: Plenary - Undiscovered Decays

Track Classification: Proton Decay

Contribution ID: **63** Type: **Poster**

Radon Emanation Analysis

Wednesday, May 11, 2022 3:47 PM (1 minute)

Highly sensitive experiments, such as the LZ dark matter experiment, have backgrounds due to radon emanating out of materials. The radon emanation system at SD Mines is used to reduce radon background by measuring the emanation rate of radon out of these materials. If the emanation rate is too high, those objects can be replaced. Analysis of the emanation rate requires corrections when the detector's gain shifts, a log-likelihood analysis, and an understanding of background rates. Due to statistical uncertainty, the background for the system and its time dependence cannot be determined accurately from a single background run. However, co-adding multiple background runs together provides sufficient statistics. I will summarize my contributions to the Python code that performs this analysis, show how the co-added data constrains the background of the radon emanation system, and discuss the implications.

Primary author: BENDIGO, Seth (South Dakota Mines)

Co-author: SCHNEE, Richard (South Dakota Mines)

Presenter: BENDIGO, Seth (South Dakota Mines)

Session Classification: Poster Session

Track Classification: Dark Matter

Contribution ID: **64** Type: **Oral**

Searching for nucleon decay in JUNO

Thursday, May 12, 2022 3:00 PM (20 minutes)

JUNO is a multi-purpose 20 kton liquid scintillator neutrino detector under construction in the southeast of China at a baseline of 52.5 km from eight nuclear reactors. The experiment will have a rich program in neutrino oscillation physics using reactor antineutrinos, as well as in the study of neutrinos from a variety of natural sources including the Sun, the Earth, and supernovae. The experiment's design, large size, and low threshold will also make it an excellent ground to search for proton decay, particularly via the kaon decay mode. This talk will provide an overview of the JUNO experiment with a focus on its potential for nucleon decay searches.

Primary author: Dr XU, Benda (Tsinghua University)

Presenter: Dr XU, Benda (Tsinghua University)

Session Classification: Proton Decay - Parallel

Track Classification: Proton Decay

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

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

Wednesday, May 11, 2022 11:05 AM (30 minutes)

The Deep Underground Neutrino Experiment (DUNE) has exciting physics prospects on the horizon, including determining the neutrino mass ordering, measuring \delta_{CP} with sufficient precision to discover CP violation in neutrino oscillation, and detecting neutrinos from core-collapse supernovae and other astrophysical phenomena. DUNE will utilize a high-intensity neutrino beam produced at the Long-Baseline Neutrino Facility (LBNF) at Fermilab, a near detector also located at Fermilab, and a far detector located deep underground at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. The far detector will utilize the LArTPC (Liquid Argon Time Projection Chamber) technology and will be large enough (total argon mass of 70 kt across four modules) to ensure high enough event rates for a successful physics program. In this talk, the prospective physics program and current status of DUNE is discussed.

Primary author: MOONEY, Michael (Colorado State University)

Presenter: MOONEY, Michael (Colorado State University)

Session Classification: Plenary - Neutrinos

Track Classification: Neutrino Oscillations

Contribution ID: **66** Type: **Oral**

Status of the XENONnT Dark Matter Search Experiment

Friday, May 13, 2022 11:10 AM (30 minutes)

The XENONnT experiment, the successor of XENON1T, sets out for the direct detection of dark matter for more than one order of magnitude in sensitivity beyond the current best limits. XENONnT uses a dual-phase Time Projection Chamber with a total of 8.5 tons of liquid xenon, of which 6 tons are in the active volume. The experiment is currently in operation underground at the Laboratori Nazionali del Gran Sasso in Italy.

The installation of a new high-flow liquid purification system and a novel radon distillation column has been demonstrated to reduce the intrinsic radioactive background down to an unprecedented level. The addition of a neutron veto system around the XENONnT cryostat allows for significant suppression of the neutron background. Designated calibration campaigns are performed to ensure accurate modeling of the detector response. This talk will focus on these upgrades of the XENONnT experiment, and review its discovery potential and scientific goals.

Primary author: LI, Shengchao (Purdue University)

Presenter: LI, Shengchao (Purdue University)

Session Classification: Plenary - Dark Matter

Track Classification: Dark Matter

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

Results from the MicroBooNE Low-Energy Excess Search

Wednesday, May 11, 2022 3:15 PM (20 minutes)

MicroBooNE is a liquid argon time projection chamber detector designed to address the excess of low energy electromagnetic events observed by the MiniBooNE detector. Two hypotheses for this excess are explored by MicroBooNE: an electron-like excess coming from a larger than expected number of charged current (CC) ν_e interactions and a photon-like excess coming from neutrino-induced neutral current (NC) resonant Δ radiative decays. Data corresponding to MicroBooNE's first three years of operations are used to select single-photon events with one or zero protons and without charged leptons in the final state for the photon hypothesis. At the same time three independent electron neutrino analyses are performed across multiple single electron final states, including an exclusive search for two-body scattering events with a single proton, a semi-inclusive search for pionless events, and a fully inclusive search for events containing all hadronic final states. This talk will present first measurements of CC ν_e and single photons from NC Δ radiative decays in the MicroBooNE detector, two leading hypotheses for the excess. With differing signal topologies, statistics, backgrounds, reconstruction algorithms, and analysis approaches, the results are found to disfavor both hypotheses in favor of the nominal expectations from the Booster Neutrino Beam and no excess of electron neutrino or Δ radiative decay events are observed.

Primary author: CARO TERRAZAS, Ivan (Colorado State University)

Presenter: CARO TERRAZAS, Ivan (Colorado State University)

Session Classification: Neutrino Oscillations - Parallel

Track Classification: Neutrino Oscillations

Contribution ID: **68** Type: **Oral**

Neutrinoless Double Beta Decay and the SNO+ Experiment

Thursday, May 12, 2022 5:10 PM (25 minutes)

SNO+ is a kilo-tonne scale low background neutrino detector with the primary goal of searching for neutrinoless double beta decay ($0\nu\beta\beta$). The experiment's target volume is currently filled with liquid scintillator, providing the scope for background characterisation as well as measurement of reactor, geo, and low-energy solar neutrinos. The scintillator will be loaded with natural tellurium in order to search for $0\nu\beta\beta$ in tellurium-130.

This talk will give an overview of the SNO+ experiment, the preparations for $0\nu\beta\beta$ search, and the projected sensitivity.

Primary author: KROUPOVA, Tereza (University of Pennsylvania)

Presenter: KROUPOVA, Tereza (University of Pennsylvania)

Session Classification: Double Beta Decay - Parallel II

Track Classification: Double Beta Decay

Contribution ID: **69** Type: **Oral**

Astrophysical neutrinos : an experimental overview

Thursday, May 12, 2022 2:20 PM (20 minutes)

This talk will provide an overview of prospects for experimental measurements of astrophysical neutrinos. A brief motivation will be given, with a focus on low-energy solar neutrinos, and a range of experimental approaches will be discussed. The sensitivity of future detectors – both those under construction and those proposed – will be presented, with focus on scintillation-based detection for precision measurements in the low-energy regime.

Primary author: OREBI GANN, Gabriel (University of California, Berkeley / Lawrence Berkeley National Laboratory)

Presenter: OREBI GANN, Gabriel (University of California, Berkeley / Lawrence Berkeley National Laboratory)

Session Classification: Supernova & Solar Neutrinos - Parallel

Track Classification: Supernova & Solar Neutrinos

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

The Theia experiment

Wednesday, May 11, 2022 5:35 PM (20 minutes)

The advent of novel scintillators, such as Water-based Liquid Scintillator (WbLS), fast photon detectors, and spectral sorting offer the exciting possibility of combining the benefits of both water Cherenkov and organic scintillation detection methods into a single experiment. This groundbreaking technology yields the prospect of deployment in the 25 kTon THEIA-25 detector. In doing so, THEIA will have the capability to become one of the most wide-ranging next generation neutrino detectors - allowing for the study of low energy physics such as neutrinoless double beta decay, geoneutrinos and nucleon decay, astrophysical properties such as supernovae events, and high-energy questions such as the level of leptonic CP-violation. This talk will highlight the current status of WbLS, ongoing R&D, and introduce THEIA as an exciting, synergistic and complementary approach to probe a wide array of unknown problems in the neutrino sector as part of the Module of Opportunity.

Primary author: Dr PICKARD, Leon (UC Davis)

Presenter: Dr PICKARD, Leon (UC Davis)

Session Classification: DUNE Module of Opportunity - Parallel

Track Classification: DUNE Module of Opportunity

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

Thermally-Induced Borehole Breakouts Experiments at SURF

Wednesday, May 11, 2022 4:40 PM (20 minutes)

To accurately assess geomechanical behavior in the deep subsurface for CO2 sequestration, it is typically necessary to measure the in situ stress directions and magnitudes. However, the current state of the art in stress measurement methods are often inadequate or have deployment limitations in the deep subsurface. In response to this data gap, a new thermal breakout technology is being developed that will provide a method for thermally inducing borehole breakouts and obtaining consistent measurements of the maximum horizontal stress magnitude. This thermal breakout technology involves heating the borehole and increasing the thermoelastic compressive stress in the rock until a breakout develops, which is directly correlated to the maximum horizontal stress magnitude.

This talk will discuss the development of the thermal breakout stress measurement technology with a special focus on field-scale demonstrations at SURF. Several tests have been successfully performed within deep, highly stressed boreholes located within SURF at approximately 1,500 meters below ground. In addition to these tests, we will discuss the development of a more refined prototype downhole tool for future field-scale demonstration tests at SURF. The end goal of the thermal breakout stress measurement technology is to provide industry with enhanced tools for subsurface characterization and improved data for geomechanical analyses.

Primary author: VOEGELI, Sam (RESPEC)

Presenter: VOEGELI, Sam (RESPEC)

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

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

Geotechnical Monitoring and Structural Support for the LBNF Project

Wednesday, May 11, 2022 5:20 PM (20 minutes)

RESPEC is currently working with Thyssen Mining Inc. and Fermilab to support their work during the Main Excavation Phase of the LBNF Far Site Facility. RESPEC has installed geotechnical monitoring equipment including seismographs and multiple point borehole extensometers (MPBX) in the underground at the 4850 Level. The seismographs are used to monitoring daily blasting activities including the ground vibrations and air overpressure readings following each blast. Multiple point borehole extensometers, inclinometers, and convergence stations will be used to monitor the stability of the large underground caverns during excavation and over the next several decades. In this presentation, RESPEC will discuss the geotechnical monitoring systems they have deployed underground, future instrumentation equipment, and the central data management system used to collect and interpret the geotechnical data. Additionally, RESPEC will discuss other projects and support they have been providing to the LBNF project.

Primary author: BELZER, Brett (RESPEC)

Presenter: BELZER, Brett (RESPEC)

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

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

Omnitrophota encompasses diverse and hyperactive nanobacteria within SURF and beyond: Putative metabolic traits and host-dependent lifestyles

Wednesday, May 11, 2022 2:00 PM (20 minutes)

Candidate bacterial phylum Omnitrophota has never been grown in axenic culture and is poorly understood. Here, we combined analysis of 421 Omnitrophota genomes representing six classes and 276 species and show that they are prevalent in water, sediments, and soils globally. Fluorescence-activated cell sorting and differential size filtration showed ultra-small (~0.2 μm) cells to be common across the phylum. Reduced genomes in all six classes maintained major biosynthetic and energy conservation pathways, particularly the acetogenic Wood-Ljungdahl pathway or diverse aerobic and anaerobic respirations. However, most genomes also encoded multiple systems typical of bacterial predators and intracellular parasites, suggesting possible predatory or parasitic lifestyles. In support of this, quantitative stable-isotope probing revealed three families with high isotope uptake rates comparable to obligate bacterial predators in diverse soils. Based on their ubiquity, small cell size, high metabolic activity, and genomic repertoire, many Omnitrophota are likely to be ecologically important in a wide range of ecosystems, possibly as predators or parasites.

Primary author: Dr HEDLUND, Brian (University of Nevada, Las Vegas)

Presenter: Dr HEDLUND, Brian (University of Nevada, Las Vegas)

Session Classification: Biology - Parallel

Track Classification: Biology

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

Astro- and Particle Physics Prospects of Solar and Supernova Neutrinos

Thursday, May 12, 2022 2:00 PM (20 minutes)

Traditionally, the study of solar and supernova neutrinos served a dual purpose. Solar neutrino measurements were the first hint of neutrino flavor physics. Although solar neutrino flavor conversion is now well understood, solar neutrinos still offer a unique environment to study neutrino properties while they also allow to peer into the inside of a star. Similarly, supernova neutrinos probe aspects of neutrino interactions that cannot be studied anywhere else while also shedding light on the dynamics of supernova explosions. My presentation will review what has been learned so far, and give an outlook on future measurements.

Primary author: Dr SMY, Michael (University of California Irvine)

Presenter: Dr SMY, Michael (University of California Irvine)

Session Classification: Supernova & Solar Neutrinos - Parallel

Track Classification: Supernova & Solar Neutrinos

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

Geotechnical Characterization and Risk Mitigation for the LBNF Project

Friday, May 13, 2022 9:30 AM (30 minutes)

The Long Baseline Neutrino Facility Far Site, which will house the DUNE experiment, is currently under construction at the Sanford Underground Research Facility. Excavation of several caverns and ancillary tunnels is being undertaken at depth through jointed and foliated rock. This presentation will give a brief overview of the geotechnical characterization of the site and what intrinsic properties of the rock mass made this site favorable to the siting of large scale excavations. A robust risk identification and mitigation strategy was also developed and is being implemented through site observations, instrumentation, and back-analyses.

Primary author: POLLAK , Seth

Presenter: POLLAK , Seth

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

Track Classification: Geology

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

An overview of physics in underground laboratories

Wednesday, May 11, 2022 8:25 AM (30 minutes)

Many physics experiments requiring low-background environments are carried out in the underground laboratories worldwide. In this theoretical overview physics being probed in those experiments will be reviewed with particular emphasis on core-collapse supernovae, particle dark matter, both two-neutrino and neutrinoless double beta decays as well as laboratory nuclear astrophysics.

Primary author: Prof. BALANTEKIN, Baha (University of Wisconsin)

Presenter: Prof. BALANTEKIN, Baha (University of Wisconsin)

Session Classification: Plenary - Underground Science & Native American Heritage

Track Classification: Plenary

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

Mitakuyepi- my relatives

Wednesday, May 11, 2022 9:25 AM (30 minutes)

The Black Hills of South Dakota is known as He Sapa or Paha Sapa to my ancestors, my people, the Lakota. The Lakota and other Tribal Nations have had special ties to this area for thousands of years. We continue this special connection. For the Lakota, the Black Hills are the heart of everything that is, the center of our universe, where special sites remain vital to our existence. It is the responsibility of the Oceti Sakowin, the Seven Council Fires, to protect and preserve these sacred places where our Lakota ceremonies are held. We hold them with reverence, where we come to pray, not play. The Black Hills remind us to be respectful of Grandmother Earth and all that is. For indeed, we are all here for a purpose. Mitakuye Oyasin –For all my relatives/We are all related.

Primary author: Prof. DECORY, Jace (Black Hills State University)

Presenter: Prof. DECORY, Jace (Black Hills State University)

Session Classification: Plenary - Underground Science & Native American Heritage

Track Classification: Plenary

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

Status of the LEGEND experiment

Thursday, May 12, 2022 8:45 AM (25 minutes)

Next-generation neutrinoless double-beta decay ($0\nu\beta\beta$) searches seek the Majorana nature of neutrinos and the existence of a lepton number violating process by covering the $0\nu\beta\beta$ half-life corresponding to the inverted-ordering neutrino mass scale, assuming the light Majorana neutrino exchange mechanism. The LEGEND experiment, building from the experience of Majorana Demonstrator and GERDA, is the next generation experiment searching for $0\nu\beta\beta$ in ^{76}Ge. The current ^{76}Ge $0\nu\beta\beta$ experiments have the lowest background levels and best energy resolution in the region of interest. The LEGEND collaboration has implemented a phased experimental program based on p-type, inverted-coaxial, point-contact ^{76}Ge detectors operating within liquid argon. The first phase (LEGEND-200) will reach a discovery sensitivity on the $0\nu\beta\beta$ half-life of 10^{27} yr in 5 years of data by operating around 200 kg of ^{76}Ge detectors at LNGS in Italy. In the final phase (LEGEND-1000), the mass of detectors will be increased to 1 ton. The technical design of LEGEND-1000, along with the energy resolution, material selection and background suppression techniques project a quasi-background-free search, achieving a discovery sensitivity on the $0\nu\beta\beta$ half-life beyond 10^{28} yr. The status of the LEGEND program, technical readiness and discovery potential will be presented.

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 IFN; 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 and SURF facilities.

Presenter: LOPEZ CASTANO, Mariano (Oak Ridge National Laboratory)

Session Classification: Plenary - Undiscovered Decays

Track Classification: Double Beta Decay

Contribution ID: **79** Type: **Poster**

Thermophilic Exopolysaccharide-derived Films for Topical Drug Delivery

Wednesday, May 11, 2022 3:49 PM (1 minute)

Microbial exopolysaccharides (EPSs) exhibit diverse functionalities and offer a variety of structural options that can be altered to fit a specific purpose. Recent decades have seen the utilization of EPSs as a potential option to assist in the field of drug delivery. Commonly used synthetic polymers have been related to issues regarding toxicity, immunogenicity, unwanted polymer-drug interactions, drug loading, and harmful degradation products, escalating the need for an alternative. More so, purification is a common and vital procedure that adds to the cost of development. Microbial exopolysaccharides (EPSs) have been noted to degrade within the body via natural biological processes, are known to be non-cytotoxic, and most are inherently antimicrobial. EPSs can degrade within the body by natural biological processes, and polysaccharides are regarded as generally safe. More so, microbial EPS is replicable from several known, inexpensive, and plentiful sources, along with their unique rheological properties that allow for continuous production regardless of negative environmental influences. This preliminary investigation explores the capabilities of 5% wt/wt drug-loaded films constructed from the crude EPS extracted from the strain Geobacillus sp. WSUCF1. Human keratinocytes and human skin-tissue fibroblasts maintained, on average, above 93% cell viability over 72-hours when exposed to the amikacin-loaded film. The drug release profile of both whole films revealed a steady release of the drug up to 12 hours. The amikacin eluted by the EPS film was seen to be active against Staphylococcus aureus, maintaining above a 91% growth inhibition over a period of 48 hours. Overall, this study demonstrates the potential of a 5% drug-loaded EPS film as a viable option for topical delivery.

Primary author: LAUBACH, Joseph (South Dakota School of Mines and Technology)

Presenter: LAUBACH, Joseph (South Dakota School of Mines and Technology)

Session Classification: Poster Session

Track Classification: Biology

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

Development of novel germanium detectors for rare event physics searches

Friday, May 13, 2022 8:30 AM (30 minutes)

The University of South Dakota (USD) has been active in germanium (Ge) crystal growth and Ge detector development for rare event physics searches for more than 10 years. This talk will give an overview of the USD's R&D on novel Ge detectors made with USD grown crystals. Three new types of Ge detectors including Ge detectors with internal charge amplification, thincontact Ge detectors, and ring-contact Ge detectors, are currently under development at USD.
The physics motivation, the technical challenges, and the current status of the detector development will be addressed. The correlation between different projects will also be presented.

Primary author: Dr WEI, Wenzhao (USD)

Presenter: Dr WEI, Wenzhao (USD)

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

Track Classification: Materials Science

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

Deep Learning Reconstruction in the NOvA Experiment

Thursday, May 12, 2022 5:40 PM (20 minutes)

The NOvA experiment is a long-baseline accelerator neutrino experiment. It uses the upgraded NuMI beam from Fermilab and measures electron neutrino appearance and muon neutrino disappearance at its Far Detector in Ash River, Minnesota. NOvA is the first neutrino experiment that implemented convolutional neural networks in event reconstruction. NOvA is also developing new deep-learning algorithms to improve performance and robustness for future analyses. In this talk, I will discuss the development of deep learning techniques at NOvA.

Primary author: Prof. BIAN, Jianming (University of California, Irvine)

Presenter: Prof. BIAN, Jianming (University of California, Irvine)

Session Classification: Advanced Data Analysis - Parallel

Track Classification: Advanced Data Analysis

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

Search for $0\nu\beta\beta$ beyond 10^{28} years half-life sensitivity with nEXO

Thursday, May 12, 2022 9:10 AM (25 minutes)

nEXO is a 5 tonne monolithic liquid xenon (LXe) time projection chamber (TPC) planned to search for the neutrinoless double beta decay of ^{136}Xe with an estimated half-life sensitivity of >10^{28} years at 90% C.L.. Advancements have been made in terms of detector design, signal modelling and data analysis to support a refined estimate of the sensitivity and discovery potential of the nEXO experiment. In particular, we updated the detector geometry in line with most recent advancements in our engineering design. We implemented a more realistic and data-driven modelling of the light and charge channel signals and developed a Deep Neutral Network based analysis to discriminate between signal and background. This talk will cover the simulation, reconstruction and the physics reach of nEXO.

Primary author: JAMIL, Ako (Yale University)

Presenter: JAMIL, Ako (Yale University)

Session Classification: Plenary - Undiscovered Decays

Track Classification: Double Beta Decay

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

Welcome

Wednesday, May 11, 2022 8:15 AM (10 minutes)

Presenter: RANKIN, Jim (South Dakota School of Mines and Technology)

Session Classification: Plenary - Underground Science & Native American Heritage

Track Classification: Plenary

Contribution ID: **84** Type: **Oral**

The EGS Collab Project –Stimulating Crystalline Rock at 1.25 and 1.5 km Depth

The EGS Collab project, funded by the US Department of Energy Geothermal Technologies Office, is performing intensively monitored rock stimulation and flow tests at the 10-m scale at the Sanford Underground Research Laboratory to inform challenges in implementing enhanced geothermal systems (EGS). We are gathering data and observations from the field tests and comparing to models to understand processes and to build confidence in numerical modeling of the processes.

Experiment 1 examined hydraulic fracturing at a depth of approximately 1.5 km (4850 level). We installed many types of geophysical monitoring instrumentation in six of eight sub-horizontal boreholes in well-characterized phyllite to allow careful monitoring of stimulation events and flow tests. The other two boreholes were also instrumented to perform and carefully measure water injection and production. We performed more than a dozen hydraulic stimulations and nearly one year of flow tests in the testbed and collected and analyzed detailed observations and numerous data sets of processes occurring during stimulation and dynamic flow tests. Data from these tests are generally openly available. Ambient temperature and chilled water flow tests were performed with many tracer tests to examine changing system behavior. We achieved adaptive control of the tests using close monitoring of rapidly disseminated data and near-real-time simulation. Numerical simulation was used to answer key experimental design questions, to forecast fracture propagation trajectories and extents, and to analyze and evaluate results. Many simulations were performed in near-real-time in conjunction with the field experiments, with more detailed simulations performed on a longer timeframe.

Experiment 2 is designed to examine hydraulic shearing in a new test bed at SURF at a depth of about 1.25 km (4100 level) in amphibolite under a different set of stress and fracture conditions than Experiment 1. This testbed consists of 9 boreholes, in addition to two earlier-drilled characterization boreholes. Of the 9 boreholes, one is used for injection, four contain grouted instrumentation, and the remaining four are adaptively used for production and monitoring. The testbed construction optimized encounters with approximately five fracture set orientations. Experiment 3 will investigate unconventional stimulation methods and will follow Experiment 2 at 1.25 km depth.

Presenter: Dr KNEAFSEY, Timothy (Lawrence Berkeley National Laboratory)

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

Contribution ID: **85** Type: **Oral**

Status of the MAJORANA DEMONSTRATOR

Thursday, May 12, 2022 5:35 PM (25 minutes)

A discovery of neutrinoless double beta decay (0νββ) would establish that neutrinos are their own antiparticles, prove total lepton number violation, and provide a mechanism for generating non-zero neutrino masses. The MAJORANA DEMONSTRATOR experiment searches for 0νββ in ^{76}Ge with two shielded modules of high purity germanium (HPGe) detectors, ~30 kg of which are enriched to 88% in ^{76}Ge. The enriched detectors of the DEMONSTRATOR took data between 2015 and 2021, when they were removed for deployment in the Large Enriched Germanium Experiment for Neutrinoless ββ Decay (LEGEND). An upgrade of a module in 2020 with improved connectors and cabling successfully made all of its detectors operational, and it allowed the deployment of four inverted coaxial point contact (ICPC) enriched 76Ge detectors to study their performance prior to use in LEGEND. Excellent energy performance has been achieved with the DEMONSTRATOR HPGe detectors, including low energy threshold, great linearity, and a FWHM energy resolution that is approaching 0.1% at the double beta decay Q-value, the best in all 0νββ experiments. The DEMONSTRATOR has successfully demonstrated the feasibility and advantages of the ton-scale LEGEND project, and it has also been highly productive and competitive in a broad range of physics topics. In this talk, we will focus on the status of the DEMONSTRATOR's 0νββ decay result.

Presenter: HOSTIUC , Alexandru (University of Washington)

Session Classification: Double Beta Decay - Parallel II

Track Classification: Double Beta Decay

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

Dark Matter Overview

Friday, May 13, 2022 10:30 AM (40 minutes)

The search for particle dark matter has seen tremendous progress and developments in the last decade. One of the primary methods for understanding the particle nature of dark matter is through direct detection, and underground laboratories such as SURF have been crucial in these efforts. In this talk, I will provide an overview of the progress made in dark matter direct detection and what we can hope to see in the next decade.

Presenter: Prof. YU, Tien-Tien (University of Oregon)

Session Classification: Plenary - Dark Matter

Track Classification: Dark Matter

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

HP-Ge Crystal Growth at USD

Wednesday, May 11, 2022 4:20 PM (16 minutes)

Detector grade High-Purity Germanium (HP-Ge) crystals are largely needed for rare event physics. At the University of South Dakota (USD), we have successfully built a product chain that can purify the commercially available germanium raw materials to detector-grade HP-Ge crystals and fabricated them into Ge detectors. High-purity germanium crystals with diameters up to 12 cm were grown by the Czochralski method. We have been trying to increase the mass of input materials and grow the germanium crystals under a higher chamber pressure to enhance the chance to have a detector-grade region from the grown crystal. A summary of our current achievement and inventory of detector grade crystals will be reported.

Primary author: MEI, Hao (University of South Dakota)

Presenter: MEI, Hao (University of South Dakota)

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

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

Advancement of Zone Refining for Purifying Germanium Ingots at USD

Wednesday, May 11, 2022 4:36 PM (16 minutes)

Detector grade High-Purity Germanium (HP-Ge) crystals are largely needed for rare event physics. At the University of South Dakota (USD), we have successfully built a product chain that can purify the commercially available germanium raw materials to detector-grade HP-Ge crystals and fabricated them into Ge detectors. Zone refining is a prerequisite procedure to purify germanium ingots. The principle is based on the difference in the solubility of the impurities in the molten and solid phase of germanium. The existing research facilities in our lab can purify commercially available germanium ingots(5N) to a impurity level of $10^{10\ 12}/\square\square^{3}$ by zone refining. We have been working on a method which can produce high purity germanium ingots consistently. A summary of our current achievement and inventory of detector grade ingots will be reported.

Primary author: DONG, Kunming (University of South Dakota)

Presenter: DONG, Kunming (University of South Dakota)

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

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

Germanium ionization detector in a cryo mode at liquid helium temperature

Wednesday, May 11, 2022 4:52 PM (16 minutes)

The high-purity germanium (HPGe) detectors are well known for operating at liquid nitrogen temperature and cryogenic temperature at mK. Very little is known about Ge detector operating at liquid helium temperature. It is expected that operating Ge detectors at liquid helium temperature reduces thermal noise and hence allows the detectors to have better energy resolution in comparing to operating at liquid nitrogen temperature. We characterized Ge ionization detectors operated at liquid helium temperature at the University of South Dakota (USD) using the home-grown crystals. We measured the impurity freeze-out temperature in Ge. Using alphas from an Am-241 source, the charge collection efficiency (CCE) as a function of bias voltage was measured for three detectors with different impurity levels. Subsequently, we studied the impact of the impurity levels on the time-dependent CCE of the Ge detectors. The implication of the CCE at low temperature is discussed for Ge detectors with a-Ge contacts in searching for rare-event physics.

Collaboration: PIRE-GEMADARC

This work was supported by NSF OISE-1743790, PHYS1902577, OIA-1738695, DOE FG02-10ER46709, the Office of Research at the University of South Dakota and a research center supported by the State of South Dakota.

Primary author: PANTH, Rajendra (University of South Dakota)

Presenter: PANTH, Rajendra (University of South Dakota)

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

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

Time-Dependent Impact Ionization in a Large-Size Ge Detector Made from a Crystal Grown at USD

Wednesday, May 11, 2022 5:08 PM (16 minutes)

To understand the charge transport in a SuperCDMS-style Ge detector made from a crystal grown at USD was performed at the University of Minnesota. The detector is patterned with four concentric charge channels on one side, and a bias electrode on the opposite side. An Am-241 movable source was used to characterize the 59.54 keV peak in the energy spectra from each channel. This study can be utilized to understand the charge generation processes inside the detector at a cryogenic temperature. We investigated the time-dependent impact ionization induced by holes at mK temperature. We observed time-dependent impact ionization, which is due to the formation of cluster dipole states. We determined charge collection efficiency and impact ionization scattering cross-section using the data taken at mK temperatures.

Collaboration: PIRE-GEMADARC

This work was supported by NSF OISE-1743790, PHYS1902577, OIA-1738695, DOE FG02-10ER46709, the Office of Research at the University of South Dakota and a research center supported by the State of South Dakota.

Primary author: ACHARYA, Pramod

Presenter: ACHARYA, Pramod

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

Contribution ID: **91** Type: **Oral**

Development of Novel Germanium Detectors in Searching for Dark Photons

Wednesday, May 11, 2022 5:24 PM (16 minutes)

We present the calculations of using advanced germanium (Ge) detectors to search for dark photons in terms of absorption and conversion to electrons. A Ge detector utilizing internal charge amplification for the charge carriers created by the ionization of impurities is a novel technology with experimental sensitivity for detecting dark photons. We calculate the sensitivity of such a Ge experiment for detecting dark photons in the low-energy region and discuss our effort to fabricate such a detector in our lab that realizes Ge internal charge amplification (GeICA). We show that, if GeICA technology becomes available, then a new opportunity arises to observe dark photons.

This work is done under the collaboration PIRE-GEMADARC. It was sponsored by NSF OISE-1743790 and NSF OIA-1738632, DOE DESC0004768, and the state of South Dakota.

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

Presenter: BHATTARAI, Sanjay (University of South Dakota)

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

Contribution ID: **92** Type: **Oral**

Development of high-resolution InSb detectors at USD for DM search

Wednesday, May 11, 2022 5:40 PM (16 minutes)

We have been successfully growing HPGe single crystals for a decade here at University of South Dakota by using the Czochralski method. These HPGe detector-grade single crystals are fabricated into radiation detectors used in many research and application areas such as rare event physics. However, new semiconductor is still necessary especially in high resolution X-rays and gamma rays spectroscopy. The most promising candidate material is Indium Antimonide (InSb), a binary semiconductor which may be developed as a future ultra-high-resolution radiation detector due to its very small band gap of 0.165 eV and its large electron mobility of around 78000 $cm^2V^{-1}s^{-1}$. This small band gap could provide even better resolution and a higher peak-to-Compton ratios than Ge does.
Most of the previous works on the InSb crystals were concentrated on infrared applications. At this work, we present some theoretical calculations of InSb detectors compared to our own HPGe radiation detectors. And also, we present the experimental set up to grow the single crystals of InSb by Czochralski method in our lab.

Primary author: RAUT, Mathbar Singh (University of South Dakota)

Presenter: RAUT, Mathbar Singh (University of South Dakota)

Session Classification: Materials Science - Parallel

Track Classification: Materials Science

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

Search for neutrinoless double beta decay with CUPID

Thursday, May 12, 2022 9:35 AM (25 minutes)

CUPID is an upcoming cryogenic bolometric $0\nu\beta\beta$ experiment with plans to provide sensitivity to the Majorana nature of neutrinos at the scales corresponding to the inverted mass ordering. Designed based on the expertise, infrastructure, and experience of CUORE, CUPID-0, and CUPID-Mo experiments, CUPID will utilize 1596 Li_2MoO_4 scintillating crystals amounting to 240 kg of ^{100}Mo.
A combination of active background rejection techniques and high Q-value of ^{100}Mo will allow CUPID to reduce the backgrounds by at least two orders of magnitude compared to CUORE.
Using a data-driven background model, CUPID projects the sensitivity to $0\nu\beta\beta$ half-life beyond 10^{27} yr.Statu
This talk will present the design, status, and sensitivity reach of the CUPID experiment.

Presenter: Dr SURUKUCHI, Pranava (Yale University)

Session Classification: Plenary - Undiscovered Decays

Track Classification: Double Beta Decay

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

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

Wednesday, May 11, 2022 11:40 AM (30 minutes)

We discuss opportunities of experiments at SURF to resolve questions in both astrophysics and particle physics by measuring astroparticle neutrinos. Massive stars produce a core-collapse supernova at the end of their life cycle. In this supernova, the majority of the binding energy of the progenitor star is released as an intense pulse of neutrinos, first observed in SN 1987a. As neutrinos are weakly interacting and promptly escape the dying star, this burst of neutrinos carries detailed information about the core-collapse process that occurs within the stellar core. We will cover the potential to observe these neutrinos and study the core-collapse mechanism with DUNE and dark matter experiments. Further, we will discuss opportunities to improve understanding of the solar neutrino flux at SURF. DUNE will be a powerful machine for precision measurements of the solar oscillation parameters and search for new physics signatures in the solar energy spectrum which we will cover.

Presenter: PERSHEY, Daniel (Duke)

Session Classification: Plenary - Neutrinos

Track Classification: Supernova & Solar Neutrinos

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

Reactor Neutrinos Overview

Wednesday, May 11, 2022 2:50 PM (20 minutes)

Nuclear reactors have played a key role in advancing the knowledge regarding neutrinos. For example, the first detection of a neutrino used a nuclear reactor as the source. Moreover, recent reactor neutrino experiments found clear evidence of neutrino oscillations and opened up the parameters' measurement precision era. There is a rich physics that we can explore with reactor neutrinos, and for the first half of this talk, I will give an overview focusing on the most recent results achieved through the inverse beta decay reaction. Additionally, in the last part, I will discuss an exciting new technology for positron tagging that has the potential to be a game-changer in the field.

Presenter: BEZERRA, Thiago (University of Sussex)

Session Classification: Neutrino Oscillations - Parallel

Track Classification: Neutrino Oscillations

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

SoLAr

Wednesday, May 11, 2022 4:45 PM (20 minutes)

SoLAr is a new concept for a liquid argon neutrino detector technology which aims to extend the sensitivities of these devices to the MeV energy range, extending the physics reach of these next-generation detectors to include solar neutrinos. The SoLAr technology will be based on the concept of monolithic light-charge pixel-based readout which addresses the main requirements for such a detector: a low energy threshold with excellent energy resolution and background rejection through pulse-shape discrimination. The SoLAr concept is timely as a possible technology choice for the DUNE "Module of Opportunity"which could serve as a next-generation multi-purpose observatory for neutrinos from the MeV to the GeV range. Presented here are the first studies, status and plans for SoLAr.

Presenter: MCCONKEY, Nicola (University of Manchester)

Session Classification: DUNE Module of Opportunity - Parallel

Track Classification: DUNE Module of Opportunity

Contribution ID: **97** Type: **Poster**

First operation of undoped CsI directly coupled with SiPM at 77 Kelvin

Wednesday, May 11, 2022 3:51 PM (1 minute)

The light yield of a small undoped CsI crystal directly coupled with two SiPMs at about 77 Kelvin (K) was measured to be 43.0 ± 1.1 photoelectrons (PE) per keV electron-equivalent (keVee) using X and gamma-ray peaks from an 241Am radioactive source. The operation of an undoped CsI crystal coupled with two SiPMs at 77 K was the first attempt in the world. The high light yield together with some other technical advantages makes it a great neutrino and dark matter detector, particularly at the Spallation Neutron Source, Oak Ridge National Laboratory.

Primary author: DING, Keyu (University of South Dakota)

Presenter: DING, Keyu (University of South Dakota)

Session Classification: Poster Session

Track Classification: Dark Matter

Contribution ID: **98** Type: **Poster**

Radiogenic Neutrons and External Gamma-ray Backgrounds at LEGEND-1000

Wednesday, May 11, 2022 3:50 PM (1 minute)

Neutrinoless double beta decay ($0\nu\beta\beta$) is a rare decay process and is considered as the most promising way to prove the Majorana nature of neutrinos, that is neutrinos are their own antiparticles. The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) aims to build a phased ^{76}Ge-based $0\nu\beta\beta$ decay experimental program with the discovery potential of a half-life beyond 10^{28} years. The first (second) phase of LEGEND will deploy 200 (1000) kg of high purity germanium detectors made from germanium enriched to at least 90\% in ^{76}Ge. In order to achieve an unprecedented background goal of 1 $\times 10^{-5}$ cts/keV kg yr at the Q-value of 2039 keV, backgrounds are being carefully investigated in LEGEND-1000. Both ambient neutrons from the laboratory room and neutrons generated by (α, n) reactions and fissions in apparatus materials are important backgrounds. Similarly, gamma rays from far-way components such as the stainless-steel cryostat are also important. In this poster, we will discuss our Monte-Carlo (MC) simulation study of these neutrons and gamma rays at LEGEND-1000.

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

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

Session Classification: Poster Session

Track Classification: Double Beta Decay

Contribution ID: **99** Type: **Poster**

Upgrading the BACoN liquid argon cryogenic system to study light yield

Wednesday, May 11, 2022 3:41 PM (1 minute)

The study of scintillation light yield from liquid argon is interesting for many nuclear and particle physics experiments. Doping a few amounts of xenon in liquid argon could significantly shift the wavelength of scintillation light, time profile, and increase yield of the scintillation light. The measurement will be performed using BACoN system at the University of New Mexico. It consists of a stainless-steel cryostat vacuum system filled with liquid argon. The BACoN system is currently being upgraded to enhance its capability of studying Xenon doped liquid argon scintillation light. An array of silicon photomultipliers (SiPMs) will be deployed and to be complemented by a new PMT. The upgrade plan also includes the deployment of germanium detectors to mimic the setup of the LEGEND neutrinoless double beta experiment. The project is supported by LANL, LDRD. In this poster, we will describe the current progress of the BACoN upgrade efforts.

Primary author: POUDYAL, Nabin (University of South Dakota)

Co-authors: Prof. FIELDS, Douglas (University of New Mexico); Dr ELLIOTTS, Steven (Los Alamos National Lab); Prof. GOLD, Michael (University of New Mexico); Dr MASSARCZYK, Ralph (Los Alamos National Lab); Dr XU, Wenqin (University of South Dakota)

Presenter: POUDYAL, Nabin (University of South Dakota)

Session Classification: Poster Session

Track Classification: Double Beta Decay

Contribution ID: **100** Type: **not specified**

3-minute poster presentation:Upgrading the BACoN liquid argon cryogenic system to study light yield

Wednesday, May 11, 2022 3:35 PM (5 minutes)

The study of scintillation light yield from liquid argon is interesting for many nuclear and particle physics experiments. Doping a few amounts of xenon in liquid argon could significantly shift the wavelength of scintillation light, time profile, and increase yield of the scintillation light. The measurement will be performed using BACoN system at the University of New Mexico. It consists of a stainless-steel cryostat vacuum system filled with liquid argon. The BACoN system is currently being upgraded to enhance its capability of studying Xenon doped liquid argon scintillation light. An array of silicon photomultipliers (SiPMs) will be deployed and to be complemented by a new PMT. The upgrade plan also includes the deployment of germanium detectors to mimic the setup of the LEGEND neutrinoless double beta experiment. The project is supported by LANL, LDRD. In this poster, we will describe the current progress of the BACoN upgrade efforts.

Presenter: POUDYAL, Nabin (University of South Dakota)

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

Contribution ID: **102** Type: **not specified**

3-minute poster presentation:Radiogenic Neutrons and External Gamma-ray Backgrounds at LEGEND-1000

Wednesday, May 11, 2022 3:30 PM (5 minutes)

Neutrinoless double beta decay ($0\nu\beta\beta$) is a rare decay process and is considered as the most promising way to prove the Majorana nature of neutrinos, that is neutrinos are their own antiparticles. The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) aims to build a phased ^{76}Ge-based $0\nu\beta\beta$ decay experimental program with the discovery potential of a half-life beyond 10^{28} years. The first (second) phase of LEGEND will deploy 200 (1000) kg of high purity germanium detectors made from germanium enriched to at least 90\% in ^{76}Ge. In order to achieve an unprecedented background goal of 1 $\times 10^{-5}$ cts/keV kg yr at the Q-value of 2039 keV, backgrounds are being carefully investigated in LEGEND-1000. Both ambient neutrons from the laboratory room and neutrons generated by (α, n) reactions and fissions in apparatus materials are important backgrounds. Similarly, gamma rays from far-way components such as the stainless-steel cryostat are also important. In this poster, we will discuss our Monte-Carlo (MC) simulation study of these neutrons and gamma rays at LEGEND-1000.

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

Session Classification: Double Beta Decay - Parallel I

Track Classification: Double Beta Decay

Contribution ID: **103** Type: **Oral**

Microbes in Space: Extremophiles from Extraterrestrial Environments

Thursday, May 12, 2022 10:30 AM (30 minutes)

Microbiome of environmental surfaces and atmosphere samples in the International Space Station (ISS) were characterized in order to examine the relationship to crew and hardware maintenance. The Microbial Tracking projects generated a microbial census of the ISS environments using advanced molecular microbial community analyses along with traditional culture-based methods. Since the "omics"methodologies generated an extensive microbial census, significant insights into spaceflight-induced changes in the populations of beneficial and/or potentially harmful microbes were gained.

Lessons learned from ISS missions on the microbial prevalence using targeted (16S, ITS) sequencing, metagenomes, and resistomes will be discussed. In addition, while characterizing ~6,000 bacterial and fungal genomes several novel species were discovered and characterization of these novel species will be presented. The virulence characteristics of fungi as well as production of secondary metabolites that are of biotechnological importance are revealed.

The findings from the Environmental "Omics"project (basic science) should be exploited to enhance human health and well-being of the closed system. In other words, the microbial tracking research aims to "translate" findings in fundamental research into medical practice (pathogen detection) and meaningful health outcomes (countermeasure development). The "omics"data sets were placed in the NASA GeneLab bioinformatics environment—consisting of a database, computational tools, and improved methods—that would subsequently be made open to the scientific research community to encourage innovation.

Primary author: Dr VENKATESWARAN, Kasthuri (NASA Jet Propulsion Laboratory)

Presenter: Dr VENKATESWARAN, Kasthuri (NASA Jet Propulsion Laboratory)

Session Classification: Plenary - Nuclear Astrophysics, Biology, DUNE Module of Opportunity

Track Classification: Plenary

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

Applications of SURF Geobiology to Ending Fugitive Emissions from Abandoned Wells

Wednesday, May 11, 2022 4:20 PM (20 minutes)

The United States contains an estimated three million oil and gas wells that were abandoned after they stopped producing economical quantities of hydrocarbons. State regulations require these to be sealed, but the proper plugging and abandoning (P&A) procedure for a well can cost about $100,000. It is often cheaper to maintain the annual lease payment and shut in the well. Over time, ownership becomes obscure as companies buy and sell leases, operators retire, and old-timers with legacy knowledge disappear. Orphan wells no longer have an identified owner, and their P&A becomes the responsibility of state agencies. Steel casings and wellbore cement deteriorate over time, and many old wells emit methane gas, volatile organic compounds (VOCs), and even hazardous substances like hydrogen sulfide into the atmosphere. Conventional P&A on millions of abandoned wells is an expensive undertaking.

We propose a cheaper solution using carbon dioxide captured from the air, injected into depleted oil and gas reservoirs, and converted into solid carbonate minerals. This durably sequesters the carbon dioxide and stops fluid migration through the pores, halting fugitive emissions. Because the carbonate in the pore space blocks fugitive emissions at the source, it will plug any orphaned wells that tap into the reservoir, including those with no visible presence at the surface.

The conversion of carbon dioxide into carbonates like calcite and magnesite occurs inorganically when carbon dioxide in seawater reacts with unstable minerals, and organically as sea creatures from clams to corals create it on a regular basis. We are investigating the potential for microbes to carry this out at the temperature, pressure, salinity, and pH conditions typical of an oil reservoir rock at depths of 2,500 to 10,000 feet. Horizontal drill cores collected for the COLLAB program from the 4100-foot level of the SURF were sampled for indigenous microbes. Species of Geobacillus were obtained from the cores that showed potential to survive at oilfield depths. Persephonella marina, a species of bacteria found at deep sea hydrothermal vents is also being studied. An enzyme called carbonic anhydrase can be used by both Geobacillus and P. marina to convert CO2 into carbonate. Laboratory assessments are currently underway to assess the viability of the microbes under a variety of pressure and temperature conditions and on a variety of different substrates.

Extremophile microbes and carbon dioxide injected into the residual saltwater brines in depleted oilfields could use cations in the brine to convert CO2 into carbonates in the subsurface pore space. This would permanently sequester the greenhouse gas and halt fugitive emissions from abandoned wells.

Primary author: Dr SOEDER, Daniel (Soeder Geoscience LLC)

Presenter: Dr SOEDER, Daniel (Soeder Geoscience LLC)

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

Contribution ID: **105** Type: **Oral**

Microbial biotechnology for sustainable development

Wednesday, May 11, 2022 5:40 PM (20 minutes)

Microorganisms are tiny cell factories that produce several metabolite, many of these are useful to mankind. Microbes can be efficiently utilized for the synthesis of fuels and high value chemicals. Most of the chemical reactions, which are harmful to the environment, can be replaced by environmentally friendly biological routes through the use of microbes. Environmental sustainability is the one of the major advantage of microbial based process where the reactions are carried out under mild condition without any use of harsh conditions and toxic catalysts. The use of agricultural and other industrial organic wastes can be utilized in the process which makes the process more sustainable and environmentally friendly. The bioconversion of low value agro-residues into a high value chemical would be an economical strategy in terms of waste disposal for biorefineries. The present study describes the use of microbes for the production of industrially important building block chemical, 1,3-propanediol. In this study Lactobacillus brevis was used to produce 1,3-propanediol in batch fermentations. Different carbon sources like pure hexose and pentose sugars, mixed pentose sugar containing acid pretreated liquor (APL) from rice straw and different concentrations of pentose sugars and acid pretreated liquor were evaluated for the production of 1,3-propanediol. The upstream and downstream process for the production of 1,3-propanediol have been optimized.

Primary author: Dr BINOD, Parameswaran (CSIR-National Institute for Interdisciplinary Science and Technology (CSIR-NIIST))

Presenter: Dr BINOD, Parameswaran (CSIR-National Institute for Interdisciplinary Science and Technology (CSIR-NIIST))

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

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

Microbial habitability of Black Hills caves: a geochemical perspective

Wednesday, May 11, 2022 2:20 PM (20 minutes)

The Black Hills of South Dakota contain extensive natural cave systems, including some of the longest mapped caves in the world. Carbonate caves globally are are known to host a diversity of microorganisms; however, we know comparatively little about the biology and geochemistry of caves in the Black Hills region. As a first step towards exploring the diversity of microbial life in natural subsurface systems, the geochemistry of five caves along the eastern margin of the Black Hills was evaluated. Major and trace element geochemistry, organic and inorganic carbon of waters and sediments indicate that caves are geochemically distinct, despite close geographic proximity and development within the same geologic unit (Pahasapa Formation). Some of the main factors separating caves in multivariate analysis include air CO2, water nitrate, calcium, magnesium, manganese, and sulfate concentrations, as well as water and sediment organic and inorganic carbon content. Collectively, the results of this study can be used to guide predictions of microbial metabolic processes likely present in each cave, and the potential for larger trends in subsurface biodiversity throughout the region. Future work includes evaluating microbial community composition and metabolic functioning to better understand Black Hills caves as subsurface habitats for life.

Primary authors: CYRIER, Michael (South Dakota Mines); Prof. KEENAN, Sarah (South Dakota Mines)

Presenter: Prof. KEENAN, Sarah (South Dakota Mines)

Session Classification: Biology - Parallel

Track Classification: Biology

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

Nuclear Astrophysics Underground –Status of CASPAR

Thursday, May 12, 2022 11:00 AM (30 minutes)

Even more than 60 years after the groundbreaking publication by Burbidge, Burbidge, Fowler, and Hoyle, Nuclear Astrophysics is still a thriving and exciting research field at the interface of nuclear physics, astrophysics, and particle physics. Current topic is associated with the evolution of stars and its impact on the production of heavy elements but also the source strength of solar neutrinos from pp chain and CNO cycle. Certain nuclear reactions play a key role for these topics depending on the stellar environment. The study of these reactions at stellar energies has been a major goal by the community, in Europe, the US and increasingly also in China. However, the large cosmic ray induced background has been prohibitive for advancing these measurements into the stellar energy range and the present reaction rates rely on theoretical extrapolations that carry high uncertainties.
Accelerator laboratories located deep underground offer unique conditions for measuring these reactions at very low interaction energies as demonstrated by the success of the LUNA facility at Gran Sasso, Italy. However, over the past years also the CASPAR (Compact Accelerator System for Performing Astrophysical Research) laboratory at the Sanford Underground Research Facility (SURF) has produced first scientific results. CASPAR operates a 1-MV fully refurbished Van de Graaff accelerator that can provide high intensity proton and alpha beams. The current status and the future program of this first underground accelerator facility in the U.S. will be discussed.

Presenter: STRIEDER, Frank (South Dakota School of Mines & Technology)

Session Classification: Plenary - Nuclear Astrophysics, Biology, DUNE Module of Opportunity

Track Classification: Nuclear Physics

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

Diversity and Ecological Niche Preferences of Subsurface-Adapted Methanotrophic Bacteria from the Deep Biosphere of Homestake Mine

Wednesday, May 11, 2022 3:20 PM (20 minutes)

Methane is one of the most common sources of energy and carbon in the deep biosphere, and methanotrophy is hypothesized to sustain diverse microbial communities alongside chemolithoautotrophy in subsurface systems. However, the extent of the contribution of methanotrophy to primary production and C-cycling remains unknown, due to our lack of knowledge about the distribution, diversity, abundance and functional features of methanotrophs in subsurface ecosystems. To fill the gap, the ecology of methanotrophic communities was characterized from borehole fluids and mineshaft materials in the former Homestake gold mine.

DNA was extracted from subsurface samples taken at the 1700 feet and 4850 feet levels and used as a template for amplifying the 16S rRNA and pmoA genes. Amplicon and metagenomic libraries were sequenced using the Illumina platforms. A high diversity of aerobic methanotrophic bacteria within a broad range of clades (some have not previously been reported in the subsurface biosphere) were observed. Type-Ib methanotrophs were enriched in biofilms, type-IIa dominated in groundwater and several uncultured lineages exclusively occurred in mineshaft sediments. It is therefore likely that subsurface methanotrophs occupy different ecological niches based on their specific geochemical preferences. Bacterial communities inhabiting mineshaft biofilms shared moderately similar community composition with those in nearby groundwater, indicating methanotrophs trapped/concentrated (~27% in bacteria) in biofilms likely originated from the seeping groundwater. Such recolonization and enrichment could change the local C-flow, as methanotrophs are likely to be the primary producers in biofilms based on network analysis of communities.

Closest-related sequences to several mine OTUs were exclusively observed in other subsurface habitats, suggesting these obligate subsurface-colonizing methanotrophs were indigenous inhabitants and potentially adapted to subterranean life. Ten methanotrophic genomes with a range of degrees of novelty were recovered, and some genomic characteristics, present in Homestake mine genomes but absent in closest surface neighbors (e.g, possession of stress-response and metal-tolerance genes) could help them cope with extreme conditions. This in-depth survey revealed that a remarkably diverse, abundant and novel subsurface-adapted indigenous aerobic methanotrophic community were present in the deep subsurface biosphere.

Primary author: Dr KRUMHOLZ , Lee (University of Oklahoma)

Presenter: Dr KRUMHOLZ , Lee (University of Oklahoma)

Session Classification: Biology - Parallel

Track Classification: Biology

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

Hidden metabolism in the terrestrial deep subsurface

Wednesday, May 11, 2022 2:40 PM (20 minutes)

The Earth's subsurface is host to significant and diverse microbial populations. The nature of this biomass is poorly characterized, partially due to the inherent difficulty of sampling, in situ studies, and isolation of the in situ microbes. Recently, many studies have focused on harnessing the ability of microbes to interact extracellularly with redox-active substrates for energy/growth. This metabolism can be mimicked using poised electrodes in an electrochemical system providing a continuous supply of energy source or sink. In this talk, I will discuss various strategies recently employed to characterize and furthermore isolate the inherent microbial community residing in the terrestrial subsurface located at the Sanford Underground Research Facility (SURF).

Primary author: Dr JANGIR, Yamini (Caltech)

Presenter: Dr JANGIR, Yamini (Caltech)

Session Classification: Biology - Parallel

Track Classification: Biology

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

EGS Collab Rock Mechanics and Fracturing Studies at SURF

Wednesday, May 11, 2022 5:00 PM (20 minutes)

SURF has proven to be an excellent venue for studying the effects and prediction of fracturing of rocks under pressure. Beginning in 2015, kISMET (Permeability (k) and Induced Seismicity Management for Energy Technologies) followed by the EGS Collab project (Enhanced Geothermal Systems) have determined a wide range of rock mechanical properties of the Poorman Formation carbonate mica phyllites and the Yates amphibolite unit. The kISMET project and Test Bed 1 of EGS Collab were developed on the 4850 Level in the West Drift, whereas the experiment site for EGS Collab Test Bed 2 is constructed on the 4100 Level near the Yates Shaft Station. The goals of the current project include refinement of the understanding of rock mass response due to stimulation by injection of fluids and performance of experiments at the 10 m spatial scale under stresses relevant to EGS. The investigations support validation of thermal-hydrological-mechanical-chemical (THMC) modeling approaches and provide a platform for testing and improving conventional and novel field monitoring tools. This work is furthering the ability to predict permeability enhancement in crystalline rock and will lead to improvements in the creation of sustained and distributed permeability to extract heat by generating new fractures that complement existing fractures within the rock.

Presenter: ROGGENTHEN, Bill (South Dakota Mines)

Session Classification: Geology/Biology - Parallel

Track Classification: Geology

Contribution ID: **111** Type: **Oral**

Future astroparticle neutrino detection with liquid argon at SURF

Thursday, May 12, 2022 3:00 PM (20 minutes)

Neutrinos are produced copiously during a star's lifetime and offer a probe to understand the dynamics within the stellar interior
where optical observation fails. Neutrinos produced from fussion reactions within the sun have been detected and studied on Earth
since the Homestake experiment and subsequently facilitated the discovery of neutrino oscillations. Though solar neutrinos have
been studied for over 70 years, open questions still remain. Futher, as a massive star dies, it releases an enormous flux of
neutrinos that is observable from across the galaxy. Recording a burst of supernova neutrinos in a modern neutrino detector would
offer the clearest description yet of the exotic stellar interior as it transitions into either a neutron star or black hole. In
this talk, we will discuss the prospect to measure these astrophysical neutrinos in liquid argon experiments, particularly DUNE at
SURF.

Primary author: PERSHEY, Daniel (Duke)

Presenter: PERSHEY, Daniel (Duke)

Session Classification: Supernova & Solar Neutrinos - Parallel

Track Classification: Supernova & Solar Neutrinos

Contribution ID: **113** Type: **Poster**

Monte Carlo simulation of a dedicated neutron detector for the COHERENT experiment at the SNS, ORNL

Wednesday, May 11, 2022 4:08 PM (1 minute)

The COHERENT collaboration studies Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) with high-quality pion-decay-at-rest neutrinos from the Spallation Neutron Source (SNS) at Oak Ridge National Lab, Tennessee. Through CEvNS detection we can know more about the properties of neutrinos and nuclei. Neutrons that survive thick shielding between the source and COHERENT detectors are a serious background for CEvNS detection. A dedicated neutron detector, MARS, is used to monitor this background. The performance of this detector has been characterized using various radioactive sources, including a DT neutron generator. A Geant4 Monte Carlo simulation package has been developed to evaluate the efficiency of neutron detection and to understand the detector response to neutrons at various energies. Reported here are the comparison of the recorded and simulated calibration data, as well as the simulated neutron detection efficiency. The efficiency is used to estimate the neutron background level of COHERENT detectors

Primary author: BOCK, Conan (University of South Dakota)

Presenter: BOCK, Conan (University of South Dakota)

Session Classification: Poster Session

Track Classification: Nuclear Physics

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

Machine learning in particle physics

Friday, May 13, 2022 9:00 AM (30 minutes)

During the last decade, research of machine learning (ML) and artificial intelligence (AI) has gone through an explosive evolution and made impacts across many domains of science and human lives. AI/ML models in computer vision can perform high quality analysis of image data from physics experiments, and models developed for natural language processing are applied to analyze sequential data. Graph models can be used to represent more general relations and thus powerful tools for analyzing data from multi-modal detector data in particle physics experiments. These models are promising not only for its performance on data analysis tasks, but also for automated optimization procedures that reduce much of human interventions needed for traditional, hand-engineered algorithms. Progress in computing hardware has enabled not only deep learning models, but also classical techniques to be applied at scale including a differentiable physics software that can utilize a gradient-based optimization. Furthermore, supported by a wide community consisting of both industries and academic institutions, the AI/ML software eco-systems lowered the entry bar for everyone to exploit these powerful tools, and public dataset gathered researchers across science domains to form research collaboration. In this talk, I discuss 1) example AI/ML models in high energy physics with a focus on experimental neutrino physics, 2) promising directions of AI/ML research in the near future, and 3) need of software and data ecosystem to develop research collaborations across science domains within HEP and beyond.

Primary author: TERAO, Kazuhiro (SLAC National Accelerator Laboratory)

Presenter: TERAO, Kazuhiro (SLAC National Accelerator Laboratory)

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

Track Classification: Advanced Data Analysis

Contribution ID: **115** Type: **Oral**

DUNE Module of Opportunity

Thursday, May 12, 2022 11:30 AM (30 minutes)

A summary of proposed new ideas and technologies for a different detector module of opportunity for the DUNE far detector underground at Sanford Lab will be presented. The potential new physics reach for the DUNE program is discussed as well for some selected ideas and technologies.

Presenter: KETTELL, steve (bnl)

Session Classification: Plenary - Nuclear Astrophysics, Biology, DUNE Module of Opportunity