Users Meeting 2023

Tuesday, June 27, 2023 - Friday, June 30, 2023

Ramsey Auditorium

Book of Abstracts

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Poster Session / 1

Applying Machine Learning to vertex recognition for neutrino interactions

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The MINERvA experiment studies neutrinos cross sections with different nuclei. Neutrino vertex recognition plays a key role in reconstructing neutrino interactions. This research aims to enhance previous Machine Learning neutrino vertex recognition models produced in MINERvA using Deep Convolutional Neural Networks (DCNN). The approach focuses on extending neutrino interaction image information used as input to generate the models. The extension allows the DCNN to look for neutrino interactions in new regions not studied before. A Domain Adversarial Neural Network (DANN) was also implemented to penalize differences between simulated data images and real data images. The model performance is evaluated using recall, precision, and the harmonical mean F1 score, a traditional well-known metric used in this field. The F1 score considers both precision and recall, providing a comprehensive assessment of the model's performance. An extra label to recognize background activity was also implemented. The new models generated are the next version to use for the MINERvA experiment, it enables analysis of all events in the detector including the calorimeters enabling new high statistics analysis in MINERvA.

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Magnetometry Cross-Calibration for Muon g-2 Experiments

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Precise determination of the muon anomalous magnetic moment in a storage ring experiment relies equally on the ability to measure the muons' spin precession frequency and the magnetic field that the muons experience. In the Fermilab E989 Muon g-2 experiment, the 1.45 T magnetic field is regularly mapped by a "trolley" containing an array of 17 Nuclear Magnetic Resonance (NMR) probes filled with petroleum jelly. The petroleum jelly probes are calibrated twice per year against a water-filled NMR probe whose material perturbations to the magnetic field are precisely known; this provides an absolute calibration relating the frequency measured by the trolley probes to the precise value of the magnetic field in Tesla. Another muon g-2 experiment is currently under development in Japan at J-PARC which will require similar magnetometry to the Fermilab experiment, but at a field of 3 T. The specific NMR techniques for these two experiments differ slightly; Fermilab uses pulsed NMR, while the J-PARC experiment uses continuous-wave (CW) NMR. To verify that both groups' absolute calibration probes agree to high precision, J-PARC style CW-NMR probes and Fermilab-style pulsed NMR probes and the associated signal processing hardware and analysis for each were compared directly by making repeated measurements of the same field in a stable solenoid magnet at Argonne National Laboratory.

Poster Session / 3

Dopant R&D in LArTPCs

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Neutrinos interact with matter very weakly making it hard to detect despite being the most abundant particle in the universe. **L**iquid **Ar**gon **T**ime **P**rojection **C**hamber (**LArTPC**) detects neutrinos by measuring the resultant charge and light after the interaction between neutrino and argon particles. However, in LArTPCs, light collection efficiency is much lower than charge collection, which limits our ability to reconstruct low-energy signals. In our project, we explore adding photosensitive dopants to the liquid argon which are expected to convert the scintillation light into more ionization charge enabling us to explore the low-energy signals in the TPC. I will discuss the R&D endeavor in the Fermilab's Nobel Liquid Test Facility showcasing its ongoing efforts and advancements.

Poster Session / 4

A Low Energy Muon test beam in the MTA Experimental Area

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A new secondary beamline was recently installed in the MeV Test Area (MTA) with the objective of enhancing mu+/mu- production by factors of 3/8 by using a tungsten target versus the conventional graphite production target using the 400 MeV Fermilab proton Linac beam. Ultra-low energy muon beams can support world-class physics experiments for fundamental muon measurements, sensitive searches for symmetry violation, and precision tests of theory. Extensive production studies have confirmed higher muon yield from heavy targets (tungsten vs carbon), but also, surprisingly, showed significant differences in production fluence and energy spectrum between modern hadronic models (GENIEhad) and between GEANT and MCNP. Studies are underway towards a high-efficiency source of muonium by stopping the mu+ beam in superfluid helium. Muon fluxes can be measured at MTA including using higher-Z and novel target geometries to test and refine hadronic and production models which are critical to understanding ongoing experiments (Mu2e) and will significantly impact the planning of future HEP experiments and planning PIP II facilities. The MTA beamline will additionally support a broad user muon test beam for future experiments and R&D.

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Time Slicing of Neutrino Fluxes in Oscillation Experiments at Fermilab

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Upcoming long baseline neutrino experiments aim to increase proton beam power and utilize large-scale detectors to overcome limited event statistics. The DUNE experiment at LBNF focuses on testing the three neutrino flavor paradigm and searching for CP violation through oscillation signatures. To achieve DUNE's scientific objectives, minimizing systematic errors, particularly those related to neutrino-nucleus interactions, is crucial. The "stroboscopic approach" is introduced as an innovative technique that leverages the correlation between true neutrino energy and measured arrival time, enabling access to energy information at the Far detector. This approach requires short proton bunch lengths, fast timing, and synchronization between detector and proton timing. Understanding cross sections is vital for the DUNE experiment and US accelerator-based neutrino beams can benefit from this technique.

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Neutrino Beam Instrumentation (NBI) for LBNF

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The upcoming Long Baseline Neutrino Facility (LBNF) will generate a world-leading neutrino beam. The baseline beamline design involves a 1.2-MW, 120-GeV primary proton beam directed at a cylindrical graphite target, measuring 1.8 m in length and 16 mm in diameter. Three magnetic horns, supported inside horn 1, focus the hadrons produced in the target using 300kA currents. Additionally, there is a 194 m helium-filled decay pipe and a hadron absorber in the setup. To achieve the desired DUNE physics goals, it is essential to maintain tight constraints on beam systematics by aligning beamline elements, ensuring beam stability, and accurate targeting. The LBNF Neutrino Beam Instrumentation (NBI) group is responsible for aligning and monitoring the secondary and tertiary beams within the beamline. NBI performs beam-based alignment and monitoring of the neutrino beam intensity and direction, while also independently measuring the positions of the focusing horns. This poster aims to provide detailed descriptions and the current status of these instrumentation systems.

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Uniform beam simulation technique for beam scans and machine learning studies at Fermilab

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Fermilab's neutrino facilities, including NuMI and the upcoming LBNF, use proton beams to produce positively and negatively charged pions and kaons. Detailed simulations are necessary to study particle interactions and beam propagation. To efficiently analyze beam scan effects, we propose a technique to generate multiple simulation samples with high statistics. These samples can be used to develop beamline simulation based machine learning applications. In this technique, we generate a uniformly distributed single simulation data sample. We calculate Gaussian weights for each beam configurations and apply them to post-processing measurements. In this poster, we demonstrate the proposed simulation technique. This technique reduces simulation time and computing resources significantly.

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The (Z,A) Dependence of Muon-to-Electron Conversion

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If muon-to-electron conversion in the field of a nucleus is found in the current generation
of experiments (i.e. Mu2e or COMET), the measurement of the atomic number dependence of the process will become
an important experimental goal. We present a new treatment of the (Z,A) dependence of muon to-electron conversion. Our approach differs from earlier work in that it combines nuclear charge distribution determinations from both electron scattering and muonic atoms, takes into account the effect of permanent quadrupole deformations, and employs a Hartree-Bogliubov model for the neutron distributions. The results are compared with earlier calculations.

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Survey of centimeter-scale AC-LGAD strip sensors with a 120 GeV proton beam

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AC-Coupled Low Gain Avalanche Diodes (AC-LGAD) are silicon sensors that are designed primarily for 4D tracking applications at future particle colliders. These sensors are capable of providing fine temporal and spatial resolution. At the Electron-Ion Collider (EIC), this technology can be used to provide particle identification and tracking while keeping an economical channel count and low power density. We will present a survey of centimeter-scale AC-LGAD strip sensors, using 120 GeV protons from the Fermilab Test Beam Facility. A study of the performance of these sensors as a function of various parameters such as thickness, capacitance, etc. is presented with the aim of optimizing the sensor geometry to maintain the desired sensor performance characteristics with increasingly larger electrodes.

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Simulation of Beam-induced Backgrounds for the Cool Copper Collider

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Electron-positron pair production and hadron photoproduction are the most critical beam-induced backgrounds at linear electron-positron colliders. Predicting them accurately governs the design and optimization of detectors at these machines and, ultimately, their physics reach. With the proposal, adoption, and first specification of the C^3 collider concept, it is of primary importance to estimate these backgrounds and begin the process of tuning existing linear collider detector designs to fully exploit the parameters of the machine. A report on the status of estimating both of these backgrounds at C^3 using the SiD detector concept is presented with a discussion on the effects of machine parameters on preliminary detector and electronics design.

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Trigger Development for Emerging Jet Analysis

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Many Beyond the Standard Model (BSM) ideas envisage a connection between the Dark Matter (DM) and Baryonic matter densities (i.e. from Standard Model (SM)) where the DM has an asymmetry in the ratio of matter over antimatter similar to baryons. The dark sector is connected to the visible sector by a heavy mediator. It is highly relevant to explore the signature of this connection as part of the full big spectrum of all the possible new physics scenarios that could be discovered at the LHC. In this presentation, we explore a strategy that utilizes calorimeter jets that are composed dominantly of displaced tracks and have many different vertices within the jet cone. A TeV scale field produces decays to two dark quarks and possibly other SM fields. These dark quarks shower and hadronize producing dark mesons, forming into two jet-like structures just like SM QCD (Quantum Chromodynamics) in the same direction as one of the initial dark quarks. The dark mesons decay into SM quarks with a lifetime of the order of centimeters which in turn emerge as a jet of SM particles. Due to the exponential decay law, each hadron will decay in a different place in the detector and the jets will emerge into the visible sector. These jets are called "emerging jets". We select events by a trigger that requires a great deal of energy in the form of jets. This trigger should take advantage of the unique features of the emergent jets. We present preliminary work towards developing a new trigger dedicated to Emerging Jets for this analysis with Run-2 Data of CMS at the Large Hadron Collider at CERN.

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Identification of Cosmic Rays in the ICARUS Experiment Using Precision Timing

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After operating for 3-years in the Gran Sasso underground laboratory and receiving significant upgrades at CERN, the ICARUS detector was transported to Fermilab to serve as the Far Detector in the Short Baseline Neutrino (SBN) program. The SBN program is composed of three Liquid Argon Time Projection Chambers (LArTPCs) with a central goal of testing the sterile neutrino hypothesis. At Fermilab this detector will operate at shallow depth where it is exposed to a high flux of cosmic rays that can fake neutrino interactions. To mitigate this effect a Cosmic Ray Tagger (CRT) and a 3-meter-thick concrete overburden were installed. Precise timing information from the CRT and an upgraded photomultiplier tube (PMT) subsystems can help to identify whether an interaction originated from inside or outside of the ICARUS cryostat. In this poster I will discuss methods for cosmogenic background reduction and timing calibration of the CRT and PMT subsystems.

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Power Over Fiber for the DUNE Vertical Drift PDS

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The Deep Underground Neutrino Experiment (DUNE) is a long-baseline neutrino experiment that will send an intense beam of neutrinos through two particle detectors; a near detector located at Fermilab (Chicago) and far detector located at ~1.5 km underground and ~1300km from the near detector at Sanford Underground Research Facility (SURF) in South Dakota.

The DUNE far detector will be comprised of four liquid argon time projection chambers (LArTPCs), each of which holds 17 kt of liquid argon. The first far detector module (FD1) will employ Horizontal Drift (HD) technology, and the second module will have the Vertical Drift (VD) technology. The second module (FD2) will vertically drift the ionized electrons from the cathode plane suspended at the mid-height of the active volume of the cryostat, dividing it into two vertically separated volumes (each 6.5 m in height).

For the first time, photon detectors called x-ARAPUCAS will be installed in the cathode plane to increase the photon detection coverage. Because the cathode is biased with a high voltage (~300 kV) it is not possible to power the photon detectors with conventional copper cables. A new solution called Power-over-Fiber (PoF) has been proposed to power the photon detection system (PDS) based on optical power transmission over glass optical fibers. This PoF technology has not been applied before in a particle physics experiment operating at cryogenic temperatures. This poster will present preliminary results on the different PoF components, their QA/QC, and their installation to supply electrical power to the PDS of the ProtoDUNE Vertical Drift (Module-0) located on the cathode plane.

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Theoretical Challenges in Neutrino Physics

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Closure

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A Measurement of the Ambient Radon Rate and MeV-Scale Calorimetry in the MicroBooNE LArTPC

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Many physics goals of future large LAr detectors like DUNE hinge on the achievement of high radio-purity to minimize backgrounds to low-energy signals like supernova and solar neutrinos. Radon in particular is a concerning source of backgrounds, as its progeny generate diffuse signals from betas, gammas, and neutrons at the MeV-scale. In this talk, we report measured limits on the specific activity of Rn222 in the bulk LAr of the MicroBooNE neutrino detector at Fermilab during standard data-taking periods. This measurement, achieved with newly developed low-energy LArTPC reconstruction and analysis techniques, is the first of its kind for a noble element detector incorporating liquid-phase purification. We also demonstrate the calorimetric capabilities of single-phase LArTPC technology at the ~MeV and sub-MeV scale with reconstructed energy spectra of betas and alphas from tagged isotope decays.

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Fermilab's Science Priorities: A Vision for the Future

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Welcome to Users Meeting

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Welcome & Director's report

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Mu2e

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Muon g-2

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New Ideas in Muon Physics

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NuMI neutrino-Ar cross-section measurements @ ICARUS

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These days, experimental neutrino physics is going through a fascinating time due to the high-precision measurements, in huge detectors, expected from experiments to come, e.g. DUNE. At Fermilab, there is a Short-Baseline Neutrino program (SBN) searching for sterile neutrino signatures. This program consists of near and far detectors that use the LAr TPC technology, positioned along the axis of the Booster Neutrino Beam (BNB). ICARUS is the far detector of the SBN program and has a broader wealth of physics measurements, for example beyond standard model searches and

cross-section measurements. ICARUS, in particular, is situated off-axis of the NuMI beam and will be sensitive to a large amount of muon and electron neutrino interactions, from the order of a few hundred MeV to multi-GeV (an energy range close to the one we expect in DUNE). This poster will discuss aspects and goals of NuMI cross-section measurements with ICARUS and highlight some of the status and plans of the effort, for example, reconstruction, muon neutrino inclusive selection, and analysis.

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Physics Program at the CMS experiment

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Software and Computing at the CMS experiment

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CMS Detector Upgrades

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Future Colliders

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Signal Processing in SBND with WireCell

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The Short Baseline Near Detector (SBND), a 112 ton liquid argon time projection chamber (LArTPC), is the near detector of the Short Baseline Neutrino Program at Fermilab. In a LArTPC, ionization electrons from a charged particle track drift along the electric field lines, inducing bipolar signals on the induction planes, and a unipolar signal collected on the collection plane. In this talk, we present the techniques by which the final digitized waveforms, comprising of the original ionization signal convoluted with detector field response and electronics response as well as noise is filtered and processed to recover the original ionization signal. The implementation of a 2D deconvolution (in time and wire dimensions) is introduced as a natural complement to the inter-wire and intra-wire induction field ranges and contours inherent to LArTPC signals.

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Enhanced Slip-Stacking Techniques for Particle Accelerators: Analytical, Numerical, and Experimental Investigation

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Particle accelerators employ slip-stacking configurations to store two particle beams with disparate momenta within a single ring. Additionally, A novel slip-stacking configuration employing a harmonic RF cavity was proposed and studied. Anticipated benefits of the harmonic cavity include mitigating parametric resonances, minimizing emittance growth, and significantly expanding the stable longitudinal phase-space area. By surpassing the requirements of PIP-II operation, the harmonic RF cavity will support extending slip-stacking operation for subsequent beam power upgrades of Main Injector, including a proposed cycle rate improvement. Our ongoing research will verify the simulation of harmonic slip-stacking (HSS) operation under RF phase-errors, such as those causes by beam-loading effects.

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Mu2e stopping target monitor data flow

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The Mu2e experiment seeks to probe BSM physics through improving upon the limit for neutrinoless muon to electron conversion in a nuclear potential by four orders of magnitude. The current experimental limit of $R_{\mu e} < 7 \times 10^{-13}$ was set by SINDRUM II in 2006. The STM provides the normalisation of the experiment by measuring the rate of muon capture on Mu2e's aluminum target determined by counting the number of X-rays emitted using both high-purity germanium and lanthanum bromide detectors. To make efficient use of the Fermilab computing infrastructure and resources without compromising any physics results, the data collected has to be suppressed online and the peaks determined offline. This poster will provide an overview of the developments made in firmware, data acquisition, data flow control, and the vertical slice test plans for this summer.

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Differential Scanning Calorimeter Calibration and Measurement

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The differential scanning calorimeter (DSC) 404 F3 is a machine that heats up to 1500 degrees Celsius, and collects/evaluates thermal properties such as heat capacity, crystallization, glass transition, and

more. The first part of the project is based around calibrating the DSC 404 F3 using the given procedures and manuals. This ensures that the DSC 404 F3 is working properly and does not have any issues moving forward. After the calibration is complete, the second part is to start testing. There will be tests conducted on known metals, such as steel and aluminum, in which there is data to compare it to. If the data collected is not accurate compared to its known values, further troubleshooting will need to ensue to ensure that the following process does not give the wrong readings. Then, testing will begin for High Entropy Alloys(HEA) and the interesting issue with these is that there is no data to compare these to. The goal of finding the values of the HEA is to find a compatible alloy that we can use in future projects.

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URA Honorary Awards Ceremony

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URA Doctoral Thesis Award

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SpinQuest

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NuMI Hadron Monitor calibration stand

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The objective of the project is to develop a calibration stand for the NuMI Hadron Monitor. This monitor consists of a 5x5 grid of ionization chambers and is positioned downstream of the target system to detect charged particles that are extracted from the target. The monitor plays a crucial role in accurately aligning the target on the beamline. The calibration stand is made to calibrate the signal of individual grid of the brand-new hadron monitor by using a radioactive source. We will develop the motion control system which reads a position of the radioactive source with respect to the individual grid location from the position sensor and feedbacks to the motor driver to position the source to the desired location.

Computational Frontier / 57

Scientific Computing (CSAID)

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Artificial intelligence at Fermilab

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Quantum Science

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Microelectronics to enable the next-generation of HEP experiments

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”Freight Train” production model on the NOvA experiment and NOvA efforts at Argonne Leadership Computing Facility

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A large obstacle for any experiment is how to store, move, and process a large amount of data effectively. On the NuMI Off-axis ν_e Appearance (NOνA) experiment this is a rather substantial obstacle. The traditional method of grabbing a file is by categorizing all the files we care about by event-type and then going through each tape and gathering all files of that type. This is not ideal as it leads to multiple readings of the same tape. The Freight Train model of production at NOνA aims to address this inefficiency. Additionally, NOνA has implemented a scheme to run a pre-reconstruction filter (neural network-based) to remove the most obvious cosmic rays from our large recorded cosmic ray sample to reduce processing needs. This step is processed at the Argonne Leadership Computing Facility (ALCF), leveraging the additional GPU resources offered by the Theta GPU system.

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Exploring the Dark Sector in MicroBooNE Through e+e- Final States

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MicroBooNE is a neutrino experiment at Fermilab that ran from 2015 to 2020. It uses a liquid Argon time projection chamber (LArTPC) to detect neutrino events from a flux of predominantly muon neutrinos. In 2018, its predecessor MiniBooNE published results showing the detection of a significant excess of electromagnetic events in its data compared to expectation. The MiniBooNE anomaly defied traditional models of three-neutrino oscillations, and MicroBooNE was designed to explore various explanations. Some dark sector theories posit the production of e^+e^- pairs through a heavy neutrino intermediary. These would be indistinguishable from single electrons or photons in MiniBooNE if produced with sufficiently low opening angle. MicroBooNE has the potential to distinguish between such events because it spatially resolves the entire path of ionizing particles. This talk/poster describes two methods of calculating the opening angle of e^+e^- pairs: traditional line-fitting and a graph neural network based on PointNet++. By utilizing these methods, MicroBooNE has the potential to shed light on the nature of the dark sector and its influence on neutrino interactions.

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Physics of Neutrino Oscillations and Neutrino Cross Sections using the NOvA Experiment

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NOvA is a long-baseline accelerator-based neutrino experiment based in the US. NOvA uses an intense neutrino beam produced at Fermilab's accelerator complex to make physics measurements of neutrino oscillations, neutrino cross sections, and much more. For its physics goals, NOvA uses two functionally-identical detectors. The Near Detector (ND) is situated at Fermilab, 1 km from the neutrino target and the Far Detector (FD) is located at Ash River, MN, a distance of 810 km from the neutrino source. The ND receives a high statistics neutrino flux which gives a unique opportunity for high-precision neutrino cross-section measurements and is used as a control for the oscillation analyses. The FD is used to analyze the appearance and disappearance of the neutrinos arriving from the Fermilab. The purpose of the oscillation analysis is to understand the dominance of matter over antimatter in the universe, to resolve the ordering of neutrino masses, and to resolve the octant of the neutrino mixing angle theta23.

In this talk, I will give an overview of the NOvA experiment. I will also talk about the status of the NOvA's cross-section physics program and the latest results from the oscillation analyses. I will also talk about the future prospects of the experiment.

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High Yield Muon Catalyzed Fusion & Muonium

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Fusion holds great promise as a clean and abundant energy source. However, traditional thermonuclear fusion encounters significant challenges due to the extreme temperatures required to overcome the coulomb barrier for two nuclei to fuse. In contrast, muon-catalyzed fusion presents an alternative approach that can surmount this barrier at significantly lower temperatures. Muons, with properties resembling those of electrons but 200 times heavier, can effectively reduce the atomic orbital radius, enabling central nuclei to overcome the coulomb force through the strong force. By introducing muons into a mixture of deuterium and tritium (two hydrogen isotopes), fusion is facilitated, releasing a 3.5MeV alpha particle and a 14.1MeV neutron. In the majority of cases, the muon is liberated and can initiate further fusions. However, approximately 0.8% of the time, it adheres to the alpha particle and remains bound until it either decays or undergoes reactivation through collisional ionization. To maximize the number of fusions per muon, it is crucial to enhance the cycling rate and reactivation fraction. Theoretical predictions and experimental data both suggest that the sticking rate decreases with increasing density. However, there exists a discrepancy between experimental observations and theoretical estimations regarding the extent of this decrease. To address these disparities, this experiment aims to investigate the cycling rate and sticking fraction under higher temperatures and pressures than previously explored.

Additionally, search for Muonium ($M \equiv \mu+ \ e\ -$, chemically a light isotope of hydrogen) to Antimonium conversions, antimatter gravity and M atomic spectrum measurements are in need of a reliable high-efficiency source of Muonium.

Both experiments can be supported at the MeV Test Area (MTA) experimental hall using the secondary production beamline. This beamline uses the 400 MeV Fermilab proton Linac beam and a tungsten target. I will be contributing to data analysis as well as simulations for this experiment.

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MTA Removable Beam Absorber

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Once commissioned, the secondary production beamline in the MeV Test Area (MTA) will require a removable beam absorber for continuous beam operation. A 4" x 4" x 4" tungsten core will absorb the full 15 Hz 400 MeV Fermilab Linac primary proton beam. However, the residual activation will constrain work activities in the hall, so a 1' marble casing is proposed entombing the core. Marble has minimal residual activation. This presentation describes the initial concept and planned ANSYS analysis.

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Reconstruction study of the 2x2 near detector prototype

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The Deep Underground Neutrino Experiment (DUNE) will address open issues in neutrino physics such as the measurement of the CP-violating phase in neutrino oscillations and the neutrino mass ordering. The 2x2 demonstrator is a single-phase liquid argon time projection chamber (LArTPC), with four modules, operated as a prototype for the DUNE liquid argon near detector (ND-LAr). Based on the ArgonCube design concept, 2x2 features a novel pixelated charge readout and advanced high-coverage photon detection system.

Machine learning is being used to form a complete reconstruction pipeline of the events of the 2x2 using the ml-reco-3d package. This attempts to explore the accuracy and efficiency of the machine learning based reconstruction pipeline.

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Logistics of High Throughput Data Transfer in High Energy Physics

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High Energy physics analysis requires a large amount of data, which is increasing at an ever faster pace. Often this data is not stored at the computing resource where it is meant to be processed especially when there is a need for GPU's due to usage of machine learning, leading to a need for fast, robust and reliable methods of data transfer. Existing methods range from scp which has the advantage of being simple to configure and transfer, to GLOBUS which allows for optimization of system resources. This poster compares the various methods for various use cases.

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Compact Muon Solenoid Forward Pixel Upgrade

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High-Luminosity Large Hadron Collider (HL-LHC) upgrade aims to increase the performance. In order to efficiently handle the larger particle flux and increased radiation, an upgrade is planned for the Forward Pixel part of the inner Tracker of the Compact Muon Solenoid (CMS) detector, which is located at the innermost part of the CMS. To maintain efficiently reconstruct and track particles, the current pixel tracker will be improved with new sensors, readout chips, and front-end electronics to manage higher data rates. These improvements will allow the detector to track particles more precisely. In the United States, we are working on assembling new sensor modules, referred to as TFPX, for installation in the CMS detector for the HL-LHC era. We are currently testing prototype versions of TFPX modules to ensure the upgrade is carried out in the best way possible. The University of Ilinois Chicago has been tasked with testing the final versions of the TFPX sensor modules before they are sent to CERN to be installed into the CMS detector.

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Assembly Automation and Quality Control for Upgrades to the CMS Outer Tracker Modules

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Last summer I worked at the Silicon Detector facility at Fermilab on automation and quality control techniques for 2S and PS sensor modules that are going into CMS at CERN in order to prepare it for the high luminosity era of LHC. While there, I worked on a laser scanning procedure that ensured that 2S sensor modules were manufactured to the proper specifications, as well as an automated gluing process that will be used to accurately manufacture PS sensor modules. These processes will be used to ensure that all the sensors going into the CMS upgrade have been manufactured properly and can collect data accurately.

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Photon Detectors for the DUNE Vertical Drift Module-0

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The Deep Underground Neutrino Experiment (DUNE) will use an intense neutrino beam starting from Fermilab (Chicago) with a Near Detector to monitor the beam and a Far Detector installed in the Sanford Underground Research Facility (SURF - South Dakota), 1300 km away. The Near Detector complex at Fermilab will have three components, including Liquid Argon and high-pressure gas TPCs which can be moved off the beam axis and an on-axis detector with tracking and calorimetry to monitor the beam and measure the flux. Four 17 kt Liquid Argon Time Projection Chambers

(LArTPC) located in underground will compose the Far Detector, to measure and reconstruct neutrino interactions using charge and light signals from ionizing radiation. The first of the four LArTPC modules (Horizontal Drift) is being constructed internationally and will be assembled at SURF. The second module (Vertical Drift), in the design and validation stage, uses liquid argon as the active medium and will detect photons with the X-ARAPUCA detector concept. A full-scale prototype ("Module-0") has been constructed for testing at the CERN Neutrino Platform in the coming year. The concept, construction, and expected performance of the X-ARAPUCA detectors for Module-0 will be presented.

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Prospects for the Measurement of the Standard Model Higgs Production at the Muon Colliders

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We study the Higgs production process at a muon collider using b-pair decays of the Higgs bosons. Efficient identification and good measurement resolution for the b-jet pair invariant mass are crucial for unearthing the Higgs signal. However, the beam-induced background has potential to drastically degrade the performance. We report on the full simulation studies of the degradation of the reconstructed b-jet pair invariant mass, considering only the beam-induced background in the calorimeter. Mitigation strategies for the suppression of the beam-induced background are under-way. We also report prospects for the measurement of the Standard Model Higgs production at the Muon Colliders at various benchmarks of the collider center of mass energy and integrated luminosity using a fast simulation program.

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In-Network DAQ Functions

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A revolution in networking is changing how we compute, but we lack the tools that can channel this new capability to benefit science. It is now possible to write programs that operate "in" the network—on network cards (NICs) and network switches themselves, rather than on servers. These programs can analyze and reduce huge volumes of data as they flow through the network—at higher throughput, lower latency, and lower power consumption than if servers (containing CPUs or GPUs) were used. That equipment offers appealing features for scientific experiments that involve huge quantities of data.
This poster will describe a prototype of part of DUNE's data acquisition pipeline, which we built as part of ongoing research to better understand how to put programmable network hardware to use in large scientific experiments.

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History of Fermilab

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From Missing Particles to Missing Scientists: A Personal Perspective

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