# New Perspectives 2019

Monday 10 June 2019 - Tuesday 11 June 2019

Fermi National Accelerator Laboratory

# Book of Abstracts

# Contents

**Monday Afternoon I / 12**

## A Preliminary $\nu_\mu$ CC $0\pi$ Event Selection in SBND

**Author:** Rhiannon Jones[None]

SBND is a Liquid Argon Time Projection Chamber (LArTPC) experiment and the near detector in the Short Baseline Neutrino (SBN) program at Fermilab. With a 110 m baseline and a 112 tonne active mass, the detector will observe ˜5,000,000 charged current muon neutrino ($\nu_\mu$ CC) interactions at energies of <$E_\nu$> $\sim$ 650 MeV in its 6.6 $\times 10^{20}$ POT (3 year) exposure. SBND will constrain the systematics on the event rate for sterile neutrino searches in the SBN program and have a rich program of neutrino cross-section measurements.
The most abundant topology in SBND, pionless charged current muon neutrino ($\nu_\mu$ CC $0\pi$), is a key channel for oscillation searches due to its simple final-state: a single muon, possibly several nucleons and no meson. However, the well-understood charged current quasielastic (CC QE) interaction on free nuclei is not sufficient to correctly model the $\nu_\mu$ CC $0\pi$ final state in nuclear target experiments. This talk will demonstrate a preliminary $\nu_\mu$ CC $0\pi$ selection using automated reconstruction in SBND, in an effort to fully understand its properties in a LArTPC for the purpose of making cross-section and oscillation measurements.

**Monday Afternoon II / 19**

## ANNIE in 10 minutes: multiplicities, cross sections, and models (oh my!)

**Author:** Teal Pershing[None]

**Corresponding Author:** pershint@fnal.gov

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a gadolinium-doped water Cherenkov detector located in the Fermilab Booster Neutrino Beam line. Many long-baseline neutrino measurements rely on efficient reconstruction of charged-current quasi-elastic (CCQE) neutrino interactions, whose final-state particles include only the recoiling nucleus, a proton, and an outgoing lepton. One known indicator of an event's inelasticity is the presence of final-state neutrons, which are often challenging to detect. Understanding the expected number of neutrons following CCQE-like inelastic events is pivotal for identifying and rejecting such events from CCQE datasets. ANNIE is sensitive to final-state neutrons and will measure the neutron multiplicity of neutrino charged-current interactions. This neutron multiplicity measurement can also help constrain and refine models for atmospheric neutrino interactions, a dominant background in proton decay searches and supernova neutrino detection. Throughout operation, ANNIE will also measure the total muon neutrino charged-current cross section and perform exclusive cross-section measurements, with an emphasis on the CC0pi cross section. This talk will provide an overview of the ANNIE physics goals and event reconstruction chain that will be used to complete these measurements.

**Monday Afternoon II / 54**

## ANNIE: Phase II Detector Design and Construction

**Author:** Emrah Tiras[1]

[1] *Iowa State University*

**Corresponding Author:** etiras@fnal.gov

The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a gadolinium-loaded water Cherenkov detector located on the Booster Neutrino Beam at Fermilab. The experiment seeks to better understand neutrino-nucleus interactions by studying the number of final state neutrons produced in charged current interactions. It will be the first experiment testing Large Area Picosecond Photodetectors (LAPPDs), and the first application of gadolinium-loaded water in a neutrino beam. The ANNIE detector is currently undergoing an upgrade for its main physics measurement and a rigorous detector R&D work is ongoing alongside. This presentation will give an overview of the detector R&D studies and detector design and construction of the ANNIE Phase II.

**Tuesday Afternoon II / 57**

## BSM theory in 10 minutes

**Author:** Yang Gao[None]

**Corresponding Author:** yanggao@fnal.gov

Despite that the Standard Model has been put through many stringent tests, it still can not be the full picture of particle physics. In this short talk, we give an overview of the motivations to go beyond the Standard Model and discuss a few plausible scenarios in its extension.

**Tuesday Morning I / 67**

## CMS in 10 minutes

**Author:** Cristina Ana Mantilla Suarez[1]

[1] *Johns Hopkins University*

The LHC is the worlds highest energy proton-proton collider with a center-of-mass energy of 13 TeV. The world's largest machine is currently running at twice its designed luminosity and represents forefront of the energy frontier. The CMS detector is a multipurpose detector that features a 4 Tesla magnet and over a 100 million active channels taking data every 25 ns. It, along with its sister experiment ATLAS, is measuring the precise properties of the recently discovered Higgs boson, and leading the search for new and exciting physics: such as supersymmetry, dark matter, and extra dimensions. In this talk we give a quick overview of the detector and the methodology for physics searches and measurements.

**Monday Afternoon I / 34**

## Chimera Events in the MicroBooNE Experiment

**Author:** Polina Abratenko[None]

**Corresponding Author:** pabraten@fnal.gov

MicroBooNE is a short baseline neutrino oscillation experiment based at Fermilab that employs a Liquid Argon Time Projection Chamber (LArTPC) to investigate the excess of low energy events observed by MiniBooNE, study neutrino-argon cross-sections, and perform detector R&D for future LArTPC experiments. The MicroBooNE detector lies along the Booster Neutrino Beamline, which produces neutrinos with energies ranging from tens of MeV to 2 GeV. To study systematic uncertainties in MicroBooNE, the performance of algorithms used must be tested against event samples with known properties. Testing purely on Monte Carlo is limited by how well we understand the discrepancies between simulation and data. An alternative is to test against samples of "chimera" events, which consist of separate single-particle components from data that are combined to create neutrino-like events. This presentation will cover the ability and performance of finding and isolating tracks that match a target neutrino topology to create chimera events in MicroBooNE.

**Tuesday Afternoon II / 68**

## Closing

**Corresponding Author:** wallbank@fnal.gov

**Tuesday Morning II / 23**

## Cold Electronics Readout System for the ProtoDUNE-SP LAr-TPC

**Author:** Maura Spanu[1]

[1] *BNL*

**Corresponding Author:** maura.spanu@cern.ch

The Deep Underground Neutrino Experiment (DUNE) is an international long-baseline neutrino experiment. DUNE will consist of an intense neutrino beam produced at Fermi National Accelerator Laboratory in Batavia, Illinois. The far detector will comprise of four Liquid Argon Time Projection Chambers (LArTPC) holding in total around 40 ktons of fiducial mass and will be placed at the Sanford Underground Research Laboratory in South Dakota at 1300 kilometres downstream of the source.
The availability of two variants of the LArTPC technology, Single- and Dual-Phase, for the DUNE far detector, has led to an extensive prototype program development at the European Research Center (CERN) Neutrino Platform facility. The Single Phase (SP) TPC readout electronics are referred to as the "Cold Electronics (CE)" because they will operate in LAr, to minimize channel capacitance and noise by keeping the length of the connection between the anode wires and its corresponding electronics input to an absolute minimum. I will summarize the CE system and present preliminary results from cold electronics after the ProtoDUNE-SP beam run in late 2018.

**Monday Afternoon II / 7**

## Cosmogenic Background Suppression at the SBN Far Detector (ICARUS) with the Cosmic Ray Tagging System

**Author:** Christopher Hilgenberg[1]

[1] *Colorado State University*

**Corresponding Author:** chilge@rams.colostate.edu

As the SBN far-detector, the ICARUS T600, a set of liquid argon time-projection chambers (TPC), will operate at shallow depth and therefore be exposed to the full surface flux of cosmic rays. This poses a problematic background to the neutrino oscillation search, especially photons produced by muons passing in close proximity to, but not through, the active volume. A direct way to reject this background is to surround the cryostat with a detector capable of tagging incident cosmic muons with high efficiency (95%), the cosmic ray tagging system (CRT). I will present my work on a method

of separating background muons from neutrino interactions in the fiducial volume by a time-of-flight measurement between the CRT and the signal from scintillation light in the TPC.

**Tuesday Afternoon I / 30**

## Cross section model tuning and multiplicity studies in NOvA

**Author:** Maria Martinez-Casales[None]

NOvA is a long baseline neutrino experiment based at Fermilab that studies neutrino oscillation parameters via electron neutrino appearance and muon neutrino disappearance. The oscillation measurements compare the Far Detector data to an oscillated prediction which accounts for the Near Detector (ND) data and our understanding of neutrino interactions and cross-sections by using GENIE simulation. By tuning the cross section model to better represent neutrino scattering data from NOvA's ND and other experiments, we can extract oscillation parameters with a more accurate representation of cross section uncertainties. This tuning process is performed in the ND, before the oscillations occur. The effectiveness of the tuning will be discussed through studies of subsets of different multiplicities in the final state. Potential improvements to the cross section tune used for NOvA's 2018 joint neutrino and antineutrino analysis will also be discussed.

**Monday Morning I / 56**

## DES in 10 Minutes

**Author:** Nora Shipp[1]

[1] *University of Chicago, Fermilab*

The Dark Energy Survey (DES) is a deep, wide-area optical imaging survey in the southern hemisphere. The unprecedented photometry from DES has allowed for exciting science results on topics ranging from cosmology to our Galaxy. I will discuss details of the survey – which completed its 5.5-year observations in January 2019 – and highlight some recent science results from the collaboration.

**Tuesday Morning II / 3**

## DUNE in 10 Minutes

**Author:** Richard Diurba[None]

**Corresponding Author:** rdiurba@fnal.gov

A brief talk on the updates and technical details of DUNE in a concentrated format.

**Summary**:

A brief talk with updates on protoDUNE and DUNE giving a summary of the past year of work.

**Monday Morning II / 37**

## Design and analysis of a halo-measurement diagnostics

**Author:** Christopher Marshall[1]

**Co-authors:** Jinhao Ruan [2] ; Joseph Guebeli [3] ; Philippe Piot [4] ; Stephen Benson [3]

[1] *Northern Illinois University*

[2] *Fermilab*

[3] *Jefferson Lab*

[4] *Northern Illinois University & Fermilab*

**Corresponding Author:** z1855719@students.niu.edu

A large dynamical-range diagnostics (LDRD) design at Jefferson Lab will be used at the FAST-IOTA injector to measure the transverse distribution of halo associated with a high-charge electron beam. One important aspect of this work is to explore the halo distribution when the beam has significant angular momentum (i.e. is magnetized). The beam distribution is measured by recording radiation produced as the beam impinges a YAG:Ce screen. The optical radiation is split with a fraction directed to a charged-couple device (CCD) camera. The other part of the radiation is reflected by a digital micromirror device (DMD) that masks the core of the beam distribution. Combining the images recorded by the two cameras provides a measurement of the transverse distribution with over a large dynamical range. The design and analysis of the optical system will be discussed including optical simulation using SRW and the result of a mockup experiment to test the performances of the system will be presented.

**Tuesday Afternoon II / 29**

## Design and status of the Mu2e crystal calorimeter

**Authors:** Luca Morescalchi[1] ; Raffaella Donghia[2]

[1] *University of Pisa*

[2] *LNF-INFN*

The Mu2e experiment at Fermilab will search for the charged-lepton flavour violating neutrino-less conversion of a negative muon into an electron in the field of an aluminum nucleus.
The Mu2e detector is composed of a tracker and an electromagnetic
calorimeter and an external veto for cosmic rays.
The calorimeter plays an important role in providing excellent particle identification capabilities, a fast online trigger filter while aiding the track reconstruction capabilities.
The calorimeter requirements are to provide a large acceptance for ˜100 MeV electrons and reach:
1) a time resolution better than 0.5 ns @ 100 MeV;
2) an energy resolution O(10%) @ 100 MeV;
3) a position resolution of 1 cm.
The calorimeter consists of two disks, each one made of 674 pure CsI
crystals readout by two large area 2x3 array of UV-extended
SiPMs of 6x6 mmˆ2 dimensions.
A large scale prototype has also been constructed and tested at the beam test facility in Frascati. It consists of 51 pre-production crystals readout by a Mu2e SiPM.

**Summary**:

All the test and progresses done to define the calorimeter design, the satisfying results obtained with the test beam of the prototype as well as the actual production phase will be presented.

**Monday Morning I / 4**

## Development of a new imager testing projector using a micromirror array

**Author:** Brody Oleson[None]

**Corresponding Author:** boleson@fnal.gov

Charge Coupled Devices and MKIDs are pixelated imaging sensors used for astronomy. FNAL in involved in the development of instruments using these sensors. I will describe the development of a novel micro-mirror array projector for the characterization of these imaging sensors. The CCD require tight control of the light intensity and the exposure time, and the micromirror array allow to also control the illumination pattern at the level of 100 um. I will describe the design of a 3D printed dark box with an automated shutter, and a focusing system to house the projector. The final device will allow new ways for the characterization of the scientific imagers.

**Monday Morning II / 9**

## E1039/SpinQuest Polarized Drell-Yan Experiment at Fermilab

**Author:** Chun-Min Jen[1]

**Co-authors:** Edward Kinney [2] ; Kenichi Nakano [3] ; Lamiaa El Fassi [4] ; Richard Tesarek [5]

[1] *Los Alamos National Lab*

[2] *University of Colorado Boulder*

[3] *Tokyo Tech*

[4] *Mississippi State University*

[5] *Fermi National Accelerator Laboratory*

E1039/SpinQuest is the first transversally-polarized Drell-Yan experiment at Fermilab. SpinQuest data-taking is anticipated to begin this coming fall 2019. In SpinQuest, a transversely-polarized NH3 or ND3 target is employed with the unpolarized 120-GeV extracted proton beam from Fermilab Main Injector to obtain various measurements of transverse single spin asymmetries in J/psi, psi', lambda, di-muon (Drell-Yan) productions without the need to account for final-state fragmentation effects. These measurements shed light on virtual-quark and gluon Sivers functions, and are sensitive to the contribution of virtual quark orbital angular momentum to the nucleon spin, as well as multi-gluon correlation dynamics, respectively.

During the entire beam-off/-on commissioning periods, my primary focus is to bring up our multi-wire proportional chambers, along with tightly related chamber readout electronics and data acquisition system to our final-state detections, ready for the data-taking late this year. E1039 comprises three stations of multi-wire proportional chambers plus one station of proportional tubes. The former is in use of track reconstruction and the determination of track kinematics, while the later is specifically designed for the final-state muon identification. During the no-beam commissioning, we re-organized the chamber gas supply system, inspect/repair chamber wires at Lab 6, set up stand-alone chamber readout electronics test bench at NM4/KTeV experimental hall and turn on high voltages to evaluation the performance of chambers from all stations.

**Monday Afternoon II / 14**

## Elastic neutrino-electron scattering within the effective field theory approach

**Author:** Oleksandr Tomalak[None]

**Co-author:** Richard Hill

**Corresponding Author:** tomalaksasha@gmail.com

Elastic neutrino-electron scattering provides an important tool for normalizing neutrino flux in modern experiments. This process is subject to large radiative corrections. We determine the Fermi effective theory performing the one-loop matching to the Standard model at the electroweak scale with subsequent running down to GeV scale. Based on this theory, we analytically evaluate virtual corrections and distributions with one radiated photon beyond the electron energy spectrum. We discuss the relevance of radiative corrections depending on conditions of modern accelerator-based neutrino experiments.

**Tuesday Afternoon I / 64**

## FSPA report

**Corresponding Author:** djena@fnal.gov

**Monday Afternoon II / 13**

## FerMINI: Fermilab Search for Minicharged Particles

**Author:** Yu-Dai Tsai[1]

[1] *Fermilab*

**Corresponding Author:** ytsai@fnal.gov

We propose a low-cost and movable setup to probe minicharged particles (or milli-charged particles) using high-intensity proton fixed-target facilities. This proposal, FerMINI, consists of a milliQan-type detector, requiring multi-coincident (nominally, triple-coincident) scintillation signatures within a small time window, located downstream of the proton target of a neutrino experiment. During the collisions of a large number of protons on the target, intense minicharged particle beams may be produced via meson photo-decays and Drell-Yan production. We take advantage of the high statistics, shielding, and potential neutrino-detector-related background reduction to search for minicharged particles in two potential sites: the MINOS near detector hall and the proposed DUNE near detector hall, both at Fermilab. We also explore several alternative designs, including the modifications of the nominal detector to increase signal yield, and combining this detector technology with existing and planned neutrino detectors to better search for minicharged particles. The CERN SPS beam and associated experimental structure also provide a similar alternative. FerMINI can achieve unprecedented sensitivity for minicharged particles in the MeV to few GeV regime with fractional charge ε=Qχ/e between 10−4 (potentially saturating the detector limitation) and 10−1.
This talk is mainly based on arxiv:1812.03998
If time allowed, I will also talk about new physics cases studied in arXiv:1806.03310, arXiv:1812.08768, arXiv:1803.03262, and arXiv:1706.00424

**Monday Morning II / 20**

## High Luminosity Spin-Polarized Target for the SpinQuest Experiment

**Author:** Joshua Hoskins[None]

**Corresponding Author:** jhoskins@fnal.gov

The SpinQuest collaboration will measure the sea quark Sivers asymmetry using Drell-Yan production from the 120 GeV proton beam of the Fermilab Main Injector incident on transversely polarized proton and deuteron targets. Measuring a nonzero Sivers asymmetry would provide strong evidence for nonzero orbital angular momentum of sea quarks. The use of both polarized hydrogen and deuterium targets will provide an independent extraction of the $\overline{u}$ and $\overline{d}$ contributions in the range of $0.1 < x < 0.5$. In order to provide high figure-of-merit measurements of the sea quark Sivers functions, high luminosity, transversely polarized targets are required. The polarized target system constructed by UVA-LANL consists of a 5T, split-coil, superconducting magnet and uses a 140 GHz microwave source to provide highly polarized protons and deuterons via dynamic nuclear polarization (DNP). The expected average target polarization for SpinQuest is 80\% and 32\% for the hydrogen and deuterium targets, respectively. A brief overview of the SpinQuest experiment and a survey of the high luminosity polarized target will be presented.

**Monday Morning I / 26**

# Improving the spatial resolution of the ATLAS IBL silicon pixel detectors

**Author:** Spoorthi Nagasamudram[None]

**Co-authors:** Jessica Metcalfe ; Vallary Bhopatkar

**Corresponding Author:** snagasam@fnal.gov

This project was realized primarily to test and improve the spatial tracking resolution of the ANL (Argonne National Laboratory) telescope consisting of the ATLAS IBL silicon pixel sensors and FE-I4 chips by making use of the test beam at Fermilab. In this paper, we will discuss the overall performance of the modules and how it can be improved. We will also discuss efforts made to improve the spatial resolution of the modules. In addition, we will also talk about successful attempts to simulate the spatial resolution of the modules using Allpix$^2$.

**Monday Afternoon II / 60**

# LArIAT in 10 minutes

**Author:** Vincent Basque[1]

[1] *University of Manchester*

**Corresponding Author:** vbasque@fnal.gov

Liquid Argon Time Projection Chambers (LArTPCs) are currently being used extensively for neutrino physics due to their excellent capabilities in performing particle identification, and precise 3D and calorimetric energy reconstruction. The Liquid Argon In A Test Beam (LArIAT) experiment was located at the Test Beam Facility where it was exposed to a known charged particle beam. The capability of understanding and knowing the charged particle beam is a crucial aspect of LArIAT that allows it to improve on LArTPCs advantages to perform state of the art analyses. This made LArIAT an excellent test-bed to perform cross-section measurements with different charged particles as well as performing R&D studies for future large LArTPCs such as the Short-Baseline Near Detector (SBND) and the Deep Underground Neutrino Experiment (DUNE). This talk will give an overview of the LArIAT detector as well as provide a highlight of recent results from on-going analyses.

**Tuesday Morning I / 24**

# Lattice QCD in 10 Minutes

**Author:** William Jay[None]

**Corresponding Author:** wjay@fnal.gov

In this talk I summarize the current status of the field in lattice QCD. My goal will be to provide an accessible overview. I will emphasize work done at Fermilab and work affecting Fermilab experiments.

**Tuesday Morning I / 28**

## Layout and performance of GE1/1 chambers for the CMS muon spectrometer upgrade

**Author:** Aashaq Shah[1]

**Co-author:** Ashok Kumar [1]

[1] *University of Delhi*

**Corresponding Author:** ashah@fnal.gov

The CMS Muon group has proposed the use of Gas Electron Multiplier (GEM) technology to maintain an efficient and reliable operation during the High Luminosity phase of the LHC (HL-LHC). This is particularly important to study many physics processes with muons in the final state. The CMS GEM chambers will cover eta region 1.6 to 2.2 of the endcap. We report on the GE1/1 layout and their performance studies estimated during the R&D and beam tests at CERN. We also provide the current status of GE1/1 project and future GEM upgrade plans.

**Summary**:

Current status, future upgrade plans, and the R&D results of CMS GE1/1 prototype chambers will be summarised.

**Monday Afternoon II / 8**

## MINERvA in 10 minutes

**Author:** Barbara Yaeggy[1]

[1] *Universidad Tecnica Federico Sta. Maria*

**Corresponding Author:** byaeggy@gmail.com

Based in the NuMI beamline at Fermi National Laboratory, the on-axis MINERvA experiment is focused on reaching precision measurements of neutrino and antineutrino interactions in diverse nuclei materials for energies up to 50 GeV. The results support the current and future oscillation experiments as well as to provide information about the structure of nuclei. A look at the latest results from the MINERvA experiment and those who will come will be presented.

**Monday Morning I / 47**

## Machine learning dark matter halo formation

**Author:** Luisa Lucie-Smith[1]

[1] *University College London*

Dark matter halos are the fundamental building blocks of cosmic large-scale structure. Improving our theoretical understanding of their structure, evolution and formation is an essential step towards understanding how galaxies form, which in turn will allow us to fully exploit the large amount of data from future galaxy surveys. I will present a machine learning approach which aims to provide new physical insights into the physics driving halo formation. We train a machine learning algorithm to learn cosmological structure formation directly from N-body simulation. The algorithm infers the relationship between the initial conditions and the final dark matter halos, based on inputs describing different properties of the local environment surrounding the dark matter particles in the initial conditions. I will demonstrate that one can infer which aspects of the early-Universe density field impact the formation of the final dark matter halos by evaluating the predictive performance of the algorithm when provided with different types of information.

**Tuesday Morning II / 48**

## Michel electron reconstruction in ProtoDUNE

**Author:** Aleena Rafique[1]

[1] *Argonne National Laboratory*

**Corresponding Author:** aleena@anl.gov

The Deep Underground Neutrino Experiment (DUNE) is a leading-edge experiment for neutrino science and proton decay studies. The single-phase liquid argon prototype detector at CERN is a crucial milestone for the DUNE that will inform the construction and operation of the far detector modules. In this talk, I will present the current status of reconstructing Michel electrons from cosmic-ray muons in the ProtoDUNE detector. These Michel electrons are distributed uniformly inside the detector and serve as a natural and powerful sample to study the detector's response for low-energy (tens of MeV) interactions as a function of position. We have developed a selection tool to identify such Michel electrons which could benefit any LArTPC experiment generically.

**Monday Afternoon I / 55**

## MicroBooNE in 10 Minutes

**Author:** Katrina Miller[1]

[1] *University of Chicago*

MicroBooNE is one of three liquid argon time projection chambers (LArTPCs) making up the Short-Baseline Neutrino Program at FNAL. Located on the Booster Neutrino Beamline, MicroBooNE has been collecting data since October 2015 to determine the source of the low-energy electromagnetic event excess previously reported by MiniBooNE and LSND. In addition to its signature analysis, MicroBooNE is employed in studying various forms of neutrino interactions in liquid argon, measuring low-energy neutrino cross sections, and developing technological advancements for future LArTPC experiments such as DUNE. This talk will summarize the current status of MicroBooNE's physics program, highlight exciting new results, and provide an outlook of future experimental efforts.

**Tuesday Afternoon II / 25**

## Mu2e in 10 minutes

**Author:** Yujing Sun[None]

**Corresponding Author:** ysun@fnal.gov

The discovery of neutrino oscillation manifests the violation of lepton number conservation. It further indicates Charged Lepton Flavor Violation (CLFV) is not explicitly forbidden in the Standard Model (SM), although it is dynamically suppressed which remain unobserved. Many well-motivated physics models predict rates for CLFV processes that are within a few orders of magnitude of the current experimental bounds, such as the MSSM with right-handed neutrinos, SUSY with R-parity violation as well as models with leptoquarks, new gauge bosons, large extra-dimensions, and a non-minimal Higgs sector. The Mu2e experiment at Fermilab will be 10,000 times more sensitive than previous experiments looking for muon-to-electron conversion with a single-event sensitivity of a few 10-17 for the ratio of μ− N → e− N conversions to conventional muon capture. Mu2e experiment has real discovery potential over a wide range of New Physics models and may prove to be a powerful discriminant among models.

**Tuesday Afternoon II / 40**

## Muon g-2 in 10 minutes

**Author:** Jason Hempstead[1]

[1] *University of Washington*

The Muon $g-2$ Experiment (E989) is measuring the magnetic anomaly, $a_\mu$, of the muon to 140 parts per billion (ppb) to resolve the outstanding discrepancy between the value predicted by the Standard Model and the best measurement to date. The magnetic anomaly receives contributions from loops of any particle type in the muon-photon vertex, so a discrepancy between theory and experiment is a strong indication of physics beyond the Standard Model. Determining $a_\mu$ involves storing muons in a well-known and highly uniform magnetic field and measuring their anomalous precession frequency, $\omega_a$—the rate at which their spins rotate relative to their momenta. Segmented electromagnetic calorimeters measure the hit times and energies of decay positrons to probe $\omega_a$. NMR probes measure and track the $1.45$ T magnetic field in terms of the Larmor precession frequency of a free proton, $\omega_p$. Pulsed magnetic kickers allow proper injection onto the $7.1$ m radius storage orbit, and pulsed electrostatic quadrupoles provide vertical focusing of the muon beam. Following explanation of the motivation and experimental technique of Muon $g-2$, some snippets of the data taken in Run 1 and Run 2 will be shown.

**Tuesday Afternoon I / 61**

## NOvA in 10 minutes

**Author:** Miranda Elkins[1]

[1] *Iowa State University*

The long-baseline neutrino oscillation experiment named NOvA is comprised of two detectors utilizing liquid scintillator tracking calorimeters. Both are positioned 14 mrad off-axis with respect to the NuMI beam with the near detector being at Fermilab. The far detector, at 14 kton, can be found approximately 810 km away in Ash River, Minnesota. The main physics goals of NOvA include, but are not limited to, the measurement of muon neutrino disappearance and electron neutrino appearance. This measurement will help resolve the mass hierarchy problem as well as put constraints on

θ23, the large mixing angle and its octant,
and the CP violating phase. The goal of this talk is to give a general description of the NOvA experiment and present the progress made on these physics goals thus far.

**Tuesday Afternoon I / 53**

## NOvA's far detector predictions and understanding key systematic uncertainties.

**Author:** Ashley Back[1]

[1] *Iowa State University*

NOvA continues as one of the leading long-baseline neutrino experiments, thanks to Fermilab's powerful 700 kW NuMI beam, which provides NOvA with a beam of predominantly muon neutrinos or antineutrinos. NOvA studies neutrino oscillations using two detectors, both constructed from plastic extrusions filled with liquid scintillator, placed 810 km apart and both slightly off-axis from the beam center. A key part of NOvA's approach is that we sample the NuMI beam with a near detector close to the target. This allows us to build an accurate far detector prediction and, since the detectors are functionally identical, largely cancel key flux and cross-section systematic uncertainties. The three-flavour long-baseline search probes undetermined physics parameters that describe neutrino mixing matrix, such as the mass hierarchy, CP violation in the lepton sector and the octant of $\theta_{23}$. Although statistical uncertainties dominate in our current results, understanding key sources of systematic uncertainty and their correlations is crucial in a joint fit to selected $\nu_\mu$ disappearance and $\nu_e$ appearance events, in both neutrino and antineutrino beam modes. In this talk, I will describe how we build up an accurate prediction at the far detector, using near detector data, and how we seek to understand key sources of systematic uncertainty by studying systematically shifted far detector predictions.

**Tuesday Afternoon I / 35**

## NOvA's approaches on estimation of wrong sign contamination

**Author:** abhilash dombara[1]

[1] *syracuse university*

NOvA is a long-baseline neutrino experiment with two functionally identical liquid scintillator detectors 809 km apart, off-axis from the NuMI beam. The main goal of this experiment is to determine the mass hierarchy and precise measurement of several neutrino oscillation parameters. To measure these parameters precisely we need to have a correct estimate of the neutrino and antineutrino composition in our beam. There are two modes of beam operation, Forward Horn Current (FHC) which is mostly neutrinos and Reverse Horn Current (RHC) which is mostly antineutrinos. The RHC beam has comparatively higher contamination from neutrinos. In NOvA we use several techniques to identify neutrinos and antineutrinos and employ various data-driven methods to estimate this contamination. A summary of our approaches to determine wrong sign contamination in RHC will be presented.

**Tuesday Afternoon I / 46**

## Neutrino Event Classification with Deep Learning in NOvA

**Author:** Grant Nikseresht[None]

**Corresponding Author:** gniksere@fnal.gov

Deep learning has aided the NOvA experiment in selection of NuMI beam neutrino events. Low statistics makes enhancements in signal efficiency especially critical to the success of the NOvA analysis. Use of convolutional neural networks (CNNs) for event and particle identification has led to significant gains in signal efficiency for neutrino event selection while also reducing the complexity of the reconstruction chain. Convolutional Visual Network (CVN) was introduced in 2016 as the class of methods and CNN architectures used for solving image recognition tasks in NOvA. Initial adoption of CNNs increased effective exposure by 30%, while optimizing training sample composition led to a 14% improvement in efficiency. Despite these advances, numerous avenues remain that show potential to increase signal efficiency. Recent efforts to improve the performance of CVN are summarized in this talk. Among these efforts, residual learning has shown the most promise for enhancing the purity and efficiency of neutrino event selection in the NOvA far detector. Large-scale hyperparameter optimization of existing CVN models is another tool for improving classifier performance despite presenting new computational challenges. Models are trained and evaluated using Monte Carlo samples of the NOvA Far Detector and results and insight from experiments with residual learning and hyperparameter optimization are shown.

**Monday Afternoon I / 21**

## Neutrino Theory in 10 Minutes

**Author:** Kevin Kelly[None]

**Corresponding Author:** kkelly12@fnal.gov

I will discuss the current state of neutrino theory work, specifically focusing on how we interface with interpretations of current experiments and predictions for upcoming experiments. I will discuss ideas that Fermilab theorists are currently exploring regarding the experimental neutrino program at Fermilab, from the SBN experiments to DUNE.

**Tuesday Afternoon I / 38**

## NuMi Beam Muon Monitor Simulation for Neutrio Beam Quality Improvement

**Author:** Yiding Yu[None]

**Co-authors:** Don Wickremasinghe ; Katsuya Yonehara [1] ; Pavel Snopok [2]

[1] *Fermilab*

[2] *IIT/Fermilab*

**Corresponding Author:** yyu@fnal.gov

Muon monitors are a very important diagnostic tool for the NOvA experiment at Fermilab. With the MINOS experiment decommissioned, MM are the only detectors to indicate and help mitigate the issues with the NuMI beam. The goal of our study is to maintain the quality of the MM signal and to establish the neutrino beam profile and MM signal correlations. This study could also inform the LBNF decision on the beam diagnostic tools. We report here on the progress of beam scan

data analysis (beam position, spot size, and magnetic horn current scan) and comparison with the simulation outcomes.

**Tuesday Morning II / 50**

## Overcoming Neutrino Interaction Mis-modeling with DUNE-PRISM

**Author:** Luke Pickering[1]

[1] *Michigan State University*

**Corresponding Author:** picker24@msu.edu

The expected precision of current long-baseline neutrino oscillation experiments (T2K, NO$\nu$A) will be limited by uncertainties in neutrino interaction models in addition to sample statistics. The interaction uncertainties will also play a significant role in next-generation experiments (DUNE, Hyper-K), which aim to collect much larger samples of oscillated neutrinos. Without significant advancements in neutrino-nucleus interaction modeling, traditional analyses will be susceptible to biased oscillation measurements.

The DUNE-PRISM (Precision Reaction Independent Spectrum Measurement) technique offers a complementary approach to the oscillation analysis methods used by T2K, NO$\nu$A, and MINOS. DUNE-PRISM uses direct extrapolation of near detector data to infer oscillation probabilities with significantly less dependence on the validity of neutrino interaction models. This is achieved by combining multiple near detector measurements, each taken with the detector at a different off beam axis position, in order to sample a variety of neutrino energy spectra.

This talk will introduce DUNE-PRISM and show how the oscillation parameters extracted using this technique are robust to unknown interaction modeling errors.

**Monday Afternoon I / 16**

## Overview of the Cold Electronics of SBND

**Author:** Ryan Lazur[None]

**Corresponding Author:** rlazur@fnal.gov

The Short-Baseline Near Detector (SBND) will be one of three liquid argon neutrino detectors sitting in the Booster Neutrino Beam (BNB) at Fermilab as part of the Short-Baseline Neutrino (SBN) Program. SBND is a 112-ton active mass liquid argon time projection chamber (LArTPC) to be located only 110 m from the BNB neutrino source. An important aspect of LArTPC detector design is that the readout and digitization electronics are placed in the liquid argon, directly on the anode planes, because digitizing the signal locally reduces both signal noise and impurities in the liquid argon by reducing the distance that analog signals must be transported and the number of cables and cryostat penetrations that are required to transport signals out of the detector. SBND's "cold electronics" consist of custom ASICs for signal amplification and shaping, commercial ADCs for digitization, and commercial FPGAs for data handling. I will present the SBND front-end electronics system design, show results of system and component performance tests, and describe the status of SBND front-end electronics production and installation.

**Tuesday Morning I / 32**

## Perturbative QCD in 10 Minutes

**Author:** Joshua Isaacson[None]

**Corresponding Author:** isaacson@fnal.gov

A brief overview of perturbative QCD and its role in precision measurements at the LHC. There will be a focus on efforts that are being done here at Fermilab. Here at Fermilab, the QCD group focuses on three distinct topics. Therefore, the talk will focus on the importance of improving precision for measurements at the LHC, through the use of higher order corrections, analytic resummation, and parton showers. Additionally, there will be some brief overview of parton distribution functions.

The talk will show the current comparison between theory and data at the LHC, and the work that is required to help drive the theoretical uncertainty down in order to improve the systematic uncertainties of the LHC. This comparison will include comparison to total cross sections and differential distributions. In addition, I will address the difficulties and importance of the $W$ mass measurement and the top mass measurement.

Finally, I will discuss the importance of improving our understanding of perturbative QCD in order to reduce the background uncertainty in BSM physics searches at the LHC.

**Tuesday Afternoon II / 49**

## Pileup Systematic Studies in the Fermilab Muon g-2 Experiment

**Author:** Meghna Bhattacharya[1]

**Co-author:** Sudeshna Ganguly [2]

[1] *University of Mississippi*

[2] *University Of Illinois At Urbana Champaign*

The Muon g-2 experiment at Fermilab (E989) aims to measure the anomalous magnetic moment of the muon, $a_\mu$, to a precision of $140$ ppb, a four-fold increase in precision over the previous experiment at Brookhaven National Laboratory (BNL). The value of $a_\mu$ from BNL currently differs from the Standard Model prediction by $\sim 3.5$ standard deviations or higher, suggesting the potential for new physics and therefore, motivating a new experiment.
The Fermilab experiment follows the measurement principles of the BNL experiment, injecting a beam of positive muons into a storage ring, which focuses the beam with a combination of magnetic and electric fields. The muon anomaly relies on the measurement of the spin precession frequency $\omega_a$ about the muon momentum. This presentation will focus on one of the most important sources of systematics to the $\omega_a$ analysis: pileup effects. Pileup refers to the overlap of decays in the detector that originate from separate muon decays, too close to each other in time and space to be resolved into individual pulses.
A complete description of how pileup events are identified will be presented along with a discussion of how the correction to a traditional $\omega_a$ analysis is formulated and applied

**Monday Morning II / 27**

## Plasma processing for LCLS-II 1.3GHz SRF cavities

**Author:** Bianca Giaccone[None]

**Co-authors:** Martina Martinello [1] ; Paolo Berrutti [1]

[1] *Fermilab*

**Corresponding Author:** giaccone@fnal.gov

This study is focused on the development of an in-situ plasma cleaning procedure for 1.3GHz 9-cell TESLA shaped SRF cavities. The goal of this technique is to reduce field emission through the removal of adsorbed hydrocarbons that lower the work function of the cavity surface.
In this work I present the first results of plasma processing applied to LCLS-II cavities focusing on plasma ignition and studies of quality factor vs accelerating field measured before and after plasma processing.

**Monday Afternoon I / 1**

## Progress towards the extraction of exclusive ν μ - 40 Ar cross sections with a single proton using the MicroBooNE LArTPC detector

**Author:** Afroditi Papadopoulou[1]

[1] *Graduate Student MIT*

**Corresponding Author:** apapadop@mit.edu

Next generation neutrino oscillation experiments aim towards high-precision extraction of oscillation parameters, which in turn requires an unprecedented understanding of neutrino-nucleus interactions. Neutrino processes producing a charged lepton and a single intact nucleon in the final state can offer an important window into the dynamics of neutrino interactions with direct importance for accelerator–based oscillation measurements. MicroBooNE is the first liquid argon time projection chamber (LArTPC) commissioned as part of the Short Baseline Neutrino (SBN) program at Fermilab and its excellent particle reconstruction capabilities allow detailed study of neutrino interactions. This poster will present the latest progress towards the first measurement of the total and differential cross–sections for exclusive ν μ - 40 Ar interactions with a single proton final state using data from the MicroBooNE LArTPC detector.

**Tuesday Morning I / 52**

## Reconstructing proton-proton collision positions at the Large Hadron Collider with a D-Wave quantum computer

**Author:** Andrew Wildridge[None]

**Co-authors:** Sachin Vaidya [1] ; Souvik Das

[1] *Purdue University*

**Corresponding Author:** anwildri@fnal.gov

Clustering of charged particle tracks along the beam axis is the first step in reconstructing the positions of proton-proton (p-p) collisions at Large Hadron Collider (LHC) experiments. In this talk, we formulate this problem for a 2048 qubit D-Wave quantum computer that works by quantum annealing. We show the performance of the quantum annealer on artificial events generated from p-p collision and track distributions measured by the Compact Muon Solenoid experiment at the LHC. The quantum clustering algorithm is found to be limited by the connectivity of the qubits and the overall efficiency of the algorithm in addressing event topologies with more than 5 collisions. We identify three obstacles to reaching current LHC event complexities and outline research directions we are embarking on to overcome each.

**Summary**:

The talk will open with a succinct description of the problem of reconstructing proton-proton collision positions, also known as primary vertexing, at LHC experiments. We will then introduce the D-Wave quantum computer and the form that problems need to take for it. While the track clustering necessary for primary vertexing is done at CMS on a classical computer using deterministic annealing, we will show a natural mapping for the problem to quantum annealing. We will then demonstrate how the D-Wave processor arrives at solutions for a simple 2 p-p collision event, and how to interpret the solutions. The solution finding efficiency as a function of increasing event complexities will be shown. Finally, we will identify three obstacles to reaching current LHC event complexities and outline research directions we are embarking on to overcome each.

**Monday Afternoon I / 44**

## SBND in 10 minutes

**Author:** Iker de Icaza Astiz[1]

[1] *University of Sussex*

**Corresponding Author:** icaza@fnal.gov

The Short-Baseline Near Detector (SBND) will be a 112 ton liquid argon time projection chamber devoted to researching neutrino oscillations. Located 110 m downstream from the Booster Neutrino Beam (BNB) target, SBND will be the near detector of the three-detector Short Baseline Neutrino (SBN) program at Fermilab. The SBN program will probe neutrino oscillations at the $\sim 1\text{eV}^2$ scale, addressing tensions pointing to the possible existence of sterile neutrinos. SBND will see the un-oscillated content of the BNB and as such its role is to constraint uncertainties in the oscillation analysis. Due to its size and proximity to the neutrino beam source, SBND will have a rich cross-section measurement program where just a few months of data will yield a record number of $\nu-\text{Ar}$ interactions. It is also a testbed for R&D of new technology for DUNE. I will summarize the physics program of SBND and the current status of its construction.

**Tuesday Morning I / 59**

## Scintillator Tiles for the High Granularity Calorimeter of the CMS Detector at the HL-LHC

**Author:** Ramanpreet Singh[None]

**Corresponding Author:** rsingh@fnal.gov

The CMS Phase II upgrade, High Granularity Calorimeter (HGCal) will have fine transverse and longitudinal segmentation to allow for superior particle identification and pileup rejection in the high radiation and large event pileup environment of the endcap region. A significant portion of the hadronic portion of the HGCal will be instrumented with scintillator tiles directly coupled to Silicon Photomultiplers. We report on the proposed design and R&D associated with tile fabrication, characterization and assembly for this detector.

**Tuesday Morning II / 43**

## Search for Supersymmetry at CMS in Events with Large Jet Multiplicity and Low Missing Transverse Momentum at sqrt(s)=13

# TeV

**Author:** Christopher Madrid[None]

**Co-authors:** Aron Soha [1] ; James Hirschauer [2] ; Kelvin Mei ; Nadja Strobbe [1] ; Owen Long [3]

[1] *Fermilab*

[2] *Fermi National Accelerator Laboratory*

[3] *UCR*

**Corresponding Author:** cmadrid@fnal.gov

In traditional searches for physics beyond the standard model, a requirement of high missing transverse momentum (MET) is often used. However, without any signs of significant deviations from the standard model expectations, we decided to relax this requirement for the search reported in this talk. Many new physics models, including versions of supersymmetry (SUSY) characterized by R-parity violation, compressed mass spectra, long decay chains, or with additional hidden sectors predict the production of events with low MET, many jets, and top quarks. The results of a general search for new physics featuring two top quarks and six additional light flavor jets are reported. The search is performed using events with at least seven jets and exactly one electron or muon. No requirement on MET is imposed. With the use of a neural-network-based signal-to-background discriminator, a background estimation was achieved where more traditional techniques was not an option. The study is based on a sample of proton-proton collisions at sqrt(s) = 13 TeV corresponding to 77.4 fb-1 of integrated luminosity collected with the CMS detector at the LHC in 2016 and 2017. Results of the search are interpreted for pair production of scalar top quarks in the frameworks of stealth SUSY and SUSY with R-parity violation.

**Tuesday Morning II / 58**

# Search for dark photons with CMS and fixed-target experiments

**Authors:** Andre Sterenberg Frankenthal[1] ; Yangyang Cheng[1]

[1] *Cornell University*

**Corresponding Author:** as2872@cornell.edu

Searches for dark matter in the past two decades have largely focused on Weakly Interacting Massive Particles (WIMPs). But what if instead of just one type of dark matter particle, there exists a richer dark sector hidden from ordinary view? This opens up a whole new paradigm for dark matter searches, allowing us to focus not only on the coupling between dark matter and the Standard Model, but also on the interactions between dark sector constituents themselves. In this talk, I describe two complementary approaches to this new kind of dark matter program: (1) PADME, a fixed-target, missing-mass experiment seeking evidence for the dark photon, a hypothetical mediator of a new U(1) gauge symmetry in the dark sector; and (2) a search for inelastic dark matter (iDM) with a unique signature in the CMS detector, using dark photons as DM-SM mediators. The complementarity of these two methods is explored, both in terms of accessible parameter space and experimental challenges.

**Summary**:

I describe two ongoing searches for rich dark sector physics relying on complementary experimental approaches: a search for inelastic dark matter (iDM) with the CMS detector and the LHC collider; and PADME, a fixed-target, missing-mass experiment to search for direct evidence of dark photons.

**Tuesday Morning II / 11**

## Searching for Dark Matter with Semi-Visible Jets at CMS

**Author:** Colin Fallon[None]

**Corresponding Author:** cfallon@fnal.gov

Most theories that predict dark matter production at colliders rely on weakly coupled dark matter and the existence of WIMPs, or weakly interacting massive particles; however, there can be dark matter signatures in colliders that emerge from strongly coupled dark matter. These signatures are varied, ranging from emerging jets to Stealth Dark Matter. Another possible signature is semi-visible jets. These occur if the dark sector is comprised of a strong-like structure with dark hadrons made up of dark quarks. Once produced, a heavy dark quark would then hadronize into stable dark "pions", which leave the detector as dark matter, and unstable dark hadrons that shower and appear as SM hadronic showers. Since the true jet is made up of visible SM quarks and missing transverse energy closely aligned with the shower, the jet is called semi-visible. This presentation will discuss a Hidden Valley theory that results in such a signature, as well as a work-in-progress analysis by members of the CMS Collaboration trying to find this signature.

**Monday Morning I / 6**

## Searching for the lowest luminosity companions of the Milky Way

**Author:** Sidney Mau[1]

**Co-author:** Alex Drlica-Wagner [2]

[1] *University of Chicago*

[2] *Fermilab*

**Corresponding Author:** smau@fnal.gov

The Milky Way satellites are among the least luminous and most dark matter-dominated galaxies in the known universe. I present on a search for low-luminosity dwarf galaxy companions of the Milky Way in three years of data from the Dark Energy Survey (DES) and the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS PS1). Together, these two surveys cover roughly three-quarters of the sky with deep multi-band optical imaging. I will describe a search algorithm, SimpleBinner, for detecting satellite galaxy candidates by their individually resolved stars. I apply this algorithm consistently to the actual survey data and simulated satellites in order to characterize our search sensitivity. In this talk, I will present on the performance of SimpleBinner on DES and PS1 data and discuss the ongoing search for new ultra-faint stellar systems in DES, PS1. I will also note our recent discovery of a faint halo star cluster in the Blanco Imaging of the Southern Sky (BLISS) Survey using DECam. Finally, using these results, I comment on constraints of dark matter models.

**36**

## Signal processing in the protoDUNE-SP LArTPC

**Author:** Carlos Sarasty Segura[1]

[1] *University of Cincinnti*

ProtoDUNE-SP, the prototype of the single-phase DUNE far detector, is constructed and operated at the CERN Neutrino Platform with total liquid argon (LAr) mass of 0.77 kt and using full-scale components of the design for DUNE. The physics program of protoDUNE-SP aims to understand and control the systematic uncertainties for future oscillation measurements at DUNE, the charged-particle beam test allows to measure the detector calorimetric response for hadronic and electromagnetic showers, to study secondary particle production and argon-hadron cross sections, to evaluate and improve particle identification mechanisms and validate Monte Carlo simulations. In a liquid argon time-projection chamber(LArTPC) ionization electrons from a charged-particle track drift towards the wire planes, the induced current in the wire is readout and digitized by low-noise electronics. In this talk, we present the noise filtering and the signal processing techniques in protoDUNE-SP by which the digitized raw waveform is processed to recover the original ionization signal in charge and time.

**Monday Morning II / 51**

## Simulation of Resonant Extraction at Fermilab's Delivery Ring

**Author:** Prudhvi Raj Varma Chintalapati[1]

**Co-author:** Mike Syphers [2]

[1] *Chintalapati*

[2] *Northern Illinois University / Fermilab*

**Corresponding Author:** raj.ch90@gmail.com

The Muon Campus at Fermilab presently houses two experiments that aim to find discrepancies (if any) in the Standard Model. The Delivery Ring is a 500m circumference storage ring which is used to deliver protons to muon experiments Muon g-2 and Mu2e. Although these experiments are based on the same particle, they require different intensities because of their detector constraints. For the Mu2e case, resonant extraction is the method used for introducing small perturbations in the transverse magnetic field of the ring in order to provide controlled extraction of protons depending upon the required particle rates at the target. Work presented here will be an analysis and simulation of resonant extraction at the Delivery Ring using the beam parameters of Mu2e to study various factors that contribute to its successful use, including meeting intensity requirements while keeping beam losses to a minimum.

**Summary**:

Preliminary results and future goals will be presented.

**18**

## Sky Survey Scheduling using Reinforcement Learning

**Author:** Andres Felipe Alba Hernandez[1]

**Co-authors:** Brian Nord [2] ; Eric Neilsen [2]

[1] *Northern Illinois University*

[2] *Fermilab*

Modern cosmic sky surveys (e.g., CMB S4, DES, LSST) collect a complex diversity of astronomical objects. Each of class of objects presents different requirements for observation time and sensitivity. For determining the best sequence of exposures for mapping the sky systematically, conventional scheduling methods do not optimize the use of survey time and resources. We present an alternative scheduling method based on reinforcement learning (RL) that aims to optimize use of telescope resources for scheduling sky surveys.
We present an exploration of RL techniques (e.g., Q Learning) in both table-look up and neural

network-approximation contexts. We compare our implementation with standard methods like the Greedy agent and standard frameworks, like Astroplan. We show that tabular-based methods are wholly insufficient for large-scale surveys with large numbers of targets and when long-range planning is required. We also demonstrate that approximation methods outperform these traditional tabular methods and may provide a path forward for optimal sky survey scheduling

**Monday Morning I / 45**

## Strong Lensing Science from Current and Future Astronomical Surveys

**Authors:** Brian Nord[1] ; Jason Poh[2]

[1] *Fermilab*

[2] *University of Chicago*

**Corresponding Author:** jasonpoh@uchicago.edu

Strong gravitational lenses are cosmic magnifying glasses that can be used as a probe of cosmic phenomena, like dark energy and dark matter. However, strong lensing systems are rare and complex, which means they are both hard to find and analyze. We present two important results in strong lensing science: 1) new deep learning techniques for finding and measuring strong lenses; and 2) dark energy forecasts for future surveys that will find hundreds of thousands of lensing systems. Current surveys, like DES, are predicted to discover thousands of galaxy-scale strong lenses, while future surveys, like LSST will increase that number by 1-2 orders of magnitude. The large number of strong lenses discoverable in future surveys will make strong lensing a highly competitive and complementary cosmic probe, but only if they can be analyzed on realistic time-scales. We demonstrate a novel deep learning regression analysis which can infer strong lensing observables from ground-based imaging for thousands of lenses to within 10-15% of their true values in a fraction of the time conventional modeling techniques take. We then use these uncertainties to inform how well we can constrain cosmology with galaxy-scale lenses in the DES and LSST era, demonstrating the statistical power of this probe in relation with other conventional probes of cosmology.

**Monday Afternoon II / 15**

## SuperCDMS in 10 Minutes

**Author:** Anthony Villano[1]

[1] *University of Colorado Denver*

**Corresponding Author:** anthony.villano@ucdenver.edu

The Super Cryogenic Dark Matter Search (SuperCDMS) is at the low-threshold frontier. Our detector technology can detect nuclear recoils at the eV-scale energies necessary for generation-two low-mass dark matter searches. The SNOLAB installation, which will be commissioned in the next two years, will produce world-class limits on the presence of low-mass (between 0.5 and 10\,GeV/c$^2$) dark matter. In this brief presentation I will discuss the detection mechanisms; SNOLAB running and backgrounds; and new mechanisms of dark matter interactions that these astonishingly sensitive detectors are beginning to probe.

**Summary**:

An overview of the SuperCDMS experiment, focusing on the Generation-2 installation at SNOLAB.

**Tuesday Afternoon I / 10**

## The NOvA Test Beam Program

**Author:** Teresa Lackey[None]

**Corresponding Author:** lackey32@fnal.gov

NOvA is a two-detector long-baseline neutrino oscillation experiment which aims to make a determination of the neutrino mass hierarchy, the octant of $\theta_{23}$, and measure possible CP violation. The NOvA Test Beam program consists of a scaled-down NOvA detector placed in a beamline capable of delivering 0.3 - 2.0 GeV/c protons, electrons, pions, and kaons. The beamline detectors provide us with particle identification and momentum measurements so we can study our detector technology with known inputs. Studying these particles will provide us a more detailed understanding of our calibration, detector response, and energy scale, which are some of the largest sources of systematic uncertainty in NOvA analyses. We will also collect a selection of single-particle data events for training particle identification algorithms. In this talk, I will present the current status of the NOvA Test Beam program and discuss plans for data taking and analysis.

**Monday Afternoon I / 17**

## Towards the measurement of the charged-current electron-neutrino inclusive cross-section on argon in MicroBooNE using the NuMI beam.

**Author:** Krishan Mistry[1]

[1] *The University of Manchester*

The MicroBooNE experiment is an 87 t active mass Liquid Argon Time Projection Chamber (LArTPC) located on the Booster Neutrino Beam (BNB) at Fermilab, Chicago. The primary physics goals of this experiment are to investigate the excess of low energy electron-like events observed by MiniBooNE, perform precise measurements of neutrino on argon cross sections, and provide research and development for future liquid argon experiments such as SBN and DUNE. MicroBooNE also receives a significant neutrino flux from the highly off-axis NuMI beam. This flux can be utilised due to its high electron neutrino component (5%) to perform independent cross section measurements. This talk will cover the current status of the flux integrated inclusive charged-current electron-neutrino cross section measurement on argon performed using data from the NuMI beam collected during MicroBooNE's first run period.

**Tuesday Afternoon I / 65**

## UEC report

**Corresponding Author:** gavin.s.davies@gmail.com

**Monday Morning I / 63**

## Welcome

**Corresponding Authors:** andrew.furmanski@manchester.ac.uk, afurmans@fnal.gov

**62**

## Welcome