New Perspectives 2017

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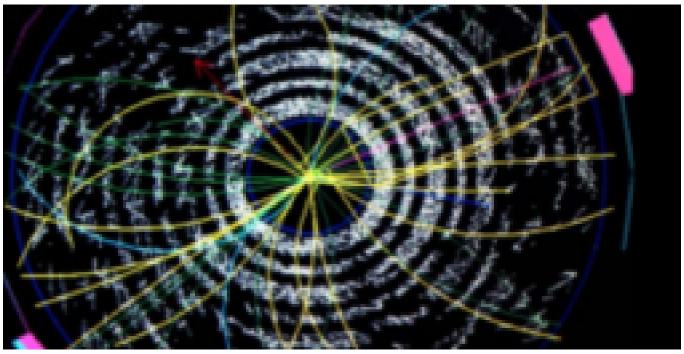
Fermilab, Wilson Hall



Book of Abstracts

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A Summary of Machine Learning Applications at Fermilab

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Co-authors: Alexander Himmel [2] ; Alexander Radovic [3] ; Auralee Edelen [4] ; Brian Nord [2] ; Gabriel Perdue [2]

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A premier challenge of HEP analysis is the interpretation of highly multivariate data. The efforts to extract the strongest measurements from the available data combined with access to large-scale computing resources allow researchers to take advantage of and contribute to the development of cutting-edge machine learning tools. Recent applications have shown that some techniques, especially deep learning, significantly improve the physics reach of running neutrino experiments. A variety of applications are under development using these tools not only for analysis but for reconstruction and even simulation.
The Fermilab Machine Learning Working Group brings together a community of scientists from across the laboratory with an interest in machine learning. This presentation will summarize the most prominent machine learning applications in use in Fermilab experiments and introduce the activities of the Working Group.

Short Baseline Neutrino Program / 72

ANNIE: Present and Future

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The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is located at SciBooNE Hall along the Booster Neutrino Beam at Fermilab. It consists of a 23-ton water Cherenkov detector loaded with gadolinium, muon range detector and a veto wall. The main goal of the experiment is to measure the final state neutron multiplicity from charged current neutrino-nucleus interactions within the gadolinium-loaded water. Currently, ANNIE is running in Phase-I and it will be upgraded to Phase-II in the summer, by installing Large Area Picosecond Photodetectors (LAPPDs) in the detector. LAPPDs are a novel photodetector technology with single photoelectron time resolutions less than 100 picoseconds, and spatial imaging capabilities to within a single centimeter. They will play a crucial role to separate events of charged-current quasi-elastic (CCQE) interactions and inelastic multi-track charged current interactions. In this talk, we discuss the current status and future plans of the experiment.

Dark Matter and Astrophysics / 66

AstroEncoder: Applications of Deep Learning to Cosmological Data

Author: Brian Nord[1]

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Current and future cosmology surveys will provide data sets unprecedented in size and precision with which to measure dark energy, dark matter and the early universe through probes like strong gravitational lensing, supernovae, and the cosmic microwave background. First, we'll discuss the challenges posed by astronomically big and complex data, and the potential for machine learning. Then, I will present a variety of successful applications of deep learning techniques to astrophysical and cosmological data, including classification, measurement, and simulation.

Neutrino Interaction Physics / 4

CC coherent/diffractive Pion Production at MINERvA in the NuMI ME era

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Charged Current Coherent pion production is a rare neutrino reaction producing a forward muon and a forward charged pion while leaving the target nucleus in its initial state. On its own, it provides a way to study the weak axial vector current, by testing theories such as PCAC and related models. After the discovery of neutrino oscillations, coherent pion production has become an important reaction, helping to reduce systematic uncertainties in both the signal and background of oscillation studies. MINERvA, a neutrino scattering experiment, has already published an analysis of coherent pion production in plastic scintillator (CH) using the NuMI low energy neutrino and anti-neutrino beams at Fermilab. The current NOvA era, with a more energetic and intense NuMI beam, allows an improved charged current coherent analysis, which is at the first stages. Here we present the highlights of both analyses.

Collider Physics / 33

CMS in 10 Minutes

Author: Julie Hogan[1]

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The Large Hadron Collider is one of the most powerful machines in the world, accelerating protons to 99.9999990% of the speed of light to provide 40 million collisions per second at particle detectors such as CMS. The CMS detector is highly versatile, featuring a 4 Tesla solenoid magnet (the largest superconducting magnet ever built!) and over 100 million detection elements in trackers, calorimeters, and muon detectors. CMS physicists were instrumental in the discovery of the Higgs boson in 2012 and are now searching for evidence of many new physics theories such as dark matter, supersymmetry, and extended Higgs sectors.

Dark Matter and Astrophysics / 39

Calibration of Photometric Redshifts from Clustering in the Dark Energy Survey

Author: Ross Cawthon[1]

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Redshift estimation is among the most significant issues in photometric cosmological surveys. Undetected biases in photometric redshift estimation can be found using clustering redshifts. In this presentation, we describe our clustering redshift estimates for weak lensing source galaxies, and redMaGiC galaxies in the Dark Energy Survey year 1 data. We also describe our methodology of applying corrections to photometric redshifts based on the clustering measurements as tested in simulations.

Long Baseline Neutrino Program / 67

Calorimetric Energy Scale in the NOvA Detectors

Author: Tyler Alion[1]

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NOvA is a long-baseline neutrino oscillation experiment consisting of a near and far detector, both comprising layers of orthogonal scintillator-filled PVC extrusions. Reconstructing hits along the orthogonal views provides 3D tracks, and scintillation light provides calorimetry important for determining the visible hadronic energy of an interaction. Selecting muon tracks which stop inside the detector and choosing hits inside a sufficiently flat region around it's point of minimum ionization isolates a constant energy in the detectors. This energy is scaled by the path length of each hit, so additional quality cuts must be imposed to ensure accurate path lengths. Care must also be taken to avoid bias from electronic thresholds, which are meant to suppress noise hits but can also suppress low-energy muon hits far from the readout. After removing reconstruction and threshold biases, cosmic muon data provides a standard candle scintillation, while well-understood Monte Carlo simulation provides a standard candle energy, equipping NOvA analyses with a precise scale factor between observed light and desired energy measurements.

Dark Matter and Astrophysics / 18

Constraining the Nature of Dark Matter with the Milky Way Satellite Galaxies

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The census of Milky Way satellite galaxies provides crucial tests of both galaxy formation models and the broader Cold Dark Matter paradigm. A total of 27 new Milky Way satellite candidates have been

discovered in the last two years, primarily in data from the Dark Energy Survey. These discoveries may represent a 100% increase in the number of known Milky Way satellite galaxies, leading a huge advance in solving the missing satellite problem, if spectroscopic follow-up observations confirm the majority of these systems are dark matter dominated dwarf galaxies. Furthermore, many of these newly discovered dwarf galaxies are excellent targets for providing constraints on WIMP dark matter cross section and MACHO dark matter abundance with the spectroscopic follow-up analysis. In this talk, I will present the initial results from a spectroscopic campaign on the newly discovered dwarf galaxy candidates using 4-8 meter class telescopes in the southern hemisphere.

Long Baseline Neutrino Program / 36

Data Monitoring and Performance of the NOvA Detectors

Author: Teresa Lackey[1]

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NOvA consists of two detectors, one at Fermilab, and the second 810km away in northern Minnesota. The experiment uses Fermilab's NuMI beam to measure the νμ to νe oscillation probability in order to learn more about the neutrino mass hierarchy, mixing angles, and CP violation in the neutrino sector. As with any large experiment, there are many components that need to operate smoothly to maximize uninterrupted data-taking and ensure the recorded data is of high quality. If any component fails it is essential know as soon as possible what failed, and why it failed, so the problem can be promptly resolved. In order to do this, NOvA has a multitude of monitoring tools and procedures to continuously monitor various aspects of the experiment. In this talk, I will discuss these tools and procedures and how they enable the high quality physics results produced by NOvA.

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Decomposition Methods for the ν_e Appearance analysis in the NOvA Near Detector

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NOvA is a long-baseline neutrino oscillation experiment that is designed to probe the neutrino mass hierarchy and mixing structure. It uses two functionally identical liquid scintillator detectors 14mrad off-axis from the NuMI beamline at Fermilab, allowing a tightly focused neutrino flux peaked at around 2 GeV. The Near Detector is located 100 m underground and is used to characterize the neutrino beam before oscillations. Since the beam components are affected differently by oscillations, the data collected at the Near Detector needs to be broken down into these components. This enables a precise prediction to be made of the beam-induced backgrounds to the ν_e appearance signal at the Far Detector, 810 km from the neutrino source. Various data-driven techniques are employed for this purpose, in particular by constraining the flux yields and correcting for observed neutrino interaction characteristics. In this talk, I will present an overview of the methodology used to decompose the Near Detector data and predict the FD spectrum in the latest ν_e appearance analysis, utilizing an accumulated exposure of 6.05×10^{20} protons-on-target.

Dark Matter and Astrophysics / 7

Deep Learning for Hidden Signals—Enabling Real-time Multimessenger Astrophysics

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We developed a new method for end-to-end time-series signal processing, based on deep convolutional neural networks, which can rapidly identify and extract signals much weaker than the background noise. We applied this method for analyzing gravitational waves from mergers of black holes and demonstrated that it significantly outperforms conventional machine learning techniques, is far more efficient than matched-filtering allowing real-time processing of raw big data with minimal resources, and extends the range of gravitational waves that can be detected by advanced LIGO. This initiates a new paradigm for scientific research which uses massively-parallel numerical simulations to train artificial intelligence algorithms that exploit emerging hardware architectures. Our approach offers a unique framework to enable coincident detection campaigns of gravitational wave sources and their multimessenger counterparts.

Muon Physics etc / **63**

Design of the Mu2e Straw Tracker Detector

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The Mu2e experiment in Fermilab will search for the coherent neutrinoless conversion of a muon into an electron in the field of an aluminum nucleus, improving sensitivity by 4 orders of magnitude over existing limits and indirectly probing new physics beyond the reach of current or planned high energy colliders. To achieve a single conversion event sensitivity better than 3e-17, the experiment requires a high precision measurement of the ˜105 MeV/c electron momentum while reducing to negligible all background contributions in the signal window. The primary detector element is a low-mass straw tracker chamber, comprising ˜21,000 thin straw drift tubes of 5 mm diameter, arranged in a 3 m long cylinder of radius 700 mm, and operated in a magnetic field of 1 T and in vacuum. The tracker is designed to reconstruct the momentum of conversion electrons with a resolution of <180 keV/c. The distance of an electron track from the straw sense wire must be extracted within 200 μm from a TDC timing measurement, while time division yields the hit position along the straw within 3 cm. The straws are also instrumented with an ADC for dE/dx capability to separate electrons from highly ionizing protons. We will present the status and design of the tracker and the scheme for its front-end electronics, which handles amplification, shaping, digitization and readout of the straw signals.

Collider Physics / **24**

Detecting kinematic boundary surfaces in phase space and particle mass measurements

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We critically examine the classic endpoint method for particle mass determination, focusing on difficult corners of parameter space, where some of the measurements are not independent, while others are adversely aected by the experimental resolution.In such scenarios, mass dierences can be measured relatively well, but the overall mass scale remains poorly constrained. Using the example of a standard SUSY decay chain we demonstrate that sensitivity to the remaining mass scale parameter can be recovered by measuring the two-dimensional kinematical boundary in the relevant three-dimensional phase space of invariant masses squared. We develop an algorithm for detecting this boundary, which uses the geometric properties of the Voronoi tessellation of the data, and in particular, the relative standard deviation (RSD) of the volumes of the neighbors for each Voronoi cell in the tessellation. We propose a new observable, which is the average RSD per unit area, calculated over the hypothesized boundary. We show that the location of the function maximum correlates very well with the true values of the new particle masses. Our approach represents the natural extension of the one-dimensional kinematic endpoint method to the relevant three dimensions of invariant mass phase space.

Short Baseline Neutrino Program / **32**

Electron Neutrino Events in MicroBooNE originating from the NuMI Beamline

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MicroBooNE is a liquid argon neutrino detector at the Fermi National Accelerator Laboratory with the unique feature to simultaneously receive neutrinos from both Fermilab neutrino beams. The electron neutrino search from the lower-energy on-axis BNB will address MicroBooNE's signature analysis investigating the low-energy electromagnetic event excess previously observed by the MiniBooNE experiment. The higher-energy neutrinos from the NuMI beam reaching the MicroBooNE detector off-axis, will be primarily used for a comprehensive understanding of electron neutrino interactions and a νe cross section measurement on Liquid Argon. These measurements using the NuMI neutrinos will be crucial for reducing cross section systematics for current and future oscillation measurements at short and long baselines. We will present ongoing simulation studies of the signal and backgrounds leading towards a measurement of the νe cross section on argon.

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Electron Neutrino Reconstruction in MicroBooNE Using Deep Learning Technique

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MicroBooNE employs the first large scale (> 100 ton) Liquid Argon Time Projection Chamber (LArTPC) in the U.S. to detect electron and muon neutrinos produced from the Fermilab Booster Neutrino Beamline (BNB). The primary goal of the experiment is to perform a definitive study of the observed electron neutrino event excess at low energy by the MiniBooNE experiment, which could indicate the presence of sterile neutrinos. The current challenge of the experiment is efficient and effective event reconstruction to identify any possible event excess above background. In this talk, I describe the use of the machine learning technique called Deep Learning to these problems in MicroBooNE, in particular for electron neutrino event reconstruction and analysis. Deep Learning is making revolutionary advancements in the field of artificial intelligence and computer vision and is also making an impact on neutrino experiments such as NOvA. We demonstrate that Convolutional Neural Networks (CNNs), a type of Deep Learning algorithm, can also be used for event reconstruction using LArTPC data. I will discuss the current status of the application of this technique for electron neutrino event reconstruction in MicroBooNE.

Long Baseline Neutrino Program / 11

Exploring the ν_μ charged-current uncontained sample at the NOvA Far Detector

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NOvA is a long-baseline neutrino oscillation experiment based at Fermilab that uses two highly active liquid scintillator detectors located off-axis of the NuMI beam.
Latest results have excluded maximal mixing at 2.6σ via the
muon-neutrino disappearance channel, which use fully contained interactions of the type $\nu_\mu + X \rightarrow \mu + X'$.
We explore potential improvement of the neutrino oscillation parameters $\sin^2 2\theta_{23}$ and Δm^2_{32}
by including uncontained events where the muon is the only final-state particle exiting the detector.
Two main problems arise with this sample. First, the signal now mimics
the cosmic ray induced background. Second, the reconstructed energy
resolution decreases due to the escaping muon.
To address these questions, we explore the use of multivariate
analysis techniques.

Muon Physics etc / 6

Extension Upgrade to the Muon g-2 Electrostatic Quadrupole System

Authors: Hogan Nguyen[1] ; Jason D. Crnkovic[2] ; Vladimir Tishchenko[3] ; Wanwei Wu[4]

Co-authors: Alexander T. Herrod [5] ; Eric F. Schmidt [6] ; Erik Ramberg [7] ; Esra B. Yucel [8] ; Mete Yucel [8] ; William Morse [3]

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The Muon g-2 experiment uses electrostatic quadrupoles for vertical focusing in the muon storage ring. High voltage (HV) feedthroughs provide electrical contact across the vacuum-air interface. Trapped electrons drift in the direction of the cross product between the electric and magnetic fields. These electrons drift along the quadrupole HV leads and eventually damage the HV feedthrough insulators on the vacuum side. Damaging these insulators increases the likelihood of sparking in the Quadrupole System. HV feedthrough extensions are used to position the HV feedthroughs in a low magnetic field region, thereby eliminating the trapped electrons that cause damage. The design and installation of the HV feedthrough extensions are presented in this poster.

Dark Matter and Astrophysics / 38

Fabrication of antenna-coupled KID array for Cosmic Microwave Background detection

Author: Qing Yang Tang[1]

[1] *University of Chicago*

Corresponding Author: tangq@uchicago.edu

Microwave Kinetic Inductance Detectors (MKIDs) have become an attractive alternative to traditional Transition Edge Sensor (TES) bolometers in the sub-mm and mm observing community due to its innate frequency multiplexing capabilities and simple lithographic processes. These advantages make MKIDs a viable option for the O(100,000) detectors needed for the upcoming Cosmic Microwave Background - Stage 4 (CMB-S4) experiment. We have fabricated dual polarization antenna-coupled MKID array in the ˜100GHz band optimized for CMB detection. The Al KIDs are made from evaporating Al on a high resistivity silicon substrate. The microstrip coupling the antenna and KID consists of growing Si3N4 between two layers of evaporated Nb. In addition, we present the preliminary characterization of these devices with a cryogenic blackbody load.

Long Baseline Neutrino Program / 77

INSS Announcement

Author: Anne Schukraft[1]

[1] *Fermilab*

Announcement about the International Neutrino Summer School being help at Fermilab in Summer of 2017.

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Increased Neutrino Yield with the new NOvA Target Design: Simulation Study

Author: Daisy Daisy Kalra[1]

[1] *Panjab University*

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NOvA (NuMI Off-axis νe Appearance) is a long baseline neutrino oscillation experiment designed to search for both νe appearance and νμ disappearance. Fermilab NuMI (Neutrinos at Main Injector) facility produces an intense neutrino beam (narrow band νμ beam peaked at 2 GeV in energy) colliding 120 GeV protons from the Main Injector into a long target with a set of two magnetic horns (Horn1 and Horn2) to focus the pions produced at the target. We studied different target designs and Horn2 configuration. Here, we present the New Target design which increases the νμ (anti-νμ) yield at the NOvA Near and Far detectors by about 17% (20%) compared to the event yield with the current NuMI target.

Short Baseline Neutrino Program / 42

LArIAT in 10 Minutes

Author: Johnny Ho[1]

[1] *University of Chicago*

Corresponding Author: johnnyho@uchicago.edu

The LArIAT (Liquid Argon in a Test Beam) experiment in Fermilab's Test Beam Facility exposes a liquid argon time projection chamber (LArTPC) to a test beam in order to study LArTPC responses to a variety of charged particles. Event identification and reconstruction techniques as well as cross section measurements from LArIAT will provide critical input to existing liquid argon neutrino experiments such as MicroBooNE, SBND, and ICARUS, and will also help to improve future precision neutrino oscillation measurements in the Deep Underground Neutrino Experiment (DUNE). The work presented here will give an overview of the experiment and highlight several recent results.

Neutrino Interaction Physics / 61

Low Energy CCQE Results from MINERvA

Author: Mehreen Sultana[1]

[1] *University of Rochester*

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MINERvA is a neutrino scattering experiment designed for high precision measurements of cross sections and studies of nuclear effects. Charged-current quasielastic (CCQE) scattering events are a significant contribution to the signal of many oscillation experiments. It is the dominant reaction near 1 GeV, a critical energy region for long baseline oscillation experiments. MINERvA has conducted many CCQE studies in the low energy NuMI beam. In this talk, I will present an overview of the Minerva detector and summarize the low energy quasi-elastic scattering results.

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Low energy single-photon search in MicroBooNE

Author: Robert Murrells[1]

[1] *University of Manchester*

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MicroBooNE, an 89 ton (active volume) liquid argon time projection chamber (TPC), began studying neutrino interactions in the Fermilab Booster Neutrino Beamline (BNB) in October 2015. One of its primary physics goals is to investigate the MiniBooNE electromagnetic "Low Energy Excess". A leading interpretation of this excess is single photon production in neutrino neutral current (NC) interactions with nuclei. I will discuss the reconstruction and event selection scheme developed and optimized for the MicroBooNE single-photon search, which aims to investigate the MiniBooNE excess under the single photon interpretation. The ongoing studies of the selected single photon signal and backgrounds that will dictate MicroBooNE's sensitivity to such an excess will also be presented.

Neutrino Interaction Physics / 76

MINERvA in 10 Minutes

Author: Marianette Wospakrik[1]

[1] *University of Florida*

The MINERvA experiment is a dedicated neutrino scattering experiment located on the NuMI beamline in Fermilab. It aims to make high precision measurement of neutrino interaction cross sections in the 1-to 10-GeV energy range, to support the current and future oscillation experiments as well as to provide information about the structure of nuclei, protons and neutrons and the strong force dynamics that affect neutrino-nucleus interactions. The MINERvA detector is comprised of a fine-grained scintillator with electromagnetic and hadronic calorimetry regions. Various nuclear targets are located inside and in front of the detector for studying nuclear medium effects in neutrino-induced interactions. This talk presents a summary of the MINERvA experiment.

Dark Matter and Astrophysics / 30

Measurement and characterization of low-energy ionization signals from Compton scattering with a Silicon CCD

Author: Karthik Ramanathan[1]

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We report results of low-energy Compton scattering calibration studies in Silicon undertaken under the umbrella of the DAMIC (Dark Matter in CCDs) experiment. We expose a calibration detector at the University of Chicago to Co-57 and Am-241 gamma-ray sources and measure and characterize the resultant spectrum. We identify several theoretically motivated, but heretofore unobserved in the literature, structural features of these spectra and validate these results with an MCNP simulation. We further report an energy detection threshold of 60 eVee. These studies provide relevant information on low-energy ionization signals from electrons Compton scattered by radiogenic gamma-rays, often a dominant background for low-mass WIMP (Weakly Interacting Massive Particle) searches.

Short Baseline Neutrino Program / 20

Measurement of Reconstructed Charged Particle Multiplicities of Neutrino Interactions in MicroBooNE

Authors: Aleena Rafique[1] ; Tim Bolton[1]

[1] *Kansas State University*

In this talk, we present a comparison of the observed charged particle multiplicity distributions in the MicroBooNE liquid argon time projection chamber from neutrino interactions in a restricted final state phase space to predictions of this distribution from several GENIE models. The measurement uses a data sample consisting of neutrino interactions with a final state muon candidate fully contained within the MicroBooNE detector. These data were collected in 2015-2016 with the Fermilab Booster Neutrino Beam (BNB), which has an average neutrino energy of 800 MeV, using an exposure corresponding to 5e19 protons-on-target. The analysis employs fully automatic event selection and charged particle track reconstruction and uses a data-driven technique to determine the contribution to each multiplicity bin from neutrino interactions and cosmic-induced backgrounds. The restricted phase space employed makes the measurement most sensitive to the higher-energy charged particles expected from primary neutrino-argon collisions and less sensitive to lower energy protons expected to be produced in final state interactions of collision products with the target argon nucleus.

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MicroBooNE in Ten minutes

Author: Jessica Esquivel[1]

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MicroBooNE is a Liquid Argon Time Projection Chamber (LArTPC) that has been operating for the past 18 months on the Booster Neutrino Beamline at Fermilab. MicroBooNE's physics goals include studying the excess of low energy electromagnetic events observed by the MiniBooNE experiment as well as performing the first set of neutrino-argon cross-section measurements in the 1 GeV energy range. MicroBooNE is also making significant contributions to LArTPC R&D that is informing the Short Baseline Neutrino (SBN) program and DUNE. This talk will give an overview and cover recent developments of the MicroBooNE experiment.

Neutrino Interaction Physics / 53

Minerva CCQE in the 'Medium Energy' Era

Author: Rob Fine[1]

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Charged-current quasielastic (CCQE) scattering events are one of the most numerous and most important categories of neutrino interactions available to us today to study neutrino cross sections and oscillations. This presentation will cover the progress of the Minerva collaboration towards fully leveraging the awesome statistics that the NuMI 'Medium Energy' exposure has to offer. Data collected during this run allow for unprecedented access to as-yet-unstudied regions of phase space, in an energy range that is of particular relevance to future long-baseline oscillation experiments.

Muon Physics etc / 73

Mu2e in 10 Minutes

Author: Jacob Colston[1]

[1] *Mu2e*

This talk will give a concise, graduate-student-level overview of the Mu2e experiment. It will describe the goal of the Mu2e experiment (to search for neutrino-less muon-electron conversion), and why this process would indicate physics beyond the Standard Model. It will further detail the implementation and design of the experiment: (1) a brief description of how the low-energy, high-intensity muon beam is produced using Fermilab's accelerator system, (2) a small discussion on the three solenoids of the Mu2e experiment and their function, and (3) a layout of the detector system with descriptions of the primary detector components.

Long Baseline Neutrino Program / 49

Multi-channel analyses for future neutrino oscillation experiments.

Author: Dennis Steve[1]

[1] *University of Liverpool*

Neutrino physics is entering the liquid argon era, and these experiments
offer large statistics with excellent reconstruction abilities.
The wealth of information available opens new opportunities
to break degenaracies between different sources of systematic uncertainty
by simultaneously fitting samples selected for different final state topologies.
At near detectors, use of many such samples can pin down specific
interaction model and flux uncertainties, while for far detectors
smaller numbers of fitted topologies can be used to separate event types
with better and worse neutrino energy resolution, optimising oscillation sensitivity.Neutrino physics
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with better and worse neutrino energy resolution, optimising oscillation sensitivity.

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Muon Neutrino Disappearance at MINOS+

Author: Thomas Carroll[1]

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The MINOS experiment ran from 2003 until 2012 and produced some of the best precision measurements of the atmospheric neutrino oscillation parameters Δm^2_{32} and θ_{23} using muon neutrino disappearance of beam and atmospheric neutrinos and electron neutrino appearance of beam neutrinos. The MINOS+ experiment succeeded MINOS in September 2013. For almost three years MINOS+ collected data from the Medium Energy NuMI neutrino beam at Fermilab. We will describe the MINOS+ muon neutrino disappearance measurement and present the results of this analysis. These results will be compared to and combined with the MINOS measurement.

Muon Physics etc / 5

Muon g-2 Electrostatic Quadrupole System Plate Alignment

Authors: Erik Ramberg[1] ; Hogan Nguyen[2] ; Wanwei Wu[3]

Co-authors: Cristina Schlesier [4] ; Jason D. Crnkovic [5] ; Jenny Holzbauer [3] ; Joe Grange [6]

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The Muon g-2 experiment uses electrostatic quadrupoles for vertical focusing in the muon storage ring, where higher-order electric field multipoles produce non linearities in the restoring forces. Top/bottom quadrupole plates are aligned to 0.5 mm and side plates are aligned to 0.75 mm over long length scales to limit the higher-order multipoles. Plate alignment techniques and an electric field map generated with OPERA 3D software are presented in this poster.

Short Baseline Neutrino Program / 50

NOvA Short-Baseline Tau-Neutrino Appearance Search

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Three-flavor neutrino oscillations have successfully explained a wide range of neutrino oscillation experiment results. However, anomalous results, such as the electron-antineutrino appearance excesses seen by LSND and MiniBooNE, do not fit the three-flavor paradigm and can be explained by the addition of a sterile neutrino at a larger mass scale than the existing three flavor mass states.
The NOvA experiment consists of two finely segmented, liquid scintillator detectors operating 14.6 mrad off-axis from the NuMI muon-neutrino beam. The Near Detector is located on the Fermilab campus, 1 km from the NuMI target, while the Far Detector is located at Ash River, MN, 810 km from the NuMI target. The NOvA experiment is primarily designed to measure electron-neutrino appearance at the Far Detector using the Near Detector to control systematic uncertainties. However, the Near Detector is well suited for searching for anomalous short-baseline oscillations. I will present a novel method for selecting tau neutrino interactions with high purity at the Near Detector using a convolutional neural network. Further, I will discuss the sensitivity to anomalous short-baseline tau-neutrino appearance due to sterile neutrino oscillations determined using this method.

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NOvA in 10 min

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NOvA is a second generation, long-baseline, neutrino oscillation experiment that uses the NuMI beam, the world's most powerful neutrino beam, from Fermilab. It consists of two functionally similar, finely segmented, liquid scintillator calorimeter detectors that operate 809 km apart, 14 mrad off-axis from the beam. NOvA's main physics goals include measuring electron (anti)neutrino appearance and muon (anti)neutrino disappearance. These measurements can provide constraints on the $\sin^2\theta_{23}$ octant, the mass hierarchy, and the CP violating phase, along with precision measurements of $\sin^2\theta_{23}$ and Δm^2_{32} . In this talk, an overview of NOvA's experimental effort will be presented.

Neutrino Interaction Physics / 19

Neutral Pion Reconstruction for NuMI at ME in MINERνA

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Many analyses in neutrino experiments require the reconstruction of neutral pions, particularly neutrino oscillation experiments measuring ν_e appearance, where pi^0 production is a background. Neutral pions are identified in the MINERνA detector by identifying the gammas that result from the neutral pion decay. The gamma candidates are energy depositions which are not associated with charged pions, protons or muons. The reconstruction that was developed in the simpler environment of the NuMI Low Energy beam is not satisfactory for the more complicated environment of the Medium Energy beam. By changing the MINERνA neutral pion reconstruction to consider only energy depositions with a well reconstructed direction and position and a set of cuts on energy, distance to the interaction vertex and dEdX, we have significantly improved the neutral pion reconstruction in the Medium Energy dataset.

Muon Physics etc / 70

New Physics Search with Experiment TREK/E36 at J-PARC

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We are potentially standing at the precipice in the quest for discovery of New Physics (NP) beyond the Standard Model (SM) by performing a precision test of lepton universality. Experiment E36 conducted at J- PARC in Japan is testing lepton universality in the RK = Γ(Ke2)/Γ(Kμ2) ratio. In the SM, the ratio of leptonic K+ decays is highly precise with an uncertainty of δRK /RK = 4 · 10−4. Any observed deviation from the SM prediction would break the universality of the lepton couplings

and provide a clear indication of NP beyond the SM. The E36 detector apparatus allows sensitivity to search for sterile neutrinos and light U(1) gauge bosons below 300 MeV/c2, which could be associated with dark matter or explain established muon-related anomalies such as the muon g − 2 value, and perhaps the proton radius puzzle. E36 data taking was completed in 2015. A scintillating fiber target was used to stop a beam of up to 1.2 Million K+ per spill. The K+ decay products were detected with a large-acceptance toroidal spectrometer capable of tracking charged particles with high resolution, combined with a CsI(Tl) photon calorimeter with large solid angle covering about 75% of 4π and particle identification systems. The status of the data analysis will be presented. This work has been supported by DOE Early Career Award DE-SC0003884 and DOE DE-SC0013941.

Long Baseline Neutrino Program / 25

Non-Standard Interaction Effects in the Neutrino Propagation in DUNE

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Based on the premise that the neutrino beam used in DUNE traverses the Earth's crust on its journey from being produced until detection, we propose a non-standard interaction (NSI) between the neutrinos and the matter of the Earth's crust. Such NSI can cause the change of the flavor and change the energy of the neutrinos. The phenomenon of the flavor oscillations that we know can produce changes that may be measurable from the analysis of the oscillation parameters. In this work we study how the proposed NSI can change the sensitivity of the DUNE in measuring the values of the parameters δCP, θ13, and θ23. NSI also affect the determination of the hierarchy of the neutrino masses.

For this study we performed simulations using the General Long Baseline Experiment Simulator (GLoBES). We determined optimal values for the oscillation parameters from the literature and tested some values for δCP. We used a method of χ^2 to test different values of δCP, θ13, and θ23. This way we were able to determine regions of sensitivity. We chose nine distinct forms of mass density distribution in the baseline and determined how the oscillation parameters change for each of them. When we compared the various sensitivity curves we elaborated a relative χ^2 for the purpose of determining the influence of the distribution of matter. Finally, we determined which values the parameters describing the NSI εαβ should be in order to be similar to the interactions we know.

With these studies, we conclude that the matter density distribution does not significantly change the sensitivity of the DUNE in measuring the parameters δCP, θ13, and θ23, however, the presence of the NSI causes sufficiently large changes in the sensitivity of the DUNE. NSI is also affected by mass hierarchy and, in this way, it can help to determine it. After an accurate study of NSI on the propagation, we intend to study NSI in the interaction, and how it may affect the events in LArTPCs.

Muon Physics etc / 2

Novel Implementation of Density Estimation in Muon Cooling

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The international Muon Ionization Cooling Experiment (MICE) is a high energy physics experiment located at Rutherford Appleton Laboratory in U.K. The aim of MICE is to demonstrate muon beam cooling for the first time. The process of reducing beam phase-space volume is known as beam cooling and this process is necessary for a beam of muons because of the large phase-space volume that they occupy upon production. Cooled muon beams are essential for future muon-based facilities such as neutrino factory or muon collider. Several beam cooling techniques exist, but the ionization cooling is the only technique fast enough for muons within their short lifetime. In MICE, commonly used figures of merit for cooling are the beam emittance reduction, the phase-space volume reduction, and the phase-space density increase. Given the precision with which MICE aims to demonstrate beam cooling, it is necessary to work around any beam effects which may lead to inaccurate cooling measurements. Non-linear effects in beam optics is an example of such effects which can result in beam heating. The Density Estimation, DE techniques are analysis tools which are insensitive to these non-linear effects and measure the muon beam phase-space density and volume. This talk will give an overview of the recent MICE results and the novel application of the DE techniques, in specific the kernel density estimation, KDE technique in MICE.

Collider Physics / 60

PROSPECT - A Precision Oscillation and Spectrum Experiment

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PROSPECT, the PRecision Oscillation and SPECTrum Experiment, is a multi-phased short baseline reactor antineutrino experiment that aims to precisely measure the U-235 antineutrino spectrum and prob for oscillation effects involving a possible Δm^2 ~ 1 eV^2 scale sterile neutrino. In PROSPECT Phase-I, an optically segmented Li-6 loaded liquid scintillator detector will be deployed at at the baseline of 7-12m from the High Flux Isotope Reactor at the Oak Ridge National Laboratory. PROSPECT will measure the spectrum of U-235 to aid in resolving the unexplained inconsistency between predictive spectral models and recent experimental measurements using LEU cores, while the oscillation measurement will probe the best fit region suggested by global fitting studies within 1-year data taking. This talk will introduce the design of PROSPECT Phase-I, the discovery potential of the experiment, and the progress the collaboration has made toward realizing PROSPECT Phase-I.

Muon Physics etc / 45

Precision Magnetic Field Calibration for the Muon $g-2$ Experiment at Fermilab

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The Muon $g-2$ Experiment at Fermilab (E989) has been designed to determine the muon anomalous magnetic moment to a precision of 140 parts per billion (ppb), a four-fold improvement over the Brookhaven E821 measurement. Key to this precision goal is the determination of the magnetic field of the experiment's muon storage ring to better than 100 ppb.

The magnetic field will be measured and monitored by nuclear magnetic resonance (NMR) probes, which are mounted on a trolley and pulled through the muon storage region when muons are not being stored. These trolley probes will be calibrated in terms of the free-proton Larmor precession frequency ω_p by a specially-constructed NMR calibration probe. In E821, the uncertainty in the field measurement was 170 ppb, of which 50 ppb was due to the calibration probe. In E989, these uncertainties will be reduced to 70 ppb and 35 ppb, respectively. To meet these stringent requirements, a new specially-designed probe called the "plunging probe" has been built which will be used to calibrate the trolley probes. This talk will present the design, fabrication, and testing of the plunging probe, along with the calibration procedure to be conducted during the experiment.

Dark Matter and Astrophysics / 16

Probing Nuclear Recoils in Liquid Argon with the ARIS Experiment

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One of the unique challenges facing direct dark matter searches is the signal characterization of the dark matter particle with the detector medium. The goal of the Argon Recoil Ionization and Scintillation (ARIS) experiment is to characterize the response of nuclear recoils in liquid argon (as expected from WIMPs) by measuring the energy scale of nuclear recoils with respect to electron recoils, the ion recombination probability as a function of electric field, and the scintillation time response of nuclear recoils at various energies. A scintillation chamber with an active mass of ˜0.5 kg was constructed with a tunable cathode to provide a varying electric field within the active volume. This detector was exposed to a highly collimated inverse kinematic neutron beam at the Institut de physique nucléaire d'Orsay in France. Events coincident with one of an array of 8 neutron detectors allowed a scan of nuclear recoil energies. The present status of the experimental analysis will be presented.

Neutrino Interaction Physics / 58

Progress of the Charged Pion Semi-Inclusive Neutrino Charged-Current Cross Section in NOvA

Authors: Andrew Norman[1] ; Aristeidis Tsaris[1] ; Jyoti Tripathi[2] ; Norm Buchanan[3] ; Paul Rojas[3]

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The NOvA experiment is a long-baseline neutrino oscillation experiment designed to measure the rates of electron neutrino appearance and muon neutrino disappearance. The NOvA near detector is located at Fermilab, 800˜m from the primary target and provides an excellent platform to measure and study neutrino interaction and cross sections. We present the status of the measurement of the double differential cross section with at least one charged pion in the final state,

$\nu_\mu + N \to N + \mu^\pm \pi^\mp X$. A convolutional neural network based approach is presented for the identification of neutrino interactions with the specific final state topology. This method of event classification has been used successfully to identify charged current electron neutrinos interactions in the NOvA oscillations measurements. The approach is nearly ideal for semi-inclusive cross section measurements as it does not require detailed a priori particle by particle reconstruction of the sub-leading tracks to classify the signal events. In this talk we present event classification efficiency studies using this event identification and classification methodology, along with background estimates and prospects for the measurement.

Neutrino Interaction Physics / 17

Progress of the Inclusive Muon Neutrino Charged-current Cross Section Measurement in the NOvA Near Detector

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NOvA is a long-baseline (810 km) neutrino oscillation experiment. It uses a NuMI neutrino beam from Fermilab and two mostly active, segmented, liquid scintillator off-axis detectors that offer a remarkable capability in event identification. The 293 ton Near Detector at Fermilab is to measure the unoscillated neutrino energy spectrum, which can be used to predict the neutrino energy spectrum at the 14 kton Far Detector at Ash River, MN. It provides an excellent opportunity to measure cross sections with high statistics. Improved understanding of neutrino- nucleus interactions will benefit current and future long-baseline neu- trino oscillation experiments. In this talk we present an update to the progress of the measurement of the inclusive ν_μ CC cross section in the NOvA Near Detector.

Neutrino Interaction Physics / 46

Progress of the Measurement of the Electron Neutrino Charged-current Inclusive Cross Section in NOvA

Authors: Andrew Norman[1] ; Leonidas Aliaga Soplin[1] ; Matthew Judah[2] ; Nitish Nayak[3] ; Norm Buchanan[2] ; Pengfei Ding[1]

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We present an update to the progress of the measurement of the electron neutrino charged-current inclusive cross section per nucleon with data collected from November 2014 to February 2017 in the NOvA near detector. The NOvA near detector, located at Fermilab 800m from the primary target, provides an excellent platform to measure and study neutrino interactions and cross sections. We are measuring the cross section in four energy bins from 1-3 GeV. This energy range is of particular importance since it corresponds to the expected region of interest for electron neutrino appearance in future neutrino oscillation experiments.

Long Baseline Neutrino Program / 59

Re-optimization of the LBNF Neutrino Beam

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The Long Baseline Neutrino Facility (LBNF) will use high energy protons impinging on a graphite target to produce kaons and pions, which will be focused by a set of magnetized focusing horns and directed into a decay pipe where they will decay, producing an intense neutrino beam. The neutrino energy spectrum can be tuned by changing a variety of parameters in the beamline such as horn and target shapes. Recent advances in computing power coupled with the development of complex optimization algorithms enable identification of parameters that are precisely tuned to optimize physics parameter sensitivity. An optimization of the LBNF beam parameters for sensitivity to CP violation has been performed. The resulting beam design and its physics performance will be discussed, as well as engineering modifications to that design and re-optimization incorporating these engineering constraints. For instance, the horn positions have been revisited and fine tuned, and the amount of material in the downstream target support carefully reviewed.

Long Baseline Neutrino Program / 31

Results From the Joint Fit to ν_e Appearance and ν_μ Disappearance in NOvA

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NOvA is a long baseline neutrino oscillation experiment at Fermilab. It uses two detectors, the Near Detector at Fermilab and the Far Detector at a distance of 810 km at Ash River, Minnesota.These two functionally identical liquid scintillator calorimeters are 14 mrad off-axis from the beam, providing a neutrino flux narrowly peaked at around 2 GeV. NOvA measures the rate of ν_e appearance and ν_μ disappearance at the Far Detector in the ν_μ beam produced by the NuMI facility at Fermilab.
In this talk,I will present the latest NOvA results from a joint fit to ν_μ disappearance and ν_e appearance. This talk will focus on the ν_e appearance analysis. The latest data set had 6.05×10^{20} protons-on-target and we observed 33 ν_e candidate events over 8.2 predicted background events in our Far Detector. I will describe the fit to the FD data and discuss constraints on δ_{CP} , mass-hierarchy and the octant of the θ_{23} mixing angle.

Short Baseline Neutrino Program / 26

SBND in 10 minutes

Author: Nicola McConkey[1]

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SBND is the Short Baseline Near Detector, which is a 112 ton liquid argon time projection chamber (TPC) that will be located 110m from the target of the Fermilab Booster Neutrino Beam. SBND,

together with MicroBooNE and ICARUS-T600 detectors at 470m and 600m, respectively, make up the Fermilab Short Baseline Program (SBN).

SBN will search for new physics in the neutrino sector by testing the sterile neutrino hypothesis in the 1 eVˆ2 mass-squared region with unrivaled sensitivity. SBND will measure the un-oscillated beam flavor composition to enable precision searches for neutrino oscillations via both electron neutrino appearance and muon neutrino disappearance in the far detectors. With a data sample of millions of neutrino interactions (both electron and muon neutrinos), SBND will also perform detailed studies of the physics of neutrino-argon interactions, even in rare channels. In addition, SBND plays an important role in an on-going R&D effort within neutrino physics to develop the LArTPC technology toward many-kiloton-scale detectors for next generation long-baseline neutrino oscillation experiments

The SBND detector is currently under construction; this talk will give an overview of the current experimental efforts and future outlook, putting this in the context of the current neutrino landscape.

Short Baseline Neutrino Program / 34

Search For Sterile Neutrinos At The NOvA Near Detector

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Anomalous results from past neutrino experiments have been interpreted as potential evidence for an additional sterile neutrino with a mass on order of 1 eV, but this evidence remains inconclusive. The NOvA Near Detector is a 300 ton almost fully-active fine-grained liquid scintillator detector, that was designed for electron-neutrino identification. The detector is placed along the Fermilab NuMI beam line 1 km from the target and 14.6 mrad off-axis. At this off-axis angle, the detector is exposed to a narrow band beam peaked at 2 GeV. Therefore the NOvA Near Detector will see neutrinos with an L/E range that is sensitive to oscillations between active neutrinos and light sterile neutrinos. In this talk I discuss NOvA sensitivity from the joint electron-neutrino appearance and muon-neutrino disappearance analysis search for short-baseline sterile neutrino mixing.

Collider Physics / 47

Search for Heavy Resonancs Decaying to diHiggs Pairs in pp Collisions at sqrt(s) = 13 TeV

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A search for heavy resonances decaying into pairs of standard model Higgs bosons is performed using 35.9 fb^{-1} of data collected by the CMS experiment during 2016 at a center of mass energy of 13 TeV. The final state consists of both Higgs bosons decaying to b quark-antiquark pairs. Results are consistent with the Standard Model expectations and are interpreted as upper limits on the production cross sections of narrow bulk gravitons and scalar radions in warped extradimensional models.

Collider Physics / 52

Search for light vector resonances decaying to quarks produced in association with a jet in pp collisions

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A search for narrow vector resonances decaying to quarks is presented using events collected in sqrt(s) = 13 TeV proton-proton collisions with the CMS detector at the LHC. The data sample, collected in 2016, corresponds to an integrated luminosity of 35.9 fb−1. The hypothetical resonance is produced with high transverse momentum such that the decay products of the resonance are merged into a single jet. The resulting experimental signature is an enhancement over background processes in the distribution of the invariant mass of the jet. No evidence for resonant particles are observed within the targeted mass range from 50-300 GeV. Upper limits at a 95% confidence level are set on the production cross-section of leptophobic vector resonances. Results are presented in a mass-coupling phase space and are the most sensitive to date, extending previous limits below 100 GeV. The limits are also presented as functions of dark matter mass, in a simplified model of interactions between quarks and dark matter with a vector mediator.

Collider Physics / 12

Search for low-mass pair-produced dijet resonances using jet substructure techniques in proton-proton collisions at $\sqrt{s} = 13$\TeV

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We present a search for low mass paired dijet resonances using jet substructure techniques. This search uses data from proton-proton collisions at a center-of-mass energy of 13~TeV, recorded by the CMS detector at the LHC. Limits at 95% confidence level are set on the production of top squarks decaying to two quarks in the framework of R-parity violating supersymmetry.

Neutrino Interaction Physics / 22

Single neutral pion production on MINERvA using ME beam

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MINERvA is a neutrino scattering experiment that uses the NuMI beamline with the goal of measuring neutrino-nucleus cross sections on targets of different materials with high precision, as well as studying the internal structure of the nuclei of those materials. Among the different kinds of neutrino interactions that could occur in the detector, charged and neutral pion production are significant since they represent a large fraction of the events that can be detected. In particular, the study of single neutral pion production in multiple targets acquires relevance since not only will it provide constraints to the systematic errors of appearance and disappearance oscillation results in the range of energies of NOvA and DUNE, but also it will help to understand and compare the underlying structure of these nuclei. A previous result on this topic using a Low Energy antineutrino beam of 3.6 GeV in plastic scintillator has been published in 2015 by the MINERvA experiment. This time, I will present the current status of the single neutral pion production in C, Fe and Pb targets using a 6 GeV neutrino beam; and the future steps in order to get a precise cross section measurement on these materials.

Collider Physics / 37

Sterile Neutrino Search with the PROSPECT Experiment

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PROSPECT is a short-baseline reactor antineutrino experiment with primary goals of performing a search for sterile neutrinos and making a precise measurement of 235U reactor antineutrino spectrum from the High Flux Isotope Reactor at Oak Ridge National Labo- ratory. PROSPECT will provide a model-independent oscillation measurement of electron antineutrinos by comparing the observed antineutrino spectrum at several baselines. By covering the baselines of 7-12 m, the PROSPECT experiment will be able to address the current eV-scale sterile neutrino oscillation best-fit region within a single year of data-taking and covers a major portion of suggested parameter space within 3 years. In this talk, we describe the PROSPECT oscillation fitting framework and expected detector sensitivity to the oscillations arising from eV-scale sterile neutrinos.

Short Baseline Neutrino Program / 40

Sterile Neutrinos: A Possible Explanation for Oscillation Excesses

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Neutrino oscillations have provided proof of the existence of massive neutrino states. The standard model currently accepts the existence of three different neutrinos, but oscillation experiments such as LSND and MiniBooNE have detected an excess of neutrinos above that expected from a standard 3 neutrino model. We will discuss this excess, and explain how an explanation could lie in the existence of additional, sterile (non-interacting), neutrino states. We will then present the latest results in our constraints for the parameters space of sterile neutrinos given the global data on oscillations.

Long Baseline Neutrino Program / 27

Sterile neutrino search in the NOvA Far Detector.

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The majority of neutrino oscillation experiments have obtained evidence for neutrino oscillations that are compatible with the three-flavor model. Explaining the apparent neutrino flavor change observed in short-baseline experiments such as LSND and MiniBooNE in terms of neutrino oscillations requires the existence of sterile neutrinos.
The search for sterile neutrino mixing conducted in NOvA is unique that it uses a long base-line of 810 km between Near Detector at Fermilab and Far Detector at Minnesota, with a well-defined neutrino beam peaked at an energy of 2 GeV. The tell-tale signal for sterile neutrino oscillations in NOvA is a deficit of neutral-current neutrino interaction at the Far Detector with respect to the Near Detector prediction. The neutral-current rate is insensitive to three-flavor oscillations, so such a deficit would indicate some of the beam muon neutrinos oscillated into non-interacting sterile neutrinos. I will present the first results of this search which demonstrate NOvA's ability to look for sterile neutrinos, and will discuss the improvements being readied for future analyses.
These improvements include a shape fit of the Far Detector energy spectrum, enabled by improved modeling of the detector response and of neutrino interactions, and a joint fit of the Far and Near detectors, extending the range of sterile mass-squared splittings NOvA can probe to larger values.

Collider Physics / 62

Supersymmetry searches in all-hadronic channel

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Presenting on searchs for the direct production of top squarks in events with multiple jets and large missing transverse energy, using 35.9 fb−1 of data collected by the CMS detector in 2016 at a center-of-mass energy of 13 TeV. Events are categorized into exclusive search regions optimized for different signal topologies. Discussing analysis that use multi variant techniques to identify tops and w's. Exclusion limits are set in the context of simplified models of top squark pair production under different decay hypotheses.

Short Baseline Neutrino Program / 51

Testing, Installation, Integration and Performance Studies of a Cosmic Ray Tagging System for the Short Baseline Neutrino Program Far Detector (ICARUS)

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The ICARUS T600 liquid argon time-projection chamber will be the far detector for the Short Baseline Neutrino Program. The detector will operate at shallow depth and therefore be exposed to the

full surface flux of cosmic rays. Application of overburden attenuates most of this background expected for muons. However, the remaining background is problematic since a photon produced by a muon passing in close proximity to the T600 active volume can be mistaken for a neutrino event. In principle, a large fraction of these events can be removed from the data through application of selection cuts as suggested by Monte Carlo studies. However, this method of background rejection reduces fiducial target mass and renders analysis of the systematics
difficult.

`A straightforward way to remove the cosmic muon background more thoroughly is to utilize a detecto`

Monte Carlo studies of the tagging efficiencies of the system and conducted an extensive research and development program of such a system based on extruded organic scintillator, wavelength-shifting fibers, and silicon photomultipliers. Subsequently, it was decided that our European colleagues would design and construct the top portion of the CRT while the US groups would provide the side (˜400 mˆ2) and bottom (˜215 mˆ2) portions using salvaged MINOS veto shield modules on the sides and Double Chooz veto modules on the bottom. These two systems will need to be tested for basic functionality and to have their detailed response characterized in order to optimize the system configuration as well as prepare for future analysis tasks and integration with the other detector sub-systems.

Muon Physics etc / 55

The Muon g-2 experiment at Fermilab

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Precise measurements of the anomalous magnetic moment, a = (g - 2)/2, of the muon provide strong tests of the Standard Model, and are more sensitive to physics beyond the Standard Model than measurements of the electron anomalous magnetic moment. The most recent measurement of the muon magnetic moment at Brookhaven E821 has hinted at new physics, with its result differing from theoretical calculations by over three standard deviations, with an uncertainty of 540 ppb. The new Fermilab E989 experiment seeks to improve on both the statistical and systematic errors of the measurement with a projected uncertainty of 140 ppb, which represents a four-fold improvement on the Brookhaven result. The experiment will use the high intensity muon beam at the new Fermilab muon campus, and store polarized muons in a magnetic storage ring. The magnetic field with be monitored by an array of calibrated NMR probes; calorimeters will measure muon decays as they travel around the ring, which indicates the spin direction. The combined measurements of the magnetic field and muon precession rate can be used to calculate the anomalous magnetic moment. A general overview of the theoretical motivation, experimental techniques, and possible implications of the experiment will be presented.

Dark Matter and Astrophysics / 65

The physical origin of long gas depletion times in galaxies

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[https://arxiv.org/abs/1704.04239]
We present a physical model that elucidates why gas depletion times in galaxies are long compared to the time scales of the processes driving the evolution of the interstellar medium. We show that global depletion times are not set by any "bottleneck" in the process of gas evolution towards the star-forming state. Instead, depletion times are long because star-forming gas converts only a small fraction of its mass into stars before it is dispersed by dynamical and feedback processes. Thus, complete depletion requires that gas transitions between star-forming and non-star-forming states multiple times. Our model does not rely on the assumption of equilibrium and can be used to interpret trends of depletion times with the properties of observed galaxies and the parameters of star formation and feedback recipes in galaxy simulations. In particular, the model explains the mechanism by which feedback self-regulates star formation rate in simulations and makes it insensitive to the local star formation efficiency. We illustrate our model using the results of an isolated L_*-sized disk galaxy simulation that reproduces the observed Kennicutt-Schmidt relation for both molecular and atomic gas. Interestingly, the relation for molecular gas is close to linear on kiloparsec scales, even though a non-linear relation is adopted in simulation cells. This difference is due to stellar feedback, which breaks the self-similar scaling of the gas density PDF with the average gas surface density.

Short Baseline Neutrino Program / 75

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