NuInt 2022

Report of Contributions

https://indico.cern.ch/e/881216

Contribution ID: **21** Type: **Talk**

High-energy neutrino measurements with FASERnu at the LHC

Friday, October 28, 2022 4:20 PM (20 minutes)

FASERν at the LHC is designed to directly detect collider neutrinos of all three flavors and provide new measurements of their cross-sections at energies higher than those detected from any previous artificial sources. In the pilot run data taken in 2018, we observed the first neutrino interaction candidates at the LHC, paving the way for studying neutrinos from high-energy colliders. In 2022-2025, during LHC Run 3, we expect to collect ∼2,000 ν_e, ∼6,000 ν_μ, and ∼40 ν_τ charged-current interactions in FASERν, along with neutral-current interactions. We installed the first physics run module into the tunnel in March 2022 and conducted the first exchange of the modules in July 2022. Here we present the latest results from FASERν.

Primary author: ARIGA, Tomoko (Kyushu University (JP))

Presenter: Dr HAYAKAWA, Daiki (Chiba University (JP))

Session Classification: Future Experiments 2

Contribution ID: **22** Type: **Talk**

Measuring coherent elastic neutrino-nucleus scattering in argon with a scintillating bubble chamber

Thursday, October 27, 2022 9:45 AM (20 minutes)

The scintillating bubble chamber is a new technology under development ideal for coherent elastic neutrino-nucleus scattering (CEνNS) detection at reactor sites. The SBC collaboration is building a 10-kg bubble chamber using liquid argon with the potential to reach and maintain sub-keV energy thresholds. This detector will combine the event-by-event energy resolution of a liquid noble scintillation detector with the leading electron-recoil discrimination capability of the bubble chamber. The CEνNS physics program of this detector will be presented in this talk, including the sensitivity to the weak mixing angle, neutrino magnetic moment, and a light Z' gauge boson mediator, in addition to other sensitivity to New Physics scenarios such as light scalar mediators, sterile neutrino oscillations, unitarity violation, and non-standard interactions.

Primary author: VAZQUEZ-JAUREGUI, Eric

Presenter: VAZQUEZ-JAUREGUI, Eric

Session Classification: Coherent Neutrino Scattering

Contribution ID: **23** Type: **Talk**

EstrellaNueva: an open-source software to study the interactions and detection of neutrinos emitted by supernovae

Wednesday, October 26, 2022 4:30 PM (20 minutes)

Supernovae emit large fluxes of neutrinos which can be detected by detectors on Earth. Future tonne-scale detectors will be sensitive to several neutrino interaction channels, with thousands of events expected if a supernova emerges in the galaxy neighborhood. There are limited tools to study the interaction rates of supernova neutrinos, although a plethora of available supernova models exist. EstrellaNueva is an open-source software to calculate expected rates of supernova neutrinos in detectors using a variety of target materials. This software considers the flavor transformation of neutrinos in the supernova through the adiabatic Mikheyev–Smirnov–Wolfenstein effect, and their interaction in detectors through several channels. Most of the interaction cross sections are analytically implemented, such as neutrino-electron and neutrino-proton elastic scattering, inverse beta decay, and coherent elastic neutrino-nucleus scattering. This software provides a link between supernova simulations and the expected events in detectors by calculating fluences and event rates to ease any comparison between theory and observation. This simple and standalone tool to explore many physics scenarios will be presented in this talk.

Primary author: VAZQUEZ-JAUREGUI, Eric

Presenter: VAZQUEZ-JAUREGUI, Eric

Session Classification: Low Energy Scattering

Contribution ID: **24** Type: **Talk**

QED radiative corrections and nuclear medium effects at GeV energies

Monday, October 24, 2022 4:30 PM (20 minutes)

We consider charged-current neutrino scattering on individual nucleons. Exploiting effective field theory, we factorize neutrino-nucleon cross sections into soft, collinear, and hard contributions. We evaluate soft and collinear functions from QED, provide a model for the hard contribution with expected infrared and collinear behavior and specify corresponding uncertainties. We present results of the calculation and validate precise relation between electron and muon neutrino cross sections at GeV energy range. Moreover, we consider how the exchange of photons with nuclear medium modifies (anti)neutrino- and electron-nucleus scattering cross sections. We provide analytical expressions for the distortion of (anti)neutrino-nucleus and charged lepton-nucleus cross sections and estimate the QED-medium effects at GeV energies. We find new permille-level distortion in (anti)neutrino-nucleus scattering and permille- to percent-level corrections in electron-nucleus scattering. We discuss how the bremsstrahlung modifies these conclusions.

Primary author: TOMALAK, Oleksandr

Co-authors: WRET, Clarence; Dr VITEV, Ivan; MCFARLAND, Kevin (University of Rochester); Dr CHEN, Qing (Interdisciplinary Center for Theoretical Study, University of Science and Technology of China, Hefei, Anhui 230026, China); HILL, Richard

Presenter: TOMALAK, Oleksandr

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 2

Contribution ID: **25** Type: **Talk**

What mean-field models can offer to the neutrino interaction community (ONLINE)

Monday, October 24, 2022 4:50 PM (25 minutes)

Within the framework of a relativisitic mean-field approach, I will discuss some relevant nuclear effects that affect neutrino-nucleus cross sections at the energies of interest for neutrino-oscillation experiments, such as Pauli blocking, binding energies and hadron final state interactions. I will stress the differences between this relativistic and quantum mechanical approach and the models and methodology that is inside the Monte Carlo neutrino event generators. The results that I will presennt are mainly based on our recent articles: PRL 123, 052501 (2019); PRC 100, 045501 (2019); PRC 105, 025502 (2022); PRC 105, 054603 (2022); arXiv:2203.09996; arXiv:2207.02086v1.

Presenter: Prof. GONZALEZ JIMENEZ, Raul (Complutense University of Madrid)

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 2

Contribution ID: **26** Type: **Talk**

Extraction of the Transverse Enhancement and Longitudinal Suppressio of quasielastic scattering data (ONLINE)

Tuesday, October 25, 2022 10:00 AM (20 minutes)

Reliable modeling of quasielastic (QE) lepton scattering on nuclei is of great interest to neutrino oscillations experiments, especially at low values of the 3-momentum transfer $\mathbf{q}$. We report on a phenomenological fit to all available electron scattering data on $^{12}_{6}\mathrm{C}$ (about 8000 differential cross section measurements) and $^{12}_{\mathrm{O}}\mathrm{C}$ (about 250 measurements) within the framework of the superscaling model (including Pauli blocking). The fit can be used as benchmark for the validation of electron and neutrino Monte Carlo generators. We find that in addition to the expected enhancement of the transverse QE response function (R_T^{QE}), at low values of momentum transfer $\mathbf{q}$ there is "Extra Suppression" of the QE longitudinal response function (R_L^{QE}) beyond the expected suppression from Pauli blocking. We extract $|\mathbf{q}|$ dependent parameterizations that can be used to determine the "Extra Suppression" factor and the "Transverse Enhancement" for any nucleon momentum distribution for use in electron and neutrino Monte Carlo generators, We obtain the best measurement of the inelastic Coulomb Sum Rule $S_L(\mathbf{q})$ for $|\mathbf{q}| < \mathbf{0.8}$ GeV . The measured $S_L(\mathbf{q})$ for $^{12}_{6}\mathrm{C}$ is consistent with but somewhat lower than the Lovato 2000 "First Principle Green's Function MC" calculation. $S_L(\mathbf{q})$ for $^{16}_{8}\mathrm{O}$ is consistent with being equal to to $S_L(\mathbf{q})$ for $^{12}_{6}\mathrm{C}$. It is consistent with but somewhat higher than the Sobczyk 2020 "coupled-cluster with singles-and doubles (CCSD) NNLO$_{sat}$" calculation. The contribution of nuclear excitations to $S_L(\mathbf{q})$ is significant (up to 29\%) and we provide parameterizations of the form factors for the electro-excitation of nuclear states in $^{12}_{6}\mathrm{C}$ and $^{16}_{8}\mathrm{O}$.

Primary author: BODEK, Arie (University of Rochester (US))

Co-author: Dr CHRISTY, M. Eric (Thomas Jeerson National Accelerator Facility)

Presenter: BODEK, Arie (University of Rochester (US))

Session Classification: Electron-Nucleus Scattering

Contribution ID: **27** Type: **Poster**

Poster: Neutrons from Antineutrino Interactions in MINERvA

Wednesday, October 26, 2022 3:30 PM (5 minutes)

Neutron production by antineutrino interactions is an important source of uncertainty for long baseline oscillation experiments. Neutrons are a source of missing energy for calorimetry-based oscillation experiments, and an extra neutron from an antineutrino CCQE-like interaction can be evidence of a 2p2h interaction. Both problems bias oscillation measurements' energy estimators, yet few experiments have studied neutron production by GeV antineutrinos.

The MINERvA collaboration demonstrated its detector's neutron detection capability in 2016 and observed discrepancies in neutron production rate that persist into MINERvA's medium energy data and across target nuclei. This poster describes an antineutrino multi-neutron production cross section analysis that will provide a detector- and model-independent measure of any discrepancies in neutron production rate. The multi-neutron sample is predicted to be particularly sensitive to 2p2h and FSI effects.

Primary author: OLIVIER, Andrew

Presenter: OLIVIER, Andrew

Session Classification: Poster under break time

Contribution ID: **28** Type: **Talk**

ENUBET: a monitored neutrino beam for high precision cross section measurements

Tuesday, October 25, 2022 2:50 PM (20 minutes)

The main source of systematic uncertainty on neutrino cross section measurements at the GeV scale is represented by the poor knowledge of the initial flux. The goal of cutting down this uncertainty to 1% can be achieved through the monitoring of charged leptons produced in association with neutrinos, by properly instrumenting the decay region of a conventional narrow-band neutrino beam. Large angle muons and positrons from kaons are measured by a sampling calorimeter on the decay tunnel walls (tagger), while muon stations after the hadron dump can be used to monitor the neutrino component from pion decays. This instrumentation can provide a full control on both the muon and electron neutrino fluxes at all energies. Furthermore, the narrow momentum width (<10%) of the beam provides a $\mathcal{O}(10\%)$ measurement of the neutrino energy on an event by event basis, thanks to its correlation with the radial position of the interaction at the neutrino detector. The ENUBET project has been funded by the ERC in 2016 to prove the feasibility of such a monitored neutrino beam and is cast in the framework of the CERN neutrino platform (NP06) and the Physics Beyond Colliders initiative.

The ERC project has entered its last year and the efforts are now devoted to the final tuning of the beamline shielding elements. These studies are being pursued exploiting a powerful genetic algorithm that scans automatically the parameter space of the focusing beamline in order to find a configuration minimizing halo particles in the tagger while preserving a large meson yield. Realistic particle identification algorithms have been setup to reconstruct muons and positrons in the decay tunnel with high signal to noise ratio on an event by event basis. A full Geant4 simulation of the facility is employed to assess the final systematics budget on the neutrino fluxes with an extended likelihood fit of a model where the hadro-production, beamline geometry and detector-related uncertainties are parametrized by nuisance parameters. In parallel the collaboration is building a section of the decay tunnel instrumentation ("demonstrator", 1.65m in length, 7 ton mass) that will be exposed to the T9 particle beam at CERN-PS in autumn 2022, for a final validation of the detector performance and as a proof of the effectiveness of the technique.

In 2019-2022 ENUBET has devised the first end-to-end simulation of the facility and demonstrated that the precision goals can be achieved in about three years of data taking employing neutrino detectors of moderate mass (ICARUS at FNAL, ProtoDUNE at CERN). The technology of a monitored neutrino beam has been proven to be feasible and cost-effective, and the complexity does not exceed significantly the one of a conventional short-baseline beam. The ENUBET results will play an important role in the systematic reduction programme of future long baseline experiments, thus enhancing the physics reach of DUNE and HyperKamiokande. In our contribution, we summarize the ENUBET design, physics performance and opportunities for its implementation in a timescale comparable with next long baseline neutrino experiments.

Presenter: Prof. LONGHIN, Andrea (Universita e INFN, Padova (IT))

Session Classification: Neutrino Flux

Contribution ID: **29** Type: **Talk**

CC Neutrino-nucleus cross-section tuning in GENIE v3

Wednesday, October 26, 2022 11:30 AM (20 minutes)

This talk presents the latest GENIE tuning of CC0π datasets from MiniBooNE, T2K and MINERvA. A partial tune for each experiment is performed, providing a common base for the discussion of tensions between datasets. The results offer an improved description of nuclear CC0π datasets as well as data-driven uncertainties for each experiment. This work is a step towards a GENIE global tune that improves our understanding of neutrino interactions on nuclei. It follows from earlier GENIE work on the analysis of neutrino scattering datasets on hydrogen and deuterium.

Primary author: TENA VIDAL, Julia

Presenter: TENA VIDAL, Julia

Session Classification: Neutrino CC and NC Scattering without Pion Production 2

Contribution ID: **30** Type: **Talk**

Measurements of electron neutrino interactions at the NOvA near detector

Monday, October 24, 2022 2:25 PM (20 minutes)

NOvA is a long-baseline neutrino oscillation experiment designed to measure the $\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillation rates for subsequent extraction of the oscillation parameters of the 3-flavor PMNS model. The NOvA detectors are exposed to Fermilab's NuMI beam, the most powerful accelerator-based neutrino beam in the world. In addition to producing competitive measurements oscillation parameters, the intense neutrino flux from NuMI enables a rich Near Detector (ND) physics program in the range of 1 - 10 GeV of neutrino energy.

The (anti)neutrino flux from NuMI at the Near Detector (ND) is composed of 95%(92%) muon- and 1%(1%) electron-type, respectively, at an average energy of 2 GeV. The NOvA detectors are functionally-identical tracking calorimeters that sit 14 mRad off-axis from the NuMI beam line. Extruded PVC modules filled with liquid scintillator make up the active mass of the detectors, which are composed mostly of CH_2. The detectors' composition and configuration are designed to maximize electron/muon separation capabilities and sensitivity to the leptonic CP-violating phase, δ_{CP}.

NOvA's energy range and heavy nuclear targets offer a unique opportunity to study the nuclear effects of $\nu - A$ interactions with high statistics (anti-)ν_μ and (anti-)ν_e samples. We present three measurements of electron neutrino interaction channels in the NOvA ND: (1) recently published results of the first-ever double-differential charged-current (CC) inclusive electron neutrino cross section featuring a novel signal estimation procedure; (2) the status of a complementary double-differential CC inclusive electron antineutrino cross section with data-driven constraint of ν_e CC background; (3) and the status of a measurement of the elastic neutrino-electron scattering rate with the potential to constrain the flux uncertainties from the NuMI beam.

Primary author: DOYLE, Derek (Colorado State University)

Presenter: DOYLE, Derek (Colorado State University)

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 1

Contribution ID: **31** Type: **Talk**

Form factor and Model Dependence in Neutrino-Nucleus Cross Section Predictions

Wednesday, October 26, 2022 12:10 PM (20 minutes)

The next generation of neutrino oscillation experiments require precise predictions of neutrino-nucleus cross sections as well as control over their uncertainties, including the contribution of model dependence to the overall error budget. To this end we compare two methods of computing $CC0\pi$ flux folded cross sections; an ab-initio method based on Greens Function Monte Carlo, and a Quantum Monte Carlo based SF with extended factorization scheme. Both models share the same underlying description of nuclear dynamics, but differ in their treatment of relativistic effects, interference terms, and the nuclear ground state. We compare these two models against flux folded differential cross sections from MiniBoone and T2K. This is the first comparison of the QMC based SF with neutrino scattering data. In addition we evaluate the effect of different parameterizations of the Axial form factor, including predictions from Lattice QCD.

Primary author: STEINBERG, Noah (Fermi National Accelerator Laboratory)

Presenter: STEINBERG, Noah (Fermi National Accelerator Laboratory)

Session Classification: Neutrino CC and NC Scattering without Pion Production 2

Contribution ID: **32** Type: **Talk**

Measurement of muon neutrino CC inclusive double differential cross section in hadronic variables using NOvA

This talk presents a measurement of the double-differential cross section for inclusive, charged-current νμ-nucleus scattering in the predominantly hydrocarbon medium of the NOvA near detector. The cross section is expressed in terms of 3-momentum transfer and available hadronic energy, variables well-suited to elicit the 2-particle-2-hole (2p2h) contribution in the 1-3 GeV region of incident neutrino energy. The cross section is compared to GENIE-based Monte Carlo predictions based on five different 2p2h implementations. The models are further tested by restricting to a phase space region where 2p2h is observed to be prevalent.

Primary author: OLSON, Travis (University of Houston)

Presenter: OLSON, Travis (University of Houston)

Session Classification: Neutrino CC and NC Scattering without Pion Production 3

Contribution ID: **33** Type: **Talk**

Neutrino-Argon Cross-Section Measurements Using the NuMI Neutrino Beam at ICARUS

Friday, October 28, 2022 2:40 PM (20 minutes)

The ICARUS experiment, employing a LAr TPC, has been installed at Fermilab in Chicago, Illinois after its original run in Italy and subsequent refurbishment and is now in a stage of advanced commissioning and preparation for analyses. While a main goal of the detector is to serve as the far detector of the Short Baseline Neutrino program searching for sterile neutrino signatures, ICARUS has a broader physics program –for example beyond standard model searches and cross-section measurements. In particular, ICARUS is situated off-axis of the NuMI beam and will be sensitive to a large amount of muon and electron neutrinos produced in the range of a few hundred MeV to a few GeV. These interactions can provide the basis for important neutrino-LAr cross-section measurements and tests of models in an energy range that overlaps with both the SBN oscillation search and part of the DUNE spectrum. This talk will discuss aspects and goals of NuMI cross-section measurements with ICARUS and will highlight some of the status and plans of the effort, for example, reconstruction, selection, and analysis.

Primary author: Dr DOLAN, Stephen (CERN)

Presenter: Dr DOLAN, Stephen (CERN)

Session Classification: Future Experiments 1

Contribution ID: **34** Type: **Talk**

Status of the Short-Baseline Near Detector at Fermilab

Friday, October 28, 2022 2:00 PM (20 minutes)

The Short-Baseline Near Detector (SBND) will be one of three Liquid Argon Time Projection Chamber (LArTPC) neutrino detectors positioned along the axis of the Booster Neutrino Beam (BNB) at Fermilab, as part of the Short-Baseline Neutrino (SBN) Program. The detector is currently in the construction phase and is anticipated to begin operation in 2023. SBND is characterized by superb imaging capabilities and will record over a million neutrino interactions per year. Thanks to its unique combination of measurement resolution and statistics, SBND will carry out a rich program of neutrino interaction measurements and novel searches for physics beyond the Standard Model (BSM). It will enable the potential of the overall SBN sterile neutrino program by performing a precise characterization of the unoscillated event rate, and constraining BNB flux and neutrino-argon cross-section systematic uncertainties. In this talk, the physics reach, current status, and future prospects of SBND are discussed.

Primary authors: Dr BLAKE, Andy (Lancaster University); Dr CASTILLO-FERNANDEZ, Raquel (University of Texas at Arlington); Dr JONES, Rhiannon (The University of Sheffield); Dr PANDEY, Vishvas (Fermilab)

Presenter: BALASUBRAMANIAN, Supraja

Session Classification: Future Experiments 1

Contribution ID: **35** Type: **Talk**

Neutrino Interaction Measurement Capabilities of the SBND Experiment

Friday, October 28, 2022 2:20 PM (20 minutes)

The Short-Baseline Near Detector (SBND) is a 100-ton scale Liquid Argon Time Projection Chamber neutrino detector positioned in the Booster Neutrino Beam at Fermilab, as part of the Short-Baseline Neutrino (SBN) program. The detector is currently under construction and is anticipated to begin operation in 2023. Located only 110 m from the neutrino production target, it will be exposed to a very high flux of neutrinos and will collect millions of neutrino interactions each year. This huge number of neutrino interactions with the precise tracking and calorimetric capabilities of liquid argon will enable a wealth of cross section measurements with unprecedented precision. In addition, SBND has the unique characteristic of being remarkably close to the neutrino source and not perfectly aligned with the neutrino beamline, in such a way that allows sampling of multiple neutrino fluxes using the same SBND detector, a feature known as SBND-PRISM. SBND-PRISM can be utilized to study distinctive neutrino-nucleus interactions channels. This talk will present the current status of the experiment along with expectations for a rich cross section measurement program ahead.

Primary author: YATES, Lauren (Fermilab)

Co-authors: Dr FURMANSKI, Andy (University of Minnesota); Dr PANDEY, Vishvas (Fermilab)

Presenter: YATES, Lauren (Fermilab)

Session Classification: Future Experiments 1

Contribution ID: **36** Type: **Talk**

Exploring Neutrino Interaction Physics with MicroBooNE

Monday, October 24, 2022 11:45 AM (25 minutes)

The MicroBooNE liquid argon time projection chamber (LArTPC) experiment operated in the Fermilab Booster Neutrino and Neutrinos at the Main Injector beams from 2015-2021. Among the major physics goals of the experiment is a detailed investigation of neutrino-nucleus interactions. MicroBooNE currently possesses the world's largest neutrino-argon scattering data set, and more than 30 ongoing analyses are studying a wide variety of interaction modes. This talk provides an overview of MicroBooNE's neutrino cross-section physics program, highlighting recent results and upcoming measurements.

Primary author: PAPADOPOULOU, Afroditi

Presenters: QIAN, Xin (Brookhaven National Laboratory); QIAN, Xin (Brookhaven National Laboratory (US))

Session Classification: Highlights on Neutrino-Nucleus Interactions

Contribution ID: **37** Type: **Talk**

First Measurement of Double-Differential CC νμ−Argon Scattering Cross Sections In Kinematic Imbalance Variables With The MicroBooNE Detector

Wednesday, October 26, 2022 10:50 AM (20 minutes)

Making high-precision measurements of neutrino oscillation parameters requires an unprecedented understanding of neutrino-nucleus scattering. In this work, we present the progress towards the first charged current double-differential cross sections in kinematic imbalance variables. These variables characterize the imbalance in the plane transverse to an incoming neutrino. We use events with a single muon above 100 MeV/c, a single final state proton above 300 MeV/c, and no recorded final state pions. Thus, they act as a direct probe of nuclear effects such as final state interactions, Fermi motion, and multi-nucleon processes. Our measurement allows us to constrain systematic uncertainties associated with neutrino oscillation results performed by near-future experiments of the Short Baseline Neutrino (SBN) program, as well as by future large-scale experiments like DUNE.

Primary author: PAPADOPOULOU, Afroditi

Presenter: PAPADOPOULOU, Afroditi

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **38** Type: **Talk**

Measurements of inclusive CC muon neutrino scattering in MicroBooNE

Wednesday, October 26, 2022 10:30 AM (20 minutes)

One of the main physics goals of the MicroBooNE experiment at Fermilab is to perform high-statistics measurements of neutrino-argon interaction cross sections. These measurements will be essential for future neutrino oscillation experiments, including the Short-Baseline Neutrino program and the Deep Underground Neutrino Experiment, to achieve an unprecedented level of precision. Inclusive cross-section data provide an important overall benchmark for the interaction modeling. In this talk, we present the latest muon-neutrino-argon cross-section measurements in MicroBooNE, with special emphasis on hadronic observables.

Primary author: COOPER-TROENDLE, London

Presenter: COOPER-TROENDLE, London

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **39** Type: **Talk**

Neutrino-induced two-proton knockout in MicroBooNE

Wednesday, October 26, 2022 2:50 PM (20 minutes)

The MicroBooNE detector is the world's longest-running liquid argon time projection chamber (LArTPC) and recently completed operating in the Fermilab Booster Neutrino Beam. One of the primary physics goals of MicroBooNE is to perform detailed studies of neutrino-argon scattering cross sections, which are critical for the success of future neutrino oscillation experiments. At neutrino energies relevant for the Short-Baseline Neutrino Program, the most plentiful event topology involves final states without visible mesons, and containing one or more protons. A low reconstruction threshold enabled by the LArTPC technology has allowed MicroBooNE to pursue various analyses studying neutrino-induced proton production at accelerator energies. This talk presents results from those efforts, including first cross-section measurements from MicroBooNE for exclusive two-proton final states.

Primary author: PAPADOPOULOU, Afroditi

Presenters: Dr KIRBY, Michael Hudson (Fermi National Accelerator Lab. (US)); KIRBY, Michael (Fermi National Accelerator Laboratory)

Session Classification: Neutrino CC and NC Scattering without Pion Production 3

Contribution ID: **40** Type: **Talk**

Measurements of pion production at MicroBooNE (ONLINE)

Friday, October 28, 2022 9:25 AM (20 minutes)

MicroBooNE is a 100-ton-scale liquid argon TPC that ran in the Fermilab Booster Neutrino Beam from 2015-2021. MicroBooNE has recorded hundreds of thousands of neutrino interactions, many of which include pions in the final state. In particular, neutral pions are a key background to any search for low-energy electron neutrinos and sub-GeV signatures of physics beyond the Standard Model. Thus, measurements of pion production are useful for the broader Short Baseline Neutrino program and the future Deep Underground Neutrino experiment. This talk will present measurements of event topologies containing pions at MicroBooNE, including both charged- and neutral-current channels.

Primary author: FINE, Rob (Los Alamos National Laboratory)

Presenters: FINE, Rob (Los Alamos National Laboratory); FINE, Rob (Los Alamos National Laboratory)

Session Classification: Neutrino Pion Productions

Contribution ID: **41** Type: **Talk**

Neutrino-Argon Cross Sections for Rare Processes in MicroBooNE

Friday, October 28, 2022 11:40 AM (20 minutes)

The MicroBooNE detector is a liquid argon time projection chamber (LArTPC) that operated in both the Booster Neutrino and the Neutrinos at the Main Injector beams at Fermilab. The LArTPC detector technology provides excellent spatial resolution and particle discrimination capabilities. From 2015 through 2021, MicroBooNE accumulated the world's largest neutrino-argon scattering data set, which enables searches targeting rare interaction channels. An example of such a channel is the Cabibbo-suppressed production of hyperons in antineutrino-argon interactions, which provides sensitivity to a range of effects, including second class currents, SU(3) symmetry violations and reinteractions between the hyperon and the nuclear remnant. This talk presents the status of the MicroBooNE effort studying rare scattering processes, including progress towards the first measurement of muon-antineutrino-induced hyperon production on argon.

Primary author: PAPADOPOULOU, Afroditi

Presenter: THORPE, Christopher

Session Classification: Pions and Other Neutrino Interactions

Contribution ID: **42** Type: **Talk**

Measurements of Electron Neutrino Interactions in MicroBooNE

Wednesday, October 26, 2022 2:30 PM (20 minutes)

Measurements of neutrino-nucleus interactions provide an important benchmark for the theoretical models needed to perform precision neutrino oscillation analyses. An understanding of electron neutrino scattering is crucial for determination of charge parity (CP) violation in the leptonic sector. Potential mismodeling of these interactions can limit the sensitivity of forthcoming experiments like DUNE, and thus direct measurements of electron neutrino cross sections are invaluable. The MicroBooNE experiment is a liquid argon time projection chamber that collected data from both the Fermilab Booster and NuMI beamlines. This presentation will discuss measurements of electron neutrino cross sections in both beams, and in both inclusive and exclusive final states, and compare these results to the predictions from modern neutrino interaction generators.

Primary author: PAPADOPOULOU, Afroditi

Presenter: SZELC, Andrzej Michal (University of Edinburgh)

Session Classification: Neutrino CC and NC Scattering without Pion Production 3

Contribution ID: **43** Type: **Talk**

MK Single pion production model (online)

Friday, October 28, 2022 9:00 AM (25 minutes)

I have developed a single pion production model in neutrino-nucleon interaction:
https://inspirehep.net/literature/1634864 .
Then I used electron scattering data to extract the nucleon form factors:
https://inspirehep.net/literature/1802724 ,
and recently I extended the model to the transition region between resonance and Deep Inelastic regions (high momentum transfer, Qˆ2, and hadron invariant mass, W):
https://inspirehep.net/literature/2059726 ,
which is extremely important for neutrino oscillation experiments such as DUNE.

I presented the first article in the last NuInt but the two recent articles have not been presented before. Therefore, I would like to present my recent work at the NuInt workshop in Seoul.

Primary author: KABIRNEZHAD, Minoo (Imperial College London)

Presenter: KABIRNEZHAD, Minoo (Imperial College London)

Session Classification: Neutrino Pion Productions

Contribution ID: **44** Type: **Talk**

Electrons for Neutrino - the next generation

Tuesday, October 25, 2022 9:00 AM (30 minutes)

The ability of current and next generation accelerator based neutrino oscillation measurements to reach their desired sensitivity and provide new insight into the nature of our Universe, requires a high-level of understanding of the neutrino-nucleus interactions. These include precise estimation of the relevant cross sections and the reconstruction of the incident neutrino energy from the measured final state particles.
The electron for neutrinos collaboration leverages wide phase-space exclusive electron scattering data with known beam energies to test energy reconstruction methods and interaction models. The dedicated 2022 data taking run was preformed with beams at the same energy region and on similar nuclear targets as expected in the next generation of accelerator based neutrino oscillation experiments. The talk will summarise our recent results and and the data taking effort.

Primary author: STEINBERG, Noah (Fermi National Accelerator Laboratory)

Co-author: ASHKENAZI, Adi

Presenter: STEINBERG, Noah (Fermi National Accelerator Laboratory)

Session Classification: Electron-Nucleus Scattering

Contribution ID: **45** Type: **Talk**

Status of Neutrino-Water interaction measurements in the NINJA experiment

Wednesday, October 26, 2022 5:10 PM (20 minutes)

NINJA experiment aims to study Sub-Multi GeV neutrino-nucleus interactions and the exploration of a sterile neutrino using an Emulsion Cloud Chamber (ECC) as the main detector at J-PARC neutrino beamline.
Thanks to sub-micron spatial resolution and high granularity of ECC, charged particles such as slow protons with a momentum of 200 MeV/c can be measured with high detection efficiency.
Currently, we are analyzing neutrino-water interactions taken in our first physics run (J-PARC E71a) which was implemented in 2019-2020 with 250 kg ECC including a 75 kg water target to measure the multi-nucleon reaction in neutrino interaction and reduce the systematic uncertainties for current and future long-baseline neutrino oscillation experiments with a large water Cherenkov detector.
In this talk, we will show the current status of neutrino-water interaction analysis and preliminary results of muon and hadron kinematics measurements.

Primary author: FUKUDA, Tsutomu (Nagoya Univ.)

Co-author: THE NINJA, Collaboration

Presenter: FUKUDA, Tsutomu (Nagoya Univ.)

Session Classification: Low Energy Scattering

Contribution ID: **46** Type: **Talk**

Measurement of numu, numu-bar CC interactions on iron using a nuclear emulsion detector in the NINJA experiment

Monday, October 24, 2022 5:15 PM (20 minutes)

The NINJA experiment aims to study neutrino-nucleus interactions in the 1 GeV energy region with a nuclear emulsion-based detector. The nuclear emulsion is suitable for measuring the positions and angles of charged particles from neutrino interactions since it has a sub-μm spatial resolution. The sub-micron spatial resolution of the emulsion detector allows us to detect short tracks of low-momentum charged particles such as protons. (The momentum threshold for protons is down to 200 MeV/c).
Data in this presentation was taken from the exposure of a 65 kg iron target in 2016 to the neutrino and anti-neutrino beam corresponding to 4.0 x 10ˆ19 and 3.5 × 10ˆ20 protons on target. Based on 183 and 770 candidate events of neutrino and anti-neutrino charged-current interactions in the target, the multiplicities and kinematics of muons, charged pions, and protons emitted from the events were measured. The data were compared to Monte Carlo predictions, and some significant differences were observed in the anti-neutrino measurement.

Primary author: MINAMINO, Akihiro (Yokohama National University)

Co-author: THE NINJA, Collaboration

Presenter: MINAMINO, Akihiro (Yokohama National University)

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 2

Contribution ID: **47** Type: **Talk**

Muon antineutrino charged-current neutral pion production differential cross-section measurement in the NOvA near detector (ONLINE)

Friday, October 28, 2022 9:45 AM (20 minutes)

NOvA is a long-baseline neutrino oscillation experiment designed to measure muon (anti)neutrino disappearance and electron (anti)neutrino appearance in Fermilab's NuMI beam. It uses two functionally identical liquid scintillator detectors separated by 810km and a narrow band beam centered around $E_\nu = 2$ GeV. Energetic neutral pions produced in resonant, deep-inelastic, or final state interactions are a significant background to the electron (anti)neutrino appearance measurement due to the misidentification of photons from neutral pion decay as electrons(positrons). Using the high statistics antineutrino mode data, the near detector can be used to measure the differential cross section for muon antineutrino charged-current neutral pion production on a hydrocarbon target. The status of this measurement including a convolutional neural network to identify neutral pions in the final state, a data-driven template fit approach used to constrain backgrounds, and the expected systematic uncertainties will be presented.

Primary authors: NAPLES, Donna; GAO, Fan (University of Pittsburgh); JUDAH, Matthew (University of Pittsburgh (US))

Presenter: JUDAH, Matthew (University of Pittsburgh (US))

Session Classification: Neutrino Pion Productions

Contribution ID: **48** Type: **Talk**

Combined neutrino and antineutrino CC cross section measurement on carbon with zero final state pions in the T2K near detector complex

Wednesday, October 26, 2022 10:10 AM (20 minutes)

T2K is a long baseline neutrino oscillation experiment, located in Japan. A muon (anti)neutrino beam peaked at 600 MeV is produced in the J-PARC facility and measured by near detectors and the Super-Kamiokande far detector. The main goal is to measure the neutrino oscillation parameters. T2K can run in both neutrino and antineutrino mode, enhancing the sensitivity to charge-parity violation (CPV) in the lepton sector. Measuring oscillation parameters requires precise knowledge of the (anti)neutrino interaction cross sections.

We present an improved cross section analysis which utilizes combined data samples of multiple detectors and in multiple beam configurations, the first of its kind. It will be used to measure the muon neutrino and antineutrino cross sections on carbon with no final state pions. This technique fully exploits the correlations between the samples' systematic uncertainties, allowing for their efficient cancellation. Since the two utilized T2K near detectors sample different neutrino energy spectra, this measurement will allow to better understand the energy dependence of neutrino interactions, thereby offering a direct probe of the physics that are responsible for the largest uncertainties in T2K oscillation analyses.

In addition, by measuring both neutrino and antineutrino cross sections, it is possible not only to better tune theoretical models of nuclear effects such as multinucleon interactions, but also to properly understand the asymmetry between neutrino and antineutrino interactions, the latter being of fundamental importance for CPV experiments that measure the asymmetry between neutrino and antineutrino oscillation rates.

Primary author: Dr SCHLOESSER, Caspar Maria (Universite de Geneve (CH))

Presenter: Dr SCHLOESSER, Caspar Maria (Universite de Geneve (CH))

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **49** Type: **Talk**

Triple Differential NumuBar Charged-Current Inclusive Cross-Section Measurement using Data Collected by the NOvA Near Detector

NOvA is a long-baseline neutrino experiment aiming to measure the neutrino oscillation parameters, especially the lepton violating phase deltaCP. The high flux received at the NOvA near detector makes the perfect environment for precision measurements of neutrino interactions. In this talk, we present our measurement and predictions of muon anti-neutrino inclusive cross section as a triple differential in terms of the antimuon kinetic energy, the cosine of the scattering angle of the outgoing antimuon with respect to the beam direction, and available energy in the event. In addition, we present single differential cross sections in terms of neutrino energy and the square of the four-momentum transfer.

Primary authors: Mr JOHNSON, Connor (Colorado State University); SINGH, Prabhjot

Presenters: Mr JOHNSON, Connor (Colorado State University); SINGH, Prabhjot

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 1

Contribution ID: **50** Type: **Talk**

The Nucleon Axial Form Factor for Neutrino Oscillation from First Principles

Wednesday, October 26, 2022 11:50 AM (20 minutes)

Next generation neutrino oscillation experiments are poised to provide answers to key questions about the nature of the neutrino. The axial form factor is a vital ingredient in the nucleon amplitudes used to predict quasielastic scattering, a primary signal measurement process for flagship neutrino oscillation experiments, yet the uncertainty on this form factor is vastly underestimated by the dipole parameterization and a model independent determination is not well constrained by elementary target data. To fulfill this experimental need, Lattice QCD can be used to compute, from first principles, the interaction of a nucleon with a weak current in the absence of a nuclear medium. Results from LQCD calculations will significantly improve constraints on the uncertainty of nucleon amplitudes and allow for a theoretically robust, systematically improvable error budget. Recent calculations of the nucleon axial vector coupling have demonstrated that sub-percent precision is within reach of current generation calculations. In this talk, I will discuss preliminary results for LQCD calculations of the axial form factor of the nucleon and outline the path toward achieving a result with a complete error budget. Results from LQCD will permit factorization of uncertainties originating from nucleon and nuclear sources in order to better isolate the source of discrepancies with experimental data.

Primary author: MEYER, Aaron (University of California Berkeley)

Presenter: MEYER, Aaron (University of California Berkeley)

Session Classification: Neutrino CC and NC Scattering without Pion Production 2

Contribution ID: **51** Type: **Poster**

Poster: Measurement of Nuclear Dependence in Inclusive Antineutrino Scattering with MINERvA

Wednesday, October 26, 2022 3:35 PM (5 minutes)

The MINERνA experiment was designed to perform precision studies of neutrino-nucleus scattering in the GeV regime on various nuclear targets using the high-intensity NuMI beam at Fermilab. This poster outlines the current progress on MINERνA's first inclusive charged-current analysis of antineutrino interactions on iron, lead, and water using antineutrino energy and Bjorken x. The interactions on carbon and hydrocarbon are also reported. The results use the NuMI antineutrino beam data with peak energy of approximately 6 GeV taken from 2016 to 2019. The measurements utilize events of energies $2 < \mathrm{E} < 50$ GeV. The importance of the Bjorken x variable to investigate nuclear modifications and the potential to observe short-range correlations at high x are discussed. The analysis will provide high-statistics, self-contained studies of nuclear effects and nuclear dependence, and comparisons to the current neutrino interaction generators such as GENIE.

Primary author: KLUSTOVA, Anezka

Presenter: KLUSTOVA, Anezka

Session Classification: Poster under break time

Contribution ID: **52** Type: **Talk**

Neutrino interactions in a modularised-LArTPC demonstrator for the DUNE near detector

Friday, October 28, 2022 4:00 PM (20 minutes)

The Deep Underground Neutrino Experiment (DUNE) adopts a design of modularised LArTPC for the near detector. It is equipped with revolutionary pixelated readout which enables true 3D projection of particle passages. The pixelated readout eliminates projection ambiguity presented in wire-readout LArTPCs and is particularly suitable for busy detector environment close to the intense neutrino beam. The LArTPC also deploys novel light detectors (ArcLight and LCM) to measure module-contained scintillation light signal with high position resolution and high light yield. The modularised LArTPC provides defined volume for charge-light matching which is particularly useful to identify neutrino events in the detector environment with high event-rate. In combination with the pixelated readout and the light detection, the modularised LArTPC design opens up the potential to study detached secondary particles from neutrino interactions. A demonstrator of this LArTPC with four modules, named as 2x2, will be moved into NuMI neutrino beamline in 2023. It will provide unique opportunity of measuring neutrino-Argon interactions in the relevant neutrino energies for DUNE. This talk will focus on the novel LArTPC design and the 2x2 in the NuMI beam.

Primary author: CHEN, Yifan (SLAC National Accelerator Laboratory (US))

Presenter: CHEN, Yifan (SLAC National Accelerator Laboratory (US))

Session Classification: Future Experiments 2

Contribution ID: **53** Type: **Talk**

Production of a 4.4-MeV gamma ray from NC neutrino-oxygen reaction in a water Cherenkov detector for supernova neutrino bursts and the isospin mixing of the 2^- states (12.97 MeV and 12.53 MeV) of O

Wednesday, October 26, 2022 4:50 PM (20 minutes)

We first discuss and determine the isospin mixing of the two 2^- states (12.53 MeV and 12.97 MeV) of ^{16}O nucleus using the inelastic electron scattering data. We then evaluate the cross section of 4.4-MeV γ rays produced in the neutrino neutral-current (NC) reaction ^{16}O(ν, ν')^{16}O$(12.97\mathrm{MeV}, 2^-)$ with a water Cherenkov detector at the low energy below 100 MeV. We have made the shell-model calculation of this NC neutrino-^{16}O$(12.97\mathrm{MeV}, 2^-)$ cross section as accurate as possible by calibrating both the vector form factor (or spin g-factor g_s) and the axial coupling constant (g_A), using real data of the (e,e') cross section, muon-capture of ^{16}O(12.97MeV,2^-), and ^{16}N β-decay from the 2^- analogue state to the ^{16}O ground state. We compare the γ-ray production rate from this process with that from the excited states (E_x>16 MeV), which was discussed previously by many authors. In this talk, we discuss a new NC reaction channel from ^{16}O$(12.97\ \mathrm{MeV}, 2^-)$ producing a 4.4-MeV γ ray, the cross section of which is more robust and even larger at the low energy (E_ν <25 MeV) than the NC cross section from ^{16}O$(E_x > 16\ \mathrm{MeV}, T = 1)$. We also evaluate the number of such events induced by neutrinos from supernova explosion which can be observed by the Super-Kamiokande, a 32 kton water Cherenkov detector in the Earth.

Primary author: SAKUDA, Makoto (Okayama University)

Co-authors: Prof. SUZUKI, Hideyuki (Tokyo University of Science); Dr NAKAZATO, Ken'ichiro (Kyushu University); Dr REEN, Mandeep (Akal University); Prof. SUZUKI, Toshio (Nihon University)

Presenter: SAKUDA, Makoto (Okayama University)

Session Classification: Low Energy Scattering

Contribution ID: **54** Type: **Talk**

Deep inelastic interactions simulation in NEUT

Tuesday, October 25, 2022 12:05 PM (25 minutes)

The NEUT interaction generator is used by the T2K, Super-Kamiokande and Hyper-Kamiokande to simulate the interaction of neutrinos in the their Monte-Carlo simulations produced to study neutrino oscillations or measure cross-sections. The generator uses a number of different models for the different types of interactions, and in this presentation we will focus on the 2 models related to deep-inelastic (DIS) interactions. We will quickly introduce the two models, and describe recent developments, in particular for neutral current events and implementation of new versions of the Bodek-Yang model, as well as on-going work on those topics and use of PYTHIA for neutrino DIS event generation. We conclude by a comparison of NEUT predictions to the ones of other generators commonly used by neutrino experiments.

Primary author: BRONNER, Christophe

Co-author: XIA, Junjie

Presenter: BRONNER, Christophe

Session Classification: Modelling on Neutrino-Nucleus Interactions

Contribution ID: **55** Type: **Talk**

The MINERvA Flux Prediction

Tuesday, October 25, 2022 3:30 PM (20 minutes)

High-intensity neutrino beams are an essential tool to study neutrino physics. Both neutrino oscillation experiments and cross-section measurements require a precise prediction of the neutrino flux. MINERvA is a dedicated on-axis high-statistics neutrino-nucleus scattering experiment in the NuMI beamline at Fermilab with an intensive campaign to study the neutrino flux. We performed several in-situ measurements using the medium energy neutrino beam with an energy peak of approximately 6 GeV to better understand the neutrino flux and control the systematic flux uncertainties. We used the analysis of charged-current neutrino interactions with low hadronic recoil to measure parameters of the neutrino flux model which suggested that the energy scale for muons reconstructed in the MINOS detector needed to be shifted by 3.6%. Furthermore, we reduced the flux uncertainty by measuring the precisely known purely leptonic process of elastic (anti)neutrino scattering off atomic electrons. Additionally, we measured the inverse muon decay with a neutrino energy threshold of ˜11 GeV to constrain the high-energy part of the flux. The combination of the measurements resulted in the overall reduction of the flux uncertainty from 7.6% to 3.3% in the neutrino beam, and from 7.8% to 4.7% in the antineutrino beam.

Primary author: KLUSTOVA, Anezka

Presenter: KLUSTOVA, Anezka

Session Classification: Neutrino Flux

Contribution ID: **56** Type: **Talk**

A new Scattering and Neutrino Detector at the LHC

Friday, October 28, 2022 5:00 PM (20 minutes)

SND@LHC is a compact and stand-alone experiment to perform measurements with neutrinos produced at the LHC in a hitherto unexplored pseudo-rapidity region of $7.2 < \eta < 8.6$, complementary to all the other experiments at the LHC. The experiment is located 480 m downstream of IP1 in the unused TI18 tunnel. The detector is composed of a hybrid system based on an 800 kg target mass of tungsten plates, interleaved with emulsion and electronic trackers, followed downstream by a calorimeter and a muon system. The configuration allows efficiently distinguishing between all three neutrino flavours, opening a unique opportunity to probe physics of heavy flavour production at the LHC in the region that is not accessible to ATLAS, CMS and LHCb. This region is of particular interest also for future circular colliders and for predictions of very high-energy atmospheric neutrinos. The detector concept is also well suited to searching for Feebly Interacting Particles via signatures of scattering in the detector target. The first phase aims at operating the detector throughout LHC Run 3 to collect a total of 150 fb^{-1}. The experiment was recently approved by the Research Board at CERN and its detector is being commissioned. A new era of collider neutrino physics is just starting.

Primary author: YOON, Chun Sil (Department of Physics Education and RINS)

Presenter: YOON, Chun Sil (Department of Physics Education and RINS)

Session Classification: Future Experiments 2

Contribution ID: **57** Type: **Talk**

Study of charged current interactions on carbon with a charged pion at the T2K near detector with 4π solid angle acceptance

Friday, October 28, 2022 10:05 AM (20 minutes)

The long baseline neutrino experiment Tokai-to-Kamiokande (T2K), located in Japan, measures neutrino oscillation parameters. The J-PARC accelerator complex in Tokai produces a beam of neutrinos; these are detected in the near detector (ND280) and at the far detector (Super-Kamiokande). Muon neutrino charged current interactions in ND280 are used to predict the event rate at the far detector. In particular, these constrain the neutrino flux and neutrino-nucleus interaction cross sections, which are the dominant systematic uncertainties in the oscillation measurements.
We present a study of charged current interactions on carbon with a muon and a single positively charged pion in the final state (CC1π) at the T2K off-axis near detector with a 4π acceptance. This channel constitutes the main background for the muon neutrino disappearance measurement, when the charged pion is not observed in Super Kamiokande. A precise understanding of it is relevant for all current and planned neutrino oscillation experiments. Single pion production is primarily sensitive to resonant processes but has non-resonant contributions as well as coherent pion production. Additionally, final-state interactions in the nuclear target have to be taken into account.
We further present a characterization of CC1π interactions through the measurement of Adler Angles, observables carrying information about the polarization of the Delta resonance and the interference with the non-resonant single pion production. Previously, these were measured with limited statistics in bubble chamber experiments.

Primary author: VARGAS OLIVA, Danaisis (University of Toronto (CA))

Presenter: VARGAS OLIVA, Danaisis (University of Toronto (CA))

Session Classification: Neutrino Pion Productions

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

Poster: Building the DUNE High-Level Data Filter (HLDF)

The Deep Underground Neutrino Experiment (DUNE) is a next-generation long-baseline neutrino experiment under construction in the US. The experiment is formed by a broadband neutrino beam from Fermilab to the Sanford Underground Research Facility (SURF) in Lead, South Dakota, a high-precision near detector, and a large liquid argon time-project chamber (LArTPC) far detector. It has a broad physics program that includes determining the neutrino mass hierarchy, measuring δ_CP with sufficient precision to discover leptonic CP violation, making precise measurements of the oscillation parameters governing electron neutrino appearance and muon neutrino disappearance, detecting neutrinos from a core-collapse supernova, searching for baryon number violating processes such as nucleon decay and neutron-antineutron oscillation, and searching for other physics beyond the Standard Model.
Due to the high volume of data that is expected the DUNE high-level data filter (HLDF) was implemented. The HLDF is at the basic level prior to permanent storage. In the HLDF event selection algorithms are applicable to online data files for pre-scaling, checking the data quality, reducing the data file size, and background reduction based on the trigger type.

Primary author: VARGAS OLIVA, Danaisis (University of Toronto (CA))

Presenter: VARGAS OLIVA, Danaisis (University of Toronto (CA))

Session Classification: Poster under break time

Contribution ID: **59** Type: **Talk**

Modeling neutrino-nucleus interaction uncertainties for DUNE long-baseline sensitivity studies

Tuesday, October 25, 2022 10:50 AM (25 minutes)

The Deep Underground Neutrino Experiment (DUNE) is a next generation experiment aiming to answer a wide range of open questions in neutrino physics. Its broad program includes a long-baseline (LBL) neutrino oscillation analysis, whose goal is to measure neutrino oscillation parameters with unprecedented precision. The intense beam exposure, coupled with the size of the near and far detectors and liquid argon (LAr) detection capabilities, will enable DUNE to reduce its statistical uncertainties to the order of 1%. At this level of precision, systematic uncertainties will become the limiting factor for the DUNE LBL analysis.

The largest systematic uncertainties currently stem from the modeling of neutrino interactions with matter. Neutrinos interact with argon nuclei, which are complex systems and difficult to model. DUNE's wide energy spectrum also covers multiple interaction regimes and their transition regions, for which several models are available. However, no theoretical or generator model seems to describe experimental data across the entire phase space relevant for DUNE. For these reasons, sufficient freedom must be provided in the neutrino interaction uncertainty model.

This talk presents the latest systematic uncertainty model for the DUNE LBL sensitivity studies. The model is based on a flexible simulation of the nuclear ground state, making it possible to test its robustness against a large spectrum of alternative predictions. We also motivate the choice of systematic uncertainties based on natural freedoms of the input model, as well as ad-hoc freedoms allowing to account for additional effects which may impact the near to far detector extrapolation.

Primary author: MUNTEANU, Laura (CERN)

Presenter: MUNTEANU, Laura (CERN)

Session Classification: Modelling on Neutrino-Nucleus Interactions

Contribution ID: **61** Type: **Talk**

Total neutron cross section measurement on CH with a novel 3D-projection scintillator detector

Friday, October 28, 2022 11:20 AM (20 minutes)

Long-baseline neutrino oscillation experiments rely on detailed models of neutrino interactions on nuclei. These models constitute an important source of systematic uncertainty, in part because current detectors have been blind to final state neutrons. A novel three-dimensional projection scintillator, called SuperFGD, will be the tracker of the upgraded off-axis near detector of the T2K experiment. Due to its good timing resolution and fine granularity, this technology is capable of measuring neutrons in (anti)neutrino interactions on an event-by-event basis and will provide valuable data for refining neutrino interaction models and ways to reconstruct neutrino energy. Two prototypes have been exposed to the neutron beamline at Los Alamos National Laboratory (LANL) in both 2019 and 2020 with neutron energies between 0 and 800 MeV. In order to demonstrate the capability of neutron detection, the total neutron cross section on CH is measured with one of the prototypes and compared to external measurements. The total neutron cross section in scintillator between 98 and 688 MeV was measured and will be presented in this talk.

Primary author: Mr GWON, SunWoo (Chung-Ang University)

Co-author: RICCIO, Ciro (Stony Brook University (US))

Presenter: Mr GWON, SunWoo (Chung-Ang University)

Session Classification: Pions and Other Neutrino Interactions

Contribution ID: **62** Type: **Talk**

Antineutrino-CH QE-Like Scattering at MINERvA: Two Views

Wednesday, October 26, 2022 9:25 AM (20 minutes)

Quasi-elastic (QE) interactions are important to model well because they are a large component of the total antineutrino cross section at low momentum transfer and a great way to reconstruct antineutrino energy in principle. In practice, final state interactions (FSI) on heavy nuclei complicate selecting QE interactions, and neutron production by antineutrino QE interactions complicates calorimetry. Integrating measurements of QE interactions, FSI, and neutron production into the next generation of antineutrino interaction models is needed to help drive down systematic uncertainties for long baseline oscillation experiments.

This presentation opens with a new double-differential QE-like antineutrino cross section measurement on CH from MINERvA. Differential cross sections are shown in muon momentum components and Q^2_{QE}. This result has greatly enhanced statistical power and improved sensitivity to DUNE's high energy tail relative to MINERvA's low energy (LE) antineutrino QE-like result. The antineutrino QE-like differential cross section is compared to MINERvA's 2020 Medium Energy neutrino QE-like cross section measurement and several leading models. MINERvA's first foray into reconstructing neutrons from LE antineutrino interactions is also described. Energy deposit, timing, and distance distributions can be shown because MINERvA is sensitive to neutron inelastic interactions. Neutron candidate multiplicity is explored as a handle on interactions with correlated nucleon pairs.

Primary author: OLIVIER, Andrew

Presenter: OLIVIER, Andrew

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **63** Type: **Talk**

Direct Measurement of Nuclear Effects in QE-like Neutrino Scattering at MINERvA

Wednesday, October 26, 2022 9:45 AM (25 minutes)

The MINERvA experiment at Fermilab presents results from several analyses of quasielastic-like (QE-like) ν_μ interactions on a variety of nuclear targets in the NuMI neutrino beams. In the low energy ($<E_\nu>\sim$3 GeV) beam, components of the muon-proton momentum imbalance, \tkidptx ˜and \tkidpty, are used to probe Fermi motion, binding energy, and non-QE contributions in scintillator. In the medium energy ($<E_\nu>\sim$6 GeV) beam, the statistical power of the sample is apparent as QE-like 2-d cross section results on C, CH, H_2O, Fe, and Pb targets are presented in bins of muon longitudinal and transverse momentum. Cross section ratios of each target relative to scintillator are also shown. In a subset of these medium energy events where protons are cleanly reconstructed, cross section and cross section ratio results on each of the five nuclear targets are presented as a function of muon, proton, and transverse kinematic imbalance variables. The results from each of the three presented analyses are sensitive to nuclear effects. All of the presented observations are compared to predictions from a series of widely used neutrino event generators with different options and tunes. Qualitatively, the spread of simulated results tends to cover the data. However, none of the simulations consistently describe the data. While some of the trends and comparisons will be discussed, an important aim of this talk is to demonstrate for the neutrino community the breadth of these results and their potential utility for constraining models.

Co-author: Prof. MANLY, Steven (University of Rochester)

Presenters: Dr KLEYKAMP, Jeffrey (University of Mississippi); Prof. MANLY, Steven (University of Rochester)

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **64** Type: **Talk**

Inclusive Cross Section Measurements at MINERvA

Monday, October 24, 2022 2:00 PM (25 minutes)

In an era of precision neutrino oscillation experiments using improved technology that generate large statistical samples, it is important to understand the properties of neutrino interactions on nuclei over a large volume of kinematic phase space. The MINERvA experiment, which utilizes the NuMI neutrino beam at Fermilab, measures cross sections across multiple materials ranging from helium to lead, and is able to compare results to models of these neutrino interactions. I will present double differential cross section measurements of charged current muon-neutrino interactions in hydrocarbon in two distinct neutrino beam energies, in variables of the longitudinal and transverse momenta of the muon. This result is advantageous for comparisons with theorists since it is done in well-defined easily measurable variables, and is able to highlight areas in which there are model deficiencies. Machine learning methods have been developed to more accurately determine which interactions occurred in each of our nuclear targets, which are being utilized to measure inclusive and deep inelastic scattering cross sections across multiple materials. Their performance will be discussed.

Primary author: FILKINS, Amy

Presenter: FILKINS, Amy

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 1

Contribution ID: **65** Type: **Talk**

Status of Neutrino Elastic-scattering Observation with NaI(Tl) experiment

Thursday, October 27, 2022 10:25 AM (15 minutes)

Coherent elastic neutrino-nucleus scattering (CEvNS) can provide interesting physics such as measuring neutrino properties and proving non-standard interactions.
Neutrino Elastic-scattering Observation with NaI(Tl) experiment (NEON) aims to detect this CEvNS in a NaI(Tl) crystal using reactor anti-electron neutrino at Hanbit nuclear power plant.
NEON detector consists of a total of 16 kg NaI(Tl) target mass which is installed 24 meters from the reactor core.
Shields include a 40 cm liquid scintillator, 10 cm leads, and 30 cm Poly-ethylene for vetoing various background radiations.
Phase 1 operated ~ 1 year from December 2020 which includes 1-month reactor-off data.
Phase 2 was started in April 2022 after the detector encapsulation design upgrade to improve the performance of the liquid scintillator veto and the stability
In this talk, we report the current status of the NEON experiment.

Primary author: Dr LEE, InSoo (IBS)

Presenter: Dr LEE, InSoo (IBS)

Session Classification: Coherent Neutrino Scattering

Contribution ID: **66** Type: **Poster**

Poster: Neutron detection with a 3D-projection scintillator tracker and its application to neutrino oscillation experiments

Wednesday, October 26, 2022 3:50 PM (5 minutes)

Neutrino oscillation experiments require a precise measurement of the neutrino energy. However, the kinematic detection of the final state neutrons in the neutrino interaction is missing in current neutrino oscillation experiments. A novel 3D projection scintillator tracker can detect the neutron kinetic energy and direction on an event-by-event basis. Through neutron detection, the neutrino energy can be reconstructed precisely. The measurement of neutron kinematics also enables an antineutrino flux measurement using the complete final state particle information in desired channels.

Primary author: GWON, SunWoo

Presenter: GWON, SunWoo

Session Classification: Poster under break time

Contribution ID: **67** Type: **Talk**

Hadron Production Measurements for Neutrino Experiments

Tuesday, October 25, 2022 2:00 PM (30 minutes)

In current measurements of accelerator-based neutrino experiments, neutrino flux uncertainties represent a leading systematic uncertainty. Neutrino beams are created from the decays of secondary hadrons produced in hadron-nucleus interactions. Primary and secondary hadron production processes for neutrino beams are the leading source of flux uncertainty. Therefore, precise hadron production measurements are essential.

The neutrino program of the NA61/SHINE experiment at CERN's Super Proton Synchrotron makes measurements of hadron production. This talk will first present recent hadron production measurements for precise neutrino flux predictions needed by T2K and Fermilab long-baseline neutrino experiments. The talk will then review the performance of the latest collected data utilizing a 90-cm-long T2K replica graphite target with the upgraded NA61/SHINE facility. Lastly, the talk will discuss the prospects for near future hadron production measurements in NA61/SHINE, including the possibility to extend the physics program to lower beamline energies.

Primary author: NAGAI, Yoshikazu (Eötvös Loránd University (HU))

Presenter: NAGAI, Yoshikazu (Eötvös Loránd University (HU))

Session Classification: Neutrino Flux

Contribution ID: **68** Type: **Talk**

Constraining the neutrino interaction model using near detector data in the T2K experiment

Tuesday, October 25, 2022 11:40 AM (25 minutes)

T2K is a world-leading long baseline neutrino oscillation experiment in Japan, studying the appearance of electron neutrinos and the disappearance of muon neutrinos in a muon neutrino beam, using both neutrinos and anti-neutrinos. With these four channels, T2K provides measurements of one neutrino mass splitting, two neutrino mixing angles, and the CP violating phase in the PMNS paradigm. T2K utilises the near detector ND280 to characterise the neutrinos before long baseline oscillations, leading to a substantial reduction in uncertainty in the oscillation analysis.
The analysis of ND280 data uses selections separated by proton and photon tagging, pion multiplicity, and the sign of the muon, to better separate the dominant CCQE interactions from 2p2h and single pion production, and the neutrino background in anti-neutrino mode. This analysis introduces new inputs from the NA61/SHINE hadron scattering experiment, which are used to constrain the neutrino flux, and a variety of neutrino and pion scattering models and data to constrain the neutrino and pion interaction model.
The results from fitting to data are presented in this talk, with an emphasis on the neutrino interaction model. Furthermore, the capabilities of T2K's upgraded ND280 are also discussed, and its goal to better understand neutrino interactions in the sub-GeV region.

Primary author: WRET, Clarence (University of Rochester (US))

Presenter: WRET, Clarence (University of Rochester (US))

Session Classification: Modelling on Neutrino-Nucleus Interactions

Contribution ID: **69** Type: **Talk**

Lepton-Hadron Correlations in QE-like Neutrino Scattering at MINERvA

Wednesday, October 26, 2022 9:00 AM (25 minutes)

This talk will cover two different analyses of muon neutrino charged current interactions on a CH target, as recorded by MINERvA in the NuMI Medium Energy beam. The first analysis focuses on the 0-pion data set which has the advantage that the recoil energy in this set is dominated by the sum of the kinetic energies of the protons that are ejected from the target nucleus. Because of the unprecedented size of this data set the correlations between the lepton and hadronic system can be used to identify and characterize different nuclear effects in exquisite detail. In addition, these events can be used to compare the neutrino energy estimator used by calorimetric (i.e. NOvA and eventually DUNE) detectors and by Cerenkov (i.e. T2K and Hyper-K, and MiniBooNE) detectors. The second analysis focuses on a slightly more expanded data set, where all charged current events at low recoil are examined as a function of momentum and energy transfer. This kinematic space, historically used by electron scattering experiments, can elucidate multi-nucleon effects and the role they can play on both quasielastic scattering and pion production.

Primary author: HARRIS, Deborah Appel (York University (CA))

Presenter: HARRIS, Deborah Appel (York University (CA))

Session Classification: Neutrino CC and NC Scattering without Pion Production 1

Contribution ID: **70** Type: **Talk**

A substandard candle: the low-nu method at few-GeV neutrino energies

Tuesday, October 25, 2022 3:10 PM (20 minutes)

The low-nu method has been discussed as a "standard candle" in the context of accelerator neutrino beam experiments which require a precise understanding of the neutrino flux. The method utilizes a sub-sample of events where there is low energy-transfer to the nucleus, and requires that the interaction cross section is approximately constant for this sub-sample as a function of neutrino energy. However, it is unclear how reliable that assumption is due to the presence of nuclear and form-factor effects inherent in the interaction models.

This talk describes the low-nu method in detail and examines its prospects as a way to improve constraints on accelerator (anti)neutrino fluxes in an experiment-independent way. Ultimately, we will show that at the few-GeV energies of interest to current and future accelerator neutrino oscillation experiments, low-nu flux constraints are severely model-dependent, and are unlikely to offer any improvement on typical neutrino flux uncertainties, even with a perfect detector.

Primary authors: WILKINSON, Callum David (Lawrence Berkeley National Lab. (US)); WRET, Carl (University of Rochester (US)); Dr PICKERING, Luke (Royal Holloway, University of London); Dr DOLAN, Stephen (CERN)

Presenter: WILKINSON, Callum David (Lawrence Berkeley National Lab. (US))

Session Classification: Neutrino Flux

Contribution ID: **71** Type: **Talk**

T2K latest results on neutrino-nucleus cross sections

Monday, October 24, 2022 12:10 PM (20 minutes)

A detailed understanding of neutrino-nucleus interactions is essential for the precise measurement of neutrino oscillations at long baseline experiments, such as T2K. The T2K near detector complex, designed to constrain the T2K flux and cross section models, also provides a complementary program of neutrino interaction cross-section measurements. Through the use of multiple target materials (carbon, water, lead, iron), and the ability to sample different neutrino spectra (with detectors located on- and off-axis with respect to the beam direction), T2K is able to investigate atomic number and energy dependence of interaction cross sections in a single experiment. In particular, T2K has recently performed the first joint on/off-axis measurement of the Charged Current channel without pion in the final state.

Moreover, T2K features a magnetized near detector (ND280) capable of reconstructing and identifying the final state particles produced in neutrino interactions. Therefore measurements of exclusive final states have been performed separately for neutrino and antineutrino interactions, as a function of various differential variables.
With increasing statistics, dedicated efforts are devoted to investigate rare or poorly studied interaction channels. Indeed, an improved analysis of the coherent pion production cross section has been recently accomplished, including an antineutrino sample for the first time.
The most recent results, together with an overview of the T2K measurement strategy, adopted to reduce the model dependence, will be presented in this talk.

Primary authors: JESUS VALLS, Cesar (IFAE-BIST); JESÚS-VALLS, César (IFAE)

Presenters: JESUS VALLS, Cesar (IFAE-BIST); JESÚS-VALLS, César (IFAE)

Session Classification: Highlights on Neutrino-Nucleus Interactions

Contribution ID: **72** Type: **Poster**

Poster: Measurement of θ13 using reactor antineutrino events with neutron capture on hydrogen at RENO

Wednesday, October 26, 2022 3:40 PM (5 minutes)

The RENO Collaboration reports a measured value of the smallest neutrino mixing angle (θ13) based on ˜2900 days of reactor electron antineutrino events with a delayed signal of neutron capture on hydrogen (H). The neutron captures on H emitting a 2.2 MeV γ-ray are not easily detected because of high environmental radioactivity below 3.5 MeV, Due to satisfactory purification of liquid scintillator, use of low–radioactivity photomultiplier tube (PMT) glass, and effective selection criteria, it is possible to extract the reactor neutrino signal against the high backgrounds and observe a clear deficit of the reactor neutrino rate. Based on a rate-only analysis, we obtain sin22θ13 =0.086±0.006(stat)±0.010(syst). This corresponds to a more precisely measured θ13 value of the n-H IBD candidates than the previous measurement from 1500 days of data. With the increased data sample, the statistical error of this measurement is reduced by roughly 40%. Based on improved background uncertainties and additional removal of PMT noise events, the systematic error is reduced by roughly 60%.

Primary author: KIM, Sang Yong (Seoul National University)

Presenter: KIM, Sang Yong (Seoul National University)

Session Classification: Poster under break time

Contribution ID: **73** Type: **Poster**

Poster: Nearest neutrino detector at Hanbit nuclear power plant.

Wednesday, October 26, 2022 3:45 PM (5 minutes)

We report a conceptual design of the nearest neutrino detector, which primarily aims to search for the sterile neutrino oscillation at $\Delta m^2_{41} \sim 2eV^2$. The joint study of RENO and NEOS experiments showed a hint for the sterile neutrinos at $\Delta m^2_{41} \sim 2.4eV^2$ and $\sim 1.7eV^2$, which overlap with the allowed region by the Reactor Anti-neutrino Anomaly. This Nearest detector can also be used for precision measurements of the flux and spectrum of the reactor electron antineutrino ($\bar{\nu_e}$) and the separation of $\bar{\nu_e}$ spectra from ^{235}U and ^{239}Pu. In this presentation, we report the detector concept of the nearest reactor neutrino detector and physics cases.

Primary authors: LEE, Wonjun; Mr YOON, Seok-Gyeong (Seoul National University)

Presenter: LEE, Wonjun

Session Classification: Poster under break time

Contribution ID: **74** Type: **Talk**

ND280 Upgrade status and sensitivity

Friday, October 28, 2022 3:00 PM (20 minutes)

Neutrino oscillation physics has now entered the precision era. In parallel with needing larger detectors with which to collect more data, future experiments further require a significant reduction of systematic uncertainties with respect to what is currently available. In the neutrino oscillation measurements from the T2K experiment the systematic uncertainties related to neutrino interaction cross sections are currently dominant. To reduce this uncertainty, a much improved understanding of neutrino-nucleus interactions is required. In particular, it is crucial to better understand the nuclear effects, which can alter the final state topology and kinematics of neutrino interactions in such a way that can bias neutrino energy reconstruction and therefore bias measurements of neutrino oscillations.

The upgraded ND280 detector will consist of a totally active Super-Fine-Grained-Detector (SFGD) composed of 2 millions 1 cm^3 scintillator cubes with three 2D readouts, two High Angle TPCs (HA-TPC) instrumented with resistive MicroMegas modules, and six TOF planes. It will directly confront our naivety of neutrino interactions thanks to its full polar angle acceptance and a much lower proton tracking threshold. Furthermore, neutron tagging capabilities in addition to precision timing information will allow the upgraded detector to estimate neutron kinematics from neutrino interactions. Such improvements permit access to a much larger kinematic phase space, which correspondingly allows techniques such as the analysis of transverse kinematic imbalances to offer important constraints on the pertinent nuclear physics for T2K analyses.

Primary author: MUNTEANU, Laura (CERN)

Presenter: MUNTEANU, Laura (CERN)

Session Classification: Future Experiments 1

Contribution ID: **75** Type: **Poster**

Measurement of Reactor Antineutrino Spectra from U(235) and Pu(239) Fission at RENO

Wednesday, October 26, 2022 4:00 PM (5 minutes)

We report the measured reactor antineutrino spectra from the fission of ^{235}U and ^{239}Pu using 2,500 days of RENO near detector data. The change of fission fraction and thus reactor neutrino yield during a fuel cycle can be used to separate ^{235}U and ^{239}Pu contributions to the observed yields. The antineutrino spectra from the ^{235}U and ^{239}Pu fission are obtained from unfolding the detector effect of separated prompt spectra. The IBD (Inverse beta decay) yields from the ^{235}U and ^{239}Pu fission are measured as 6.11 ±0.14 cm^2 per fission and 4.35 ±0.21 cm^2 per fission, corresponding to deficits of (9.4 ±2.1)% and (1.0 ±4.7)% with respect to the prediction by Huber, respectively.
The deficit of the ^{235}U fission is alleviated in comparison with the Kurchatov Institute(KI) conversion model and the Estienne-Fallot (EF) summation model. The prompt (antineutrino) spectrum from ^{235}U fission shows a 5 MeV (6 MeV) excess of prompt (neutrino) energy with 3.9σ significance while such a clear excess is not seen in the ^{239}Pu spectrum.

Primary authors: YOON, Seok-Gyeong (Seoul National University); KIM, Dojin

Presenter: KIM, Dojin

Session Classification: Poster under break time

Contribution ID: **76** Type: **Talk**

BSM physics @ FASERnu from the neutrino nucleon scattering

Friday, October 28, 2022 4:40 PM (20 minutes)

FASERν is a newly approved (working) high-energy neutrino scattering experiment using the neutrino beam from the decays of hadrons downstream from the interaction point of ATLAS and positioned at about 480 m away from the ATLAS detector. We are exploring the features of FASERν for the Deep-Inelastic Neutrino Nucleon Neutral current scattering. We study the various BSM physics scenarios at FASERν involving Z' boson and Heavy Neutrino N.

Primary author: C.J., Ouseph (National Tsing Hua University Taiwan)

Co-author: Prof. CHEUNG, kingman (National Tsing Hua University Taiwan)

Presenter: C.J., Ouseph (National Tsing Hua University Taiwan)

Session Classification: Future Experiments 2

Contribution ID: **77** Type: **Talk**

Modelling neutrino-nucleus interactions for the T2K experiment (rescheduled on Thursday morning)

Tuesday, October 25, 2022 11:15 AM (25 minutes)

In order to achieve the ambitious goal of characterising neutrino flavour oscillations with percent-level precision, it is critical for current and future long-baseline neutrino oscillation experiments to substantially reduce existing systematic uncertainties. The most challenging of such systematic uncertainties is related with the modelling few-GeV neutrino-nucleus interactions.

To improve our understanding, the T2K collaboration is engaged in a continuous effort to implement up-to-date theoretical models in T2K's Monte Carlo event generator (NEUT) and to define a suitable parametrisation of the model's uncertainties as an input for neutrino oscillation analyses. The new uncertainty model, developed for the latest T2K oscillation measurement, will be presented, as well as a comparison of the model to available global lepton- and hadron-scattering data. Among other improvements, the latest model includes: a parametrisation offering substantial freedom to the input Spectral Function for charged-current quasi-elastic (CCQE) interactions; a momentum transfer dependent correction to the nuclear removal energy for CCQE interactions based on inclusive electron scattering data; and an updated treatment of nuclear medium effects in resonant pion production interactions.

Presenter: Dr DOLAN, Stephen (CERN)

Session Classification: Modelling on Neutrino-Nucleus Interactions

Contribution ID: **78** Type: **Talk**

New results from JLab e-Ar experiment (ONLINE)

Tuesday, October 25, 2022 9:30 AM (30 minutes)

In this talk I will present the recent results on inclusive and exclusive electron scattering cross section measurements on Ar at Jefferson Lab Hall A. I will describe how this experiment will inform the future neutrino oscillation experiment like DUNE and I will describe how the electron scattering data can be used to determine accurate nuclear model that describes neutrino-nucleus interaction. High accuracy in understanding neutrino nucleus scattering is crucial for future long baseline neutrino experiments.

Primary author: MARIANI, Camillo (Virginia Poly. Inst. & State Univ. (US))

Presenter: MARIANI, Camillo (Virginia Poly. Inst. & State Univ. (US))

Session Classification: Electron-Nucleus Scattering

Contribution ID: **79** Type: **Talk**

Neutrino Pion Production at MINERvA

Friday, October 28, 2022 10:55 AM (25 minutes)

The enormous flux of neutrinos the NuMI's medium energy beam enables a number of new measurements of coherent and incoherent pion production on MINERvA's scintillator and passive carbon, water, iron, and lead targets. These measurements show a number of discrepancies with current generator models, and provide information about the correct scaling of single pion production with different nuclei. The future and final results from MINERvA that can be expected from single pion production measurements are also previewed.

Primary author: Prof. MCFARLAND, Kevin (University of Rochester)

Presenter: Prof. MCFARLAND, Kevin (University of Rochester)

Session Classification: Pions and Other Neutrino Interactions

Contribution ID: **80** Type: **Talk**

Neutrino cross sections at the transition region between shallow- and deep-inelastic scattering

Monday, October 24, 2022 4:10 PM (20 minutes)

Neutrino experiments at the LHC such as FASERν, SND@LHC and potentially the FPF will detect neutrinos at the energy range of a few GeV to a few TeV. In neutrino scattering, there is a transition region from the so-called shallow inelastic scattering (SIS) to deep inelastic scattering (DIS). Although the boundary of the SIS and DIS is not clearly defined, the SIS region is generally considered as 1.4 GeV $< W <$ 2 GeV and $Q^2 < 1\ \mathrm{GeV}^2$ for the final state hadronic invariant mass and the momentum transfer, respectively. One of the essential components in evaluating the neutrino cross sections is the structure functions, and their perturbative treatment is not reliable for $Q^2 < 1\ \mathrm{GeV}^2$. There are several prescriptions to construct the structure functions for such non-perturbative regime by fitting to the data, and the most well-known is the Bodek-Yang model. In this work, we use the alternative phenomenological structure functions, known as the CKMT parameterization to evaluate the neutrino DIS CC interaction cross section and compare with the Bodek-Yang prescription. We investigate the dependence on the W and Q^2 in the SIS region and find that contributions to the neutrino-nucleon cross section from the transition region are applicable for $E_\nu < 100$ GeV.

Primary authors: Dr JEONG, Yu Seon (Chung-Ang University); Prof. RENO, Mary Hall (University of Iowa)

Presenter: Dr JEONG, Yu Seon (Chung-Ang University)

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 2

Contribution ID: **81** Type: **Poster**

Poster: Feasibility study on the spectrum of light emitted by LED using a CMOS RGB-based image sensor and its application

Wednesday, October 26, 2022 3:55 PM (5 minutes)

Bi-alkali photomultiplier tube (PMT) has a maximum quantum efficiency (QE) around 430nm. Fluor components dissolved in liquid scintillator (LS) are needed to have an emission wavelength in the PMT's QE region. We analyzed digital images for estimating the spectrum of LS, instead of using a spectrophotometer. Digital image was taken by camera based on complementary metal oxide semiconductor (CMOS) sensor and Bayer color filter array. This image has RGB components and we convert it to hue. Since hue and wavelength (H-W) are closely related, so we reconstruct H-W relationship with raw image to find out the emission wavelength of LS. In addition, various factors affecting the digital raw image were investigated.

Primary authors: PARK, HW (Chonnam National University, Department of physics); CHOI, JW; KIM, NR (Chonnam national University); JOO, KK

Presenter: PARK, HW (Chonnam National University, Department of physics)

Session Classification: Poster under break time

Contribution ID: **82** Type: **Talk**

Reassessing the models of neutrino-nucleus interactions (ONLINE)

Wednesday, October 26, 2022 3:10 PM (20 minutes)

Recent results showing that lattice calculations provide a remarkably good description of the measured vector form factors of the nucleon indicate that this approach has reached a high level of reliability. I will report the results of calculations of the cross section of the process 12C(νμ,μ- p) averaged over the neutrino fluxes of the MiniBooNE and T2K experiments. The analysis has been carried out using the spectral function formalism and the axial form factor obtained from lattice QCD 1. Based on the results of this study, I will propose a reassessment of the roles of mechanisms other than single-nucleon knock out in the determination of the neutrino nucleus cross section.

1 S. Park et al., Phys. Rev. D 105, 054505 (2022)

Primary author: Prof. BENHAR, Omar (INFN, Roma)

Presenter: Prof. BENHAR, Omar (INFN, Roma)

Session Classification: Neutrino CC and NC Scattering without Pion Production 3

Contribution ID: **83** Type: **Talk**

First analysis result of the KDAR neutrino search with JSNS2 experiment

Wednesday, October 26, 2022 5:30 PM (20 minutes)

Kaon Decay-At-Rest (KDAR) provides a neutrino signal with well-known neutrino energy, which is an important probe for measuring the neutrino cross-section in an energy range that is otherwise difficult to access experimentally. The J-PARC Sterile Neutrino Search at the J-PARC Spallation Neutron Source (JSNS2) experiment is in a unique place for measuring monoenergetic neutrinos at 236 MeV from charged Kaon decay-at-rest (KDAR). JSNS2 is located at the J-PARC's Material and Life Science Facility (MLF) where the world's most intense source of KDAR created by a 3 GeV proton beam incident on a liquid mercury target. In this presentation, We will present the first result of the search for the KDAR neutrinos conducted with the JSNS2 experiment with the data during the JSNS2's first long-term physics run during 2021, consisting of more than 115 days of data and 1.45x10ˆ22 POT.

Primary author: JEON, Hyoungku (SungKyunKwan University)

Presenter: JEON, Hyoungku (SungKyunKwan University)

Session Classification: Low Energy Scattering

Contribution ID: **84** Type: **Talk**

Hadron Production Measurements with EMPHATIC

Tuesday, October 25, 2022 2:30 PM (20 minutes)

One of the leading sources of systematic uncertainty in neutrino experiments is the modeling of the neutrino flux. Neutrino flux uncertainties are dominated by hadron scattering and hadron production cross section uncertainties, and new, dedicated measurements are needed. The EMPHATIC collaboration aims to measure the forward-scattering and production of hadrons for a variety of beam momenta and targets relevant for neutrino experiments. In 2022, EMPHATIC collected data ranging from 2 to 120 GeV/c, with aluminium, CH2, graphite, and iron targets. I will provide an overview of the design and operations of the experiment thus far, future upgrades and data-taking plans, and the current status of analysis work.

Primary author: LACKEY, Teresa (Fermilab)

Presenter: LACKEY, Teresa (Fermilab)

Session Classification: Neutrino Flux

Contribution ID: **102** Type: **Talk**

Update on Bodek-Yang Model

Monday, October 24, 2022 2:45 PM (20 minutes)

Primary author: Prof. YANG, Un-Ki (Seoul National University (KR))

Co-author: BODEK, Arie (University of Rochester (US))

Presenter: Prof. YANG, Un-Ki (Seoul National University (KR))

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 1

Contribution ID: **146** Type: **Talk**

Experimental Summary and Prospects

Saturday, October 29, 2022 10:40 AM (40 minutes)

Presenter: Dr WILKINSON, Callum David (Lawrence Berkeley National Lab. (US))

Session Classification: Workshop Summarys

Contribution ID: **147** Type: **Talk**

Theoretical Summary and Prospects (ONLINE)

Saturday, October 29, 2022 10:00 AM (40 minutes)

Presenter: Prof. JACHOWICZ, Natalie Yvonne (Ghent University (BE))

Session Classification: Workshop Summarys

Contribution ID: **148** Type: **Talk**

Announcement of NUINT 2023 (Jorge G. Morfín)

Saturday, October 29, 2022 11:20 AM (10 minutes)

Presenter: Dr MORFIN, Jorge G.

Session Classification: Workshop Summarys

Contribution ID: **149** Type: **Talk**

Closing Remark

Saturday, October 29, 2022 11:30 AM (10 minutes)

Session Classification: Workshop Summarys

Contribution ID: **151** Type: **Talk**

Welcome from Dean of College of Natural Sciences, Seoul National University

Monday, October 24, 2022 10:00 AM (10 minutes)

Session Classification: Welcome and Introductory Talks

Contribution ID: **152** Type: **Talk**

Welcome from Organzier

Monday, October 24, 2022 10:10 AM (10 minutes)

Presenters: Prof. YOO, JONGHEE (Seoul National University); Prof. YANG, Un Ki (Seoul National University (KR))

Session Classification: Welcome and Introductory Talks

Contribution ID: **153** Type: **Talk**

Overview of Neutrino-Nucleus Interactions

Monday, October 24, 2022 10:20 AM (40 minutes)

Presenter: Prof. KATORI, Teppei (King's College London)

Session Classification: Welcome and Introductory Talks

Contribution ID: **154** Type: **Talk**

Highlights from MINERvA (ONLINE)

Monday, October 24, 2022 11:20 AM (25 minutes)

Primary author: CAI, Tejin

Co-author: MCFARLAND, Kevin (University of Rochester)

Presenters: MCFARLAND, Kevin (University of Rochester); CAI, Tejin (York University); CAI, Tejin

Session Classification: Highlights on Neutrino-Nucleus Interactions

Contribution ID: **155** Type: **Talk**

Understanding the Shallow-to-Deep Inelastic Transition

Monday, October 24, 2022 3:05 PM (25 minutes)

Presenter: Dr MORFIN, Jorge (Fermilab)

Session Classification: Shallow Inelastic, Deep Inelastic and Inclusive Scattering 1

Contribution ID: **158** Type: **Talk**

Review of COHERENT experiments

Thursday, October 27, 2022 9:20 AM (25 minutes)

The COHERENT collaboration made the first measurement of coherent elastic neutrino nucleus scattering (CEvNS) in 2017 using a low-background, 14.6-kg CsI[Na] detector at the Spallation Neutron Source (SNS). We have also measured CEvNS using a 24-kg argon scintillation calorimeter. These measurements are part of a multi-target campaign to measure CEvNS on four nuclei, Na, Ar, Ge, and Cs/I, to test the standard model cross section, predicted to scale like the square of the neutron number. We will show current progress in deployment of new COHERENT detectors, including those that will study CEvNS on Na and Ge.

With first-light discovery of CEvNS accomplished, COHERENT is now transitioning to precision measurements of CEvNS and other low-energy neutrino scattering processes. This precision era will facilitate strong probes for searches for beyond-the-standard-model (BSM) physics. We discuss recent, full-dataset results from our CsI[Na] detector which achieved a 16% measurement of the CEvNS cross section through an improved understanding of the detector response and a doubling of detector exposure relative to the initial measurement. These data have already placed leading limits on neutrino-quark non-standard interactions and accelerator-produced dark matter. In this talk, new searches for BSM physics will be presented based on this dataset.

Primary author: PERSHEY, Daniel

Presenter: PERSHEY, Daniel

Session Classification: Coherent Neutrino Scattering

Contribution ID: **159** Type: **Talk**

Neutrino interactions with a ton-scale liquid argon detector for the COHERENT experiment

Thursday, October 27, 2022 10:05 AM (20 minutes)

Neutrino interactions with a ton-scale liquid argon detector for the COHERENT experiment

The COHERENT collaboration operates an array of detectors at the ORNL Spallation Neutron Source (SNS) to measure coherent elastic neutrino nucleus scattering (CEvNS), low-energy inelastic neutrino interactions, and to search for dark matter. We observed the first CEvNS events in 2017 with a cesium-iodide scintillation detector. We followed up with a measurement using a 24 kg liquid argon detector (CENNS-10) thus confirming the CEvNS hypothesis. COHERENT is expanding in the next years with more detectors to increase the precision of those results thur increasing our physics reach into beyond-standard-model physics tests. As part of that, we are building a 750 kg liquid argon scintillation detector (COHAr-750) that will increase the event rate substantially to allow precision measurements of the CEvNS process as well as allow sensitivity to inelastic neutrino processes and accelerator-produced dark-matter. In this talk we will present the physics topics that will be investigated along with design details of COHAr-750.

Primary author: TAYLOE, Rex (Indiana U.)

Presenters: TAYLOE, Rex (Indiana University); TAYLOE, Rex (Indiana U.)

Session Classification: Coherent Neutrino Scattering

Contribution ID: **160** Type: **Talk**

Physics Opportunities of Coherent Scattering

Thursday, October 27, 2022 9:00 AM (20 minutes)

Since the first discovery of coherent elastic neutrino-nucleus scattering (CEvNS) events, a lot of experiments are operational or projected for precision measurements of CEvNS. Such experiments typically feature low energy and high intensity of particles including neutrinos, while their detectors feature low threshold and proximity to their source points. Therefore, they are expected to provide unique opportunities for various physics cases including not only standard model parameter measurements but new physics searches. In this talk, I will briefly survey and discuss phenomenology and future prospects of various physics cases available in the CEvNS experiments.

Primary author: KIM, Doo Jin

Presenter: KIM, Doo Jin

Session Classification: Coherent Neutrino Scattering

Contribution ID: **161** Type: **Talk**

Status of Genie event generator(ONLINE)

Tuesday, October 25, 2022 4:20 PM (30 minutes)

Presenter: RODA, Marco (University of Liverpool (GB))

Session Classification: Neutrino Interaction Generators

Contribution ID: **162** Type: **Talk**

Status of Neut event generator(ONLINE)

Tuesday, October 25, 2022 4:50 PM (30 minutes)

Presenter: Dr PICKERING, Luke (Royal Holloway, University of London)

Session Classification: Neutrino Interaction Generators

Contribution ID: **163** Type: **Talk**

Status of NUISANCE

Tuesday, October 25, 2022 5:20 PM (25 minutes)

Co-authors: WILKINSON, Callum David (Lawrence Berkeley National Lab. (US)); Dr PICKERING, Luke (Royal Holloway, University of London); Dr DOLAN, Stephen (CERN)

Presenter: Dr WRET, Clarence (University of Rochester (US))

Session Classification: Neutrino Interaction Generators

Contribution ID: **164** Type: **Talk**

Modelling neutrino-nucleus interactions for the T2K experiment (from Modeling nu-N session)

Thursday, October 27, 2022 10:40 AM (25 minutes)

In order to achieve the ambitious goal of characterising neutrino flavour oscillations with percent-level precision, it is critical for current and future long-baseline neutrino oscillation experiments to substantially reduce existing systematic uncertainties. The most challenging of such systematic uncertainties is related with the modelling few-GeV neutrino-nucleus interactions.

To improve our understanding, the T2K collaboration is engaged in a continuous effort to implement up-to-date theoretical models in T2K's Monte Carlo event generator (NEUT) and to define a suitable parametrisation of the model's uncertainties as an input for neutrino oscillation analyses. The new uncertainty model, developed for the latest T2K oscillation measurement, will be presented, as well as a comparison of the model to available global lepton- and hadron-scattering data. Among other improvements, the latest model includes: a parametrisation offering substantial freedom to the input Spectral Function for charged-current quasi-elastic (CCQE) interactions; a momentum transfer dependent correction to the nuclear removal energy for CCQE interactions based on inclusive electron scattering data; and an updated treatment of nuclear medium effects in resonant pion production interactions.

Presenter: Dr DOLAN, Stephen (CERN)

Session Classification: Coherent Neutrino Scattering

Contribution ID: **165** Type: **not specified**

Search for Hidden Neutrinos: 숨겨진중성미자를찾아서

Tuesday, October 25, 2022 8:00 PM (1h 30m)

Primary author: Prof. PARK, Inkyu (University of Seoul, Department of Physics (KR))

Presenter: Prof. PARK, Inkyu (University of Seoul, Department of Physics (KR))

Session Classification: Public Lecture on Neutrinos (in Korean)

Contribution ID: **166** Type: **not specified**

Discussions

Wednesday, October 26, 2022 2:00 PM (30 minutes)

Primary authors: HARRIS, Deborah Appel (York University (CA)); Prof. QIAN, Xin (Brookhaven National Laboratory (US))

Presenters: WILKINSON, Callum David (Lawrence Berkeley National Lab. (US)); HARRIS, Deborah Appel (York University (CA)); MC FARLAND-PORTER, Kevin Scott (University of Rochester (US)); Prof. QIAN, Xin (Brookhaven National Laboratory (US))

Session Classification: Discussions