Fall 2016 NPC Scholar Abstracts

Masters Students:

Kamiya, Felipe Garcia Ken

Focusing on pion production from neutrino interactions, I will investigate the signature of neutrino events in liquid argon (LAr).

I will use LArIAT data from pion interactions for energies relevant in the short baseline neutrino (SBN) program. The aim is to help in the fine-tuning of the simulation and reconstruction of SBND events. These studies will help in the understanding of the systematic uncertainties associated with the Monte Carlo method used to simulate the detector response and the neutrino interactions.

I will consider the different interaction channels in LArIAT like pion absorption, decay, charge exchange, and elastic scattering whenever possible and use their signature to help in the simulation of SBND pion production events, also for different detector devices' layouts. Understanding well the events of interest and the detector in the simulation will contribute on planning the experiment and data analysis tools with respect to the desired physics and sensitivities.

Santos, Marcos Vinicius dos

The SBN program, hosted by Fermilab, is designed to search for a possible sterile neutrino, accessible only through very short baseline oscillations. Evidence for this elusive state was first observed by LSND and later corroborated by MiniBooNE and Gallium source experiments, although no conclusive evidence has ever been provided. In this context the development of an analysis strategy as well as a deeper knowledge of available models is crucial for the study of the SBN data, coming from no less than three detectors, SBND, MicroBooNE and ICARUS, in the search for new physics in the neutrino sector. As a NPC fellow, I plan to study the sensibility of this experimental setup to 3+N sterile neutrino models, using Monte Carlo techniques.

PhD Students:

Adams, Corey

As a Neutrino Physics Center fellow, I will lead the MicroBooNE experiments daily operations as it searches for new physics. MicroBooNE is a liquid argon time projection chamber, the largest in the United States, and is the first stage of Fermilab's Short Baseline Neutrino program. The goal of MicroBooNE is to confirm or refute the MiniBooNE low energy excess with a dedicated and precise measurement of electron neutrinos in the Booster Neutrino Beam. The experiment requires data collection and operation twenty four hours per day. As Deputy Run Coordinator and subsequently Run Coordinator I will be responsible for the continued smooth operation of MicroBooNE while it receives neutrinos, and to ensure the health and stability of the detector is maintained.

Cohen, Erez O

The current and future large neutrino detectors are all made of nuclei. In our opinion the ability to extract the interesting neutrino physics will be, at some point, limited by our knowledge of the nuclear physics involved. Consequently, the study of neutrino-oscillations have renewed interest in neutrino-nucleus interactions. In the energy range most relevant for oscillation studies (neutrino energies from 0.3GeV to 3GeV), the dominant neutrino interaction is via Quasi-Elastic (QE) neutrino-nucleon scattering in nuclei.

We propose to study neutrino induced charge-current QE scattering with one or two protons and no pions in the final state. Our interest in such events is double: Firstly, we wish to study nuclear dynamics using neutrino-nucleon scattering data. secondly, we aim to improving the reconstruction of neutrino energy for oscillations studies.

We wish to categorize these events according to their full topology, and try to associate them with specific nuclear physics processes (e.g., breaking of short range correlated pairs, pion absorption). We will try to compare the measurement to existing calculations and simulations, aiming to challenge the assumed nuclear model and identify parts of the phase space that are not well reproduced within the current models.

Investigating these events may allow extending the use of such semi-exclusive process to reconstruct the energy distribution of the neutrinos that initiate them. In the context of oscillation, it is clear that one will loose statistics compare to inclusive processes, however the gain in the ability to know the energy might improve our ability to characterize oscillations.

I will focus on single and double proton emission from charge current neutrino-neutron QE interactions. This will be accomplished by developing and evaluating

existing algorithms for proton detection, followed by the analysis of the cosmic and beam induced MicroBooNE data, with one and two protons tracks.

Coplowe, David

As an NPC Fellow my research is focused on understanding how neutrinos interact with matter using the MINERvA Experiment. The key aim of this work is to show that a novel technique, developed by a colleague and I at Oxford, can be applied to MINERvA data to isolate neutrino interactions on hydrogen in composite nuclear targets. This will not only provide us access to the primary neutrino-nucleon interaction and remove ambiguities that arise from interactions on heavy nuclei, but may also be used to improve the reconstructed neutrino energy spectra. Both are crucial steps forward in reducing the systematic uncertainties required for future long baseline neutrino experiments to probe the presence of any matter-antimatter asymmetry in the neutrino
sector. During my time at Fermilab I am focussing on developing reconstruction algorithms to better MINERvA's selection capability of exclusive three charged track final states. This will be done in conjunction with efforts to improve the reconstruction of hadronic momenta. Once these critical steps have been taken, work will focus on applying our technique to measure the first cross section of neutrino scattering on hydrogen in over 25 years.!

Nunes, Mônica Soares

My PhD work is related to the measurement of liquid argon purity using cosmic rays that cross the detector, with the LArIAT experiment. This study is important because it can be extended to neutrino experiments that are being planned and are also going to use LArTPCs.

I am already working with this measurement doing the calculation of the electron lifetime inside the chamber using the cosmic muons that cross the chamber in between beam spills. During this fellowship I plan to develop the studies about the impact of the impurities on the reconstruction of events, looking at the effects on charge and light collected by the detector. I'm also going to work with other tasks that are going to be helpful for the third run of the LArIAT experiment.

Zavanin, Eduardo Marcio

A series of new experiments have been planned to determine and improve the constraints in some parameters of neutrino physics, for example the DUNE experiment has the main objective of measure the CP phase furnishing a fundamental information about a possible break of symmetry between particles and antiparticles in the neutrino sector, furthermore the DUNE experiment will probe the mass hierarchy providing a definitive answer in favor of the normal or the inverted ordering of the neutrino masses. Besides the DUNE experiment, the JUNO

experiment has also been developed to measure the hierarchy of the neutrino masses. The experiments Hyper-Kamiokande, NOvA and T2K will also provide constraints for the values of the CP phase.

We will analyze the sensitivity of the new generation of experiments applying the idea of sterile neutrinos and understand how the combination of different experiments in medium/long base-line can account for the constraints in the sterile parameters as well to the standard parameters, we will also probe the possibility of the combination of different experiments improve the sensitivity to the CP phases, after the study of sterile neutrinos we can also use this global fit to understand how to alleviate tensions generated in the context of non-standard interactions.

PostDocs:

Falcone, Andrea

My project is focused on the LArIAT experiment, a liquid argon time projection chamber (LArTPC) which has been positioned in a charged particle beam at the Fermilab Test Beam Facility. One of the primary goals of the experiment is to measure the cross-section of different charged particle species as they interact in the argon as well as develop reconstruction and analysis techniques for use by future LArTPC neutrino experiments.

I hope to complete an analysis on the exclusive hadronic pion cross section, whose topology is an identified positively charged pion that interacts and produces highly ionizing tracks (protons). This topology is chosen to allow for the exploration of utilizing LArIAT's light detection system to provide an additional measurement of the calorimetry: in this simplified topology a direct comparison of the light and charge information should be possible. The development of this analysis technique will allow for a greater understanding of what can be extracted from the scintillation light collected in neutrino-argon interactions. I`ll also contribute to the upcoming Run-III of the LArIAT experiment. It will test the effect of various wire pitches (3, 4, 5 mm) on the calorimetric as well as topological reconstruction of charged particle events, similar to those produced in a neutrino-argon interaction.

FARNESE, CHRISTIAN

I am a post-doc experimental physicist presently working at I.N.F.N. Padova. I am experienced in running and exploiting LAr-TPC detectors. I have been working within the ICARUS collaboration on the neutrino event analysis, selection and reconstruction. During the T600 run at LNGS I also developed and applied an automatic system for the identification of cosmic muons, for the application of the necessary geometrical and physical requirements to the selected tracks and finally for the extraction of the electron lifetime.

In view of the SBN project I am deeply involved on the development of analysis tools and on the integration of the present ICARUS reconstruction tools within the general LArSoft framework. During my NPC fellow at FNAL I will work on an automatic selection and reconstruction of the cosmic ray muons crossing the detector, in view of their exploitation to obtain a measurement of the Argon purity. I will restrict my activity to the porting of the necessary tools to the new framework and their first application to MC events, with the milestone to make them working at least in a single particle case, assuming that the space charge distortion, impacting the details of electron collection on wires, is fully understood.

Flanagan, Will Hogan

I propose to use the TallBo cryostat to make measurements relevant to LArIAT and generic liquid argon light collection R&D. In particular, I will be conducting a side-by-side comparison between three SiPMs which are uncoated, coated with TPB, or VUV-sensitive. These tests will also inform LArIAT Run III and allow for further testing of our cold preamplification boards.

Ghosh, Monojit

In this proposed project, our goal is to study the degenerate parameter space of the neutrino oscillations in the presence of sterile neutrino in the DUNE experiment. In the standard three flavour scenario, there are two degeneracies which are relevant in the present scenario. They are: (i) the hierarchy-δ_{CP} degeneracy and (ii) the octant-δ_{CP} degeneracy. Now if there exists a sterile neutrino apart from the three active neutrinos, there will be three additional mixing angles: θ_{14}, θ_{24} and θ_{34}, two additional Dirac type CP phases and one additional mass squared difference. Thus in this extended parameter space there will be new degeneracies and our aim is to study these degeneracies in detail.

Lin, Shih-Kai

Many modern long baseline neutrino oscillation experiments use the ν_μ/anti-ν_μ-nucleus charged-current (CC) interactions to infer oscillation parameters. A good understanding of the CC interactions is crucial to the precise measurements of the oscillation parameters. The NOvA experiment uses the off-axis NuMI beam with a neutrino energy spectrum peaking at about 2 GeV. In this energy range, the quasielastic, the resonant production, and the deep inelastic scattering processes come into play in the total cross section. An inclusive measurement including all channels, together with measurements of individual channels, could provide a more complete picture. I will be analyzing a small dataset of the reversed horn current (RHC) data taken right before the 2016 summer shutdown. This dataset could not only shed light on questions remaining for the forward horn current (FHC) runs, but also provide a measurement of the anti-ν_μ-nucleus CC inclusive cross section measurement, which is even less measured than that for ν_μ in NOvA's energy range. One of the topics of particular interest is the data Monte Carlo disagreement in the reconstructed visible hadronic energy. It is known that neutrinos could interact with 2 nucleons as a whole. This process is modeled by the meson exchange current (MEC). By including MEC, the FHC data agree with Monte Carlo well. However, the data for RHC still disagree with Monte Carlo even with MEC included. Besides, there is data excess over Monte Carlo in very small hadronic energy, which is not seen in the FHC case. These are also interesting and important topics to be understood with this RHC run.

Luo, Xiao

MicroBooNE's goals are understanding the low energy excess observed from the MiniBooNE, as well as neutrino argon cross section measurements and detector R&D of Liquid Argon Time projection Chamber. I'm serving as the run coordinator for MicroBoone during the period of this fellowship. I will continue the two analysis topics that I have been working on and plan to produce two publications regarding the detector physics and the first cross-section measurement of inclusive charge current in MicroBooNE.

Soubasis, Brandon J

At LArIAT, the study of stopped muons and pions is an important direction as it assists the particle identification and a number of other analyses. It was pointed out earlier in an ArgoNueT (the predecessor of LArIAT) that muons and pions should stop within the TPC volume providing their momenta are less than 280 MeV/c and 330 MeV/c, respectively. At this range of momentum, time of flight and mometum information is insufficient for tagging the two particles.

Aerogel is an ultra light material in which the liquid component of the gel has been replaced with a gas. The result is a solid with extremely low density, low thermal conductivity and low index of refraction. The goal of having an aerogel threshold Cherenkov detector in LArIAT beam line is to separate muons and pions in a momentum range, where muons emit Cherenkov radiation while pions do not. This technique was demonstrated by the MICE and Belle II experiments and in LArIAT we use two aerogel threshold Cherenkov detector with index of refraction of 1.057 and 1.103. Having different indices of aerogel allows LArIAT to do this separation in different momentum ranges. This leads to need of incorporating aerogel threshold Cherenkov counters into the analysis framework.

Varanini, Filippo

I am a post-doc experimental physicist with a long experience in LAr-TPC detectors. I took part in the commissioning, data-taking and analysis of ICARUS-T600 at LNGS underground laboratory. I mainly focused on muon momentum measurement by multiple Coulomb scattering and on the study of wire signals and electronics response.

I am currently analyzing data from a 50 liter LAr-TPC test facility equipped with the new electronics developed by the ICARUS-T600 collaboration in view of the SBN experiment, currently under construction, studying its impact on wire signal identification and reconstruction.

During my stay at FNAL, I will work on the integration of the ICARUS-T600 software in the general LArsoft framework in view of the SBN project. I will be responsible for porting into LArsoft a detailed description of the ICARUS wire signal shaping

accounting for the response of the new electronics using simulated data and applying realistic noise conditions extrapolated from the ICARUS LNGS run.
In particular the treatment of the signal from the intermediate induction wire plane has been drastically modified, in order to allow a measurement of the ionization density *dE/dx also in this projection*, which would allow a significant (≈20%) improvement of the identification efficiency for νeCC events during the SBN run.

Professors:

Ioannisian, Ara

1)The study of the possibility to scan the Earth at DUNE via solar neutrinos. At DUNE in the nighttime (when neutrinos travel through the Earth) one expects about 4.5% more detected solar neutrino than in the day time for KamLAND's $\delta m^2_{21} \sim 7.5 \times 10^{-5}$ eV^2 (7% for $\delta m^2_{21} \sim 5 \times 10^{-5}$ eV^2). That huge asymmetry will allow the field to learn about chemical composition of the Earth's deep interior.

2)To find a simple approximate analytic formula for ν_μ to ν_e oscillation probability in matter for neutrino energy below the second MSW resonance. That will be useful for experiments to determine the CP (Dirac) phase of the lepton charged current mixing matrix (PMNS).

3)To investigate a possible influence of matter density non uniformity (along the neutrino beam) on neutrino oscillation at long baseline experiments.

Kemp, Ernesto

The Liquid Argon Time Projection Chambers (LArTPC) have been shown to be the most promising technique to raise the level of quality of data from neutrino interactions in terms of spatial and energy resolutions. The LArTPCs form the basis of the neutrino research program at Fermilab, which strategy is based on have experiments with gradual increase on the detector size/enhancements until reaches the state of the art that will be used in the ambitious DUNE project, a 50 kiloton LArTPC to be installed in the Sunford Underground Facility, 1300 km downstream of the the neutrino beam at Fermilab. The photon detection system is an essential part of LArTPCs. The neutrino group from UNICAMP (Brazil) proposed an innovation in the photon collection system, the ARAPUCA device, based on the combination of wavelength shifters and dichroic filters that trap the Argon scintillation photons, increasing the efficiency in light collection. My project is to work on R&D for ARAPUCA, to find optimal parameters of the optics, geometric configuration, mechanics and readout electronics in order to get maximum performance of the device. I am also working on other components of LArTPC, such as the anodic plans of the LArIAT experiment, which signals combined with those from the light detection system, provide the information necessary for a good reconstruction of neutrino events in LArTPCs.

Minakata, Hisakazu

One of the most intriguing questions that remained after we learned a lot about neutrino masses and lepton flavor mixing is the nature of neutrinos, ``Are neutrinos Majorana or Dirac particles?''. Recently, A. J. Long, C. Lunardini and E. Sabancilar made an interesting observation that the total capture rate of detection of the

Cosmic Neutrino Background via neutrino capture on tritium depends on the origin of the neutrino mass, twice larger for Majorana than Dirac neutrinos. Since it is extremely interesting conclusion, Stephen Parke and I are going to reexamine this problem.

Probably, another most important thing that remain to be done is the paradigm test: Does the standard three-flavor mixing scheme describe our world? Following Stephen Parke and Mark Ross-Lonergan, we made recently a refined proposal of 3 active plus N sterile unitary model as a framework of testing leptonic unitarity within the framework we called the "low scale unitarity violation". See arXiv:1609.08623. Based on this work, Pilar Coloma and I (together with my team) will examine unitarity violation in DUNE, T2HK, and JUNO.

Nunokawa, Hiroshi -- To be announced

Yu, Jaehoon

With the support of the neutrino center fellow, I will primarily be working on Deep Underground Neutrino Experiment (DUNE) and the Long Baseline Neutrino Facility (LBNF) in two important areas essential to the success of them: 1) beam hadron monitor development and 2) beam line design and optimization. For the hadron monitor, I will work with Fermilab team on R&D, design and a prototype construction of the hadron monitor for DUNE TDR, including preparation for possible prototype testing in FTBF and in NuMI beams. For the beam line optimization, I will work with the beam simulations group and study various optimization schemes and investigate potential offaxis effect with Milorad Popovic in the accelerator division not just in DUNE/LBNF but that in SBN experiments, resulting from NuMI/LBNF beams with nominal incident angle.