NuFact 2018, 20th workshop on neutrinos from accelerators

Sunday, August 12, 2018 - Saturday, August 18, 2018

Book of Abstracts

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Final results from the OPERA experiment in the CNGS neutrino beam

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The OPERA experiment at the Gran Sasso Laboratory was designed to study nu_mu → nu_tau oscillations in appearance mode in the CERN-to-Gran Sasso neutrino beam. We report the final analysis of the full data sample based on looser selection criteria than in previous analyses and multivariate approach. Oscillation parameters have been determined with a reduced statistical uncertainty, and the discovery of tau neutrino appearance is confirmed with an improved significance level. Moreover, the search for electron neutrino events has been extended to the full dataset exploiting an improved method for the
electron neutrino energy estimation. New limits have been set in the 3+1 neutrino model.

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Modeling neutrino-nucleus interactions in the few-GeV region

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A good understanding of neutrino-nucleus scattering mechanisms is essential to reduce the systematic errors in neutrino oscillation experiments. Recent interest of the Ghent group focus on providing a consistent description of this process in the intermediate energy region. We describe the low energy response with collective nuclear excitations and the quasielastic peak using a Hartree-Fock-CRPA (continuum random phase approximation) model that takes into account nuclear long-range correlations as well as hadronic final-state interactions. The two-body current mechanisms, which are especially important in the region between the quasielastic and the delta-resonance peak, are included through short-range correlations and meson-exchange currents, treated within the same mean-field based model. Our description of intermediate-energy neutrino-nucleus scattering is completed by modeling neutrino-induced pion production. For that, we consider the dominant contribution from the decay of the delta resonance as well as other terms required by chiral symmetry, working in a fully relativistic formalism with a refined treatment of nuclear effects.

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Distinguishing muon LFV effective couplings using \mu+e->e+e

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We discuss how to discriminate muon LFV couplings one from the other using the mode \mu+e -> e+e.

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The Mu2e Experiment at Fermilab

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The Muon-to-Electron-Conversion (Mu2e) Experiment is a high-precision, intensity-frontier experiment being developed at Fermilab which will search for coherent, neutrino-less muon to electron conversion in the presence of an atomic nucleus. Such a process would exhibit charged lepton flavor violation (CLFV), which has not yet been observed. Continuing the search for CLFV, Mu2e will improve the sensitivity by four orders of magnitude over the present limits. In the search for beyond the standard model (BSM) physics, Mu2e is uniquely sensitive to a wide range of models by indirectly probing mass scales up to the energy scale of 10^4 TeV. While muon-to-electron-conversion is permissible in the standard model through neutrino oscillations, the rate is extremely low at about one event in 10^52. By design, the background for the experiment will be well-understood and kept at a sub-event level, which will mean the observation of muon-to-electron conversion is a direct confirmation of BSM physics. The physics motivation, the design, and the current status of the experiment will be presented.

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A High-efficiency Cosmic Ray Veto Detector for the Mu2e Experiment

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The Mu2e experiment at Fermilab will search for the charged lepton flavor violating process of coherent muon-to-electron conversion in the presence of a nucleus with a sensitivity four orders of magnitude beyond current limits. The experiment will have a single event sensitivity of about 3×10^−17 while limiting the total background to about 0.5 events. One potential background is due to cosmic-ray muons producing an electron that is indistinguishable from signal within the Mu2e apparatus. The cosmic-ray-veto system of the Mu2e experiment is tasked with vetoing cosmic-ray-induced backgrounds with high efficiency, without inducing significant dead time and while operating in a high-intensity environment. The design of the cosmic-ray-veto system will be discussed.

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Performance of Scintillation Counters as Measured at the Fermilab Test Beam Facility for the Mu2e Cosmic Ray Veto System

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Photoelectron yields of extruded scintillation counters with titanium dioxide coating and embedded wavelength shifting fibers read out by silicon photomultipliers have been measured at the Fermilab Test Beam Facility using 120 GeV protons. The yields were measured as a function of transverse, longitudinal, and angular positions for a variety of scintillator compositions, reflective coating mixtures, and fiber diameters. Timing performance was also studied. These studies were carried out by the Cosmic Ray Veto Group of the Mu2e collaboration as part of their R&D program.

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Fabrication of A High-efficiency Cosmic Ray Veto Detector for the Mu2e Experiment

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The Mu2e experiment at Fermilab will search for the charged-lepton-flavor-violating process of coherent muon-to-electron conversion in the presence of a nucleus with a sensitivity four orders of magnitude beyond the current strongest limits. The goal of single-event sensitivity requires that all backgrounds must sum to significantly less than one event. One potential background is due to cosmic-ray muons producing an electron with signal characteristics within the Mu2e apparatus. The cosmic-ray-veto system of the Mu2e experiment is tasked with vetoing such cosmic-ray-induced backgrounds with high efficiency while inducing low dead time and while operating in the high-intensity environment of the Mu2e experiment. The UVA HEP group has been leading the effort to design and prototype the CRV and has recently started the fabrication this detector on site. Highlights of this effort including production detector performance will be presented.

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Performance of Wavelength-Shifting Fibers for the Mu2e Cosmic Ray Veto Detector

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The Mu2e experiment will search for a neutrino-less muon-to-electron conversion process with almost four orders of magnitude of sensitivity improvement relative to the current best limit. One important background is caused by cosmic ray muons, and particles produced by their decay or interactions, mimicking the conversion electron signature. In order to reach the design sensitivity, Mu2e needs to obtain a cosmic ray veto (CRV) efficiency of 99.99%. The CRV system consists of four layers of plastic scintillating counters read out by silicon photo-multipliers (SiPM) through wavelength shifting fibers. The CRV counters must produce sufficient photo statistics in order to achieve the required veto efficiency. We study the light properties of several wavelength shifting fiber sizes in order to optimize the total light yield for the CRV system. The measurements are performed using a scanner designed to ensure fiber quality for the CRV. Results from prototype and production fiber studies will be presented.

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Studies of the Aging Properties of the Mu2e Cosmic Ray Veto System

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The Muon-to-Electron Conversion experiment (Mu2e) operates at extremely high sensitivities, requiring a means of reducing experimental background. The Cosmic Ray Veto system (CRV) is a particle detector that will surround the Mu2e apparatus to veto penetrating particles that present background. The CRV must have a detection efficiency of 99.99% throughout the expected three year lifetime of the Mu2e experiment. The CRV is comprised of extruded polystyrene scintillating strips and fiber which degrade over time, decreasing the efficiency of the CRV. Using a standard accelerated aging technique, several scintillator and fiber samples were heated to increase their rate of degradation. The results of these studies and the impact of aging on the CRV will be presented.

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Neutrino trident production at near detectors

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The large statistics expected at the near detectors of neutrino oscillation experiments opens up the possibility to search for rare neutrino interactions. One example is neutrino trident production, the scattering of a neutrino by the Coulomb field of a nucleus producing a pair of charged leptons. In this talk, I will revisit the calculation of the trident scattering rate, addressing certain inconsistencies in the literature and presenting revised predictions for the total and differential event rates for relevant experiments. I will then argue that backgrounds can be kept under control and that certain channels could be seen for the first time at these facilities. Finally, I will dedicate some time to discuss what kind of of new physics one can look for in these processes.

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Search for K+->pi+nunu at CERN

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The decay K+⟶π+νν, with a very precisely predicted branching ratio of less than 10-10, is one of the best candidates to reveal indirect effects of new physics at the highest mass scales. The NA62 experiment at CERN SPS is designed to measure the branching ratio of the K+⟶π+νν with a decay-in-flight technique, novel for this channel. NA62 took data in 2016, 2017 and another year run is scheduled in 2018. Statistics collected in 2016 allows NA62 to reach the Standard Model sensitivity for K+⟶π+νν, entering the domain of 10-10 single event sensitivity and showing the proof of principle of the experiment. The analysis data is reviewed and the preliminary result from the 2016 data set presented.

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The search for neutral currents in muonic X-rays

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Muonic X-ray measurements at the Paul Scherrer Institute

Negative muons at rest quickly get captured by nearby atoms in highly exited atomic states. These muonic atoms subsequently de-exite via radiative and Auger transitions until the muon ends up in the 1s orbital. At the lower orbits, there is substantial overlap between the muon wave function and the nucleus, making this system an excellent laboratory to study the interaction between the muon and atomic nucleus.
MuX is a renewed effort at the Paul Scherrer to measure muonic X-rays in medium- and high-Z nuclei, fully exploiting the coverage and multiplicity of a germanium detector array and the high yield of negative muons available. The physics program focuses on atomic parity violation (APV). A measurement of the charge radius of 226Ra, derived from the 2s-1s transition energy, will serve as crucial input for an upcoming APV experiment with a single Ra ion. A second measurement program is exploring the possibility of measuring APV directly in muonic atoms. In the Standard Model, APV arrises from the mixing of the opposite parity 2p and 2s atomic states, leading to parity violation in the 2s-1s transition. We focus on Z=30 nuclei, where a measurable branching ratio of the single photon 2s-1s transition is expected. The high granularity of a large solid angle germanium detector array is exploited to suppress background from more intense transitions in the cascade.
In the summer of 2017, we successfully commissioned a novel target for the 226Ra charge radius measurement, which is planned to run in 2018. In addition, 2 weeks of beam time were dedicated to observe the 2s-1s transition for the first time, and quantify the background.

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Recent results of neutrino interactions from the T2K Near Detector

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Neutrino-nucleus cross-section measurements in the GeV regime are crucial for future accelerator-based precision neutrino oscillation measurements. The T2K Near Detector has provided important results for the study of nuclear effects in neutrino-nucleus interactions and therefore stringent constraints on model development. In this talk, I will present our recent cross-section measurements, highlight on-going progress and discuss future possible developments in T2K.

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Details of the T2K oscillation analyses

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T2K is a long-baseline neutrino experiment in which a muon neutrino beam produced by J-PARC in Tokai is sent 295 km across Japan to the Super-Kamiokande detector. The experiment studies neutrino oscillations via the disappearance of muon neutrinos and the appearance of electron neutrinos. T2K has conclusively observed muon neutrino to electron neutrino oscillations, opening the door to the observation of CP violation in the lepton sector. Since 2014, the experiment has run alternating neutrino and antineutrino beams in order to precisely measure the corresponding oscillation probabilities, resulting in leading measurements of the muon antineutrino disappearance parameters and results on CP violation in the lepton sector. Different oscillation analyses are performed. They differ for the adopted statistical approach, either frequentist or bayesian, and the kinematical variables used for the analysis templates. In this talk, we will present recently-updated results, focusing on the details of the oscillation analysis methods.

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Constraining neutrino transition magnetic moments

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We are presenting a preliminary results on the studies of neutrino transition magnetic moments using DUNE LAr, HK and JUNO detectors. Neutrinos, if Majorana particles, the combined effect of magnetic field and matter effect in core-collapse Super Nova can transform some of ν_e to $\bar{\nu}_e$ due to spin flavour conversions. As a result of this conversions the inverse beta decay signal will have an increment indicating evidence of transition magnetic moments. The DUNE LAr is sensitive to ν_e so will observed a deficiency of ν_e due to this conversion whereas both HK and JUNO which are sensitive to $\bar{\nu}_e$ will see excess of $\bar{\nu}_e$. The DUNE LAr and JUNO are more or less sensitive to other type of neutrinos due to use of ^{40}Ar and ^{12}C. So can estimate the event ratio using both neutrinos and hence sensitivity on transition magnetic moments. Even an non observation of such conversion put a restrictive bounds on the neutrino transition magnetic moments.

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Muonic X-ray measurements with radioactive elements

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Muonic X-rays are an excellent tool to measure the nuclear charge radius, the radii of almost all stable nuclei have been measured with this method. More challenging are radioactive nuclei due to the amount of material needed to stop negative muons produces at accelerator facilities. At the Paul Scherrer Institute we have developed a novel method, stopping the muons is a gaseous hydrogen-deuterium mixture. Initially muonic hydrogen is formed, then the muon transfers to deuterium. Due to a minimum in the scattering cross section, this muonic deuterium quickly reaches the target chambers walls, where the muons transfer a higher Z element. A layer as thin as a few nanometers of the element of interest is sufficient to produce the muonic atoms with a efficiency of O(10%). We aim to measure the muonic X-rays in 226Ra. The charge radius derived from this data will serve as a crucial input for an upcoming atomic parity violation experiment with a single trapped radium atom.

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Constraints on neutrino decay scenarios with electron anti-neutrino disappearance experiments.

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Neutrino decay provides a very interesting case for the "beyond PMNS" neutrino physics. It has been shown that this phenomenon can also explain some of the anomalies seen in neutrino experiments. We study the constraints that $\bar{\nu}_e$ disappearance experiments like JUNO and KamLAND can put on neutrino decay scenarios. In particular, we consider a model where a heavier neutrino can decay giving active daughter neutrinos which can then be detected in these experiments. We find that the experiments JUNO and KamLAND can together constrain τ_3/m_3 10^{-10} s/eV for the normal hierarchy and τ_2/m_2 10^{-9} s/eV for the inverted hierarchy. We discuss an interesting physics case because of which the bounds are better for the inverted hierarchy. Unlike ν_e appearance experiments, the $\bar{\nu}_e$ disappearance events do not change much depending on whether the decay products are visible or not. This is due to the smallness of $|Ue3|$.

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Recent Cross Section Results from T2K

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Measurements of the PMNS oscillation parameters by the T2K experiment are improving our understanding of neutrino mixing. Using the two multi-purpose near detectors, ND280 and INGRID, T2K also extensively measures neutrino-nucleus interactions in the low GeV region. With multiple targets and on/off-axis detector placement, the near detectors investigate target dependence and the effects of different neutrino fluxes. This talk introduces T2K and its cross section measurements, with emphasis on recent and upcoming results.

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The Role of Cross Sections in the Oscillation Analysis: The T2K Experience

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The T2K experiment measures long baseline neutrino oscillations with neutrinos in the 0.1-1.5 GeV energy range. Thanks to excellent beam performance T2K is rapidly gathering statistics, increasing the relative importance of the parameterisation of systematics. Neutrino-nucleus interactions are large contributors to the error budget at T2K, affecting crucial components such as neutrino energy estimation and event selection. This talk gives an overview of T2K's treatment of interaction systematics, the constraints that are placed upon them, and their impact on oscillation analyses.

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Mini-CAPTAIN measurements in the LANSCE WNR Neutron Beam

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All neutrino experiments face the problem of reconstructing the incoming neutrino energy using the visible interaction products. Unfortunately, the initial neutrino interaction is not well understood, not all of the interaction products are visible, and the secondary interactions may not be well understood. In preparation the analysis of neutrino oscillation data collected using liquid argon time projection chambers, the CAPTAIN collaboration is addressing this problem with a measurement of the cross section of neutrons impinging on an argon target. Using the WNR neutron facility, which produces a well known flux of neutrons up to a kinetic energy of 800 MeV, the total cross section will be measured for neutron kinetic energies above approximately 50 MeV, and partial cross sections will be measured for $n + Ar \longrightarrow p + X$ and $n + Ar \longrightarrow \pi^{\pm} + X$. Data for this measurement was collected during the Summer of 2017 using a 400 kg fiducial Liquid Argon TPC that was instrumented with a photon-detection system (PDS). The interaction by interaction neutron energy is determined using time of flight as determined by the PDS while the ionization yield is measured in the TPC.

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Future prospects for CAPTAIN experiment

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The CAPTAIN (Cryogenic Apparatus for Precision tests of Argon Interactions with Neutrinos) experiment is a five-ton liquid argon time projection chamber (LArTPC) at Los Alamos National Laboratory. CAPTAIN is designed to make measurements of liquid argon interactions relevant to neutrino physics in particular for the proposed Deep Underground Neutrino Experiment (DUNE). A prototype detector called Mini-CAPTAIN, with 400 kg of liquid argon, collected data at a neutron beam at LANL in the summer of 2017. We present plans for the future of the CAPTAIN experiment to take data at other neutrino sources and measure low-energy neutrino interactions on argon.

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Studying Neutral Current Elastic Scattering and the Strange Axial Form Factor in MicroBooNE

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One of the least constrained contributions to the neutral current (NC) elastic neutrino-proton cross section is the strange axial form factor, which represents the strange quark spin contribution to the spin of the proton. Knowledge of this form factor is important for many areas of physics including sterile neutrino searches, spin-dependent dark matter searches, and supernova explosion mechanisms. The strange axial form factor can be determined by studying NC elastic scattering events in the MicroBooNE detector at low negative four-momentum transfer squared (Q^2). MicroBooNE's unique ability to detect low-energy protons is expected to allow the measurement of these events with a Q^2 as low as 0.10 GeV^2. We present a selection of neutral current elastic events in a subset of MicroBooNE neutrino data, as well as our plan to extract the strange axial form factor from this selection in the full data set.

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Recent progress on radiation damage studies at RaDIATE

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In the recent past, major accelerator facilities have been limited in beam power not by their accelerators but by target and/or window survivability. With present plans to upgrade accelerator facilities at FNAL and J-PARC to higher beam powers (1.2+ MW) in the next decade, timely R&D of robust high power targets and beam windows is needed to fully realize the physics benefits of the higher beam power. An international team of researchers, under the aegis of the Radiation Damage In Accelerator Target Environments (RaDIATE) Collaboration, fabricated test specimens which were irradiated by 181 MeV protons in the Brookhaven Linac Isotope Producer (BLIP) facility at BNL, starting in spring of 2017. Test specimens, including candidate materials for various beam intercepting device applications, were provided by participating facilities. Post-irradiation examination (PIE) is being conducted at participating RaDIATE institutions with appropriate "hot-cell"facilities. The work includes efforts to provide BLIP irradiated samples to in-beam thermal shock test at CERN's HiRadMat beam-line facility. Thermal shock testing in beam allows observation of how the radiation damaged property data affects material behavior when exposed to actual beam loading conditions. The HiRadMat beam-line experiment proposal was accepted by the HiRadMat Scientific Board and is currently scheduled to run in October, 2018. In this talk up-to-date status of the experiments, PIEs, and prospect for the works conducted by RaDIATE collaboration will be over-viewed.

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Nuclear Theory, Data and Event Generators

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Ab Initio Methods

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Theory of neutrino pion production

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Open Issues in Nuclear SIS and DIS Scattering

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Electron vs Muon Neutrinos

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Theory of electron scattering and neutrinos

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Removal and Binding Energy in Lepton-Nucleus Scattering

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Probing neutrino coupling to a light scalar with coherent neutrino scattering

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Average CsI neutron density distribution from COHERENT data

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Coherent Elastic Neutrino Nucleus Scattering (CEνNS) as a probe of Z-prime through kinetic and mass mixing effects

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Neutrino trident at DUNE

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The Mu2e Experiment at Fermilab

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Low energy neutrino interactions

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NOvA Cross Section Model / Oscillation Needs

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Nucleon axial form-factor from a Bayesian neural network analysis of scattering data

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Future Upgrade of J-PARC Target and Beam Window

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Status and Physics Potential of MOMENT Study

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The LBNF Beamline

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Development and operational experience of T2K magnetic horn for over-MW beam

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Design and Challenges of ESSnusB Accumulator

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Status of the ENUBET

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Neutrino Physics with Deep Learning on NOvA

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The NOvA experiment has made both ν_μ disappearance and ν_e appearance measurements in Fermilab's NuMI beam, and is working on cross section measurements using near detector data. At the core of NOvA's measurements is the use of deep learning algorithms for identification and reconstruction of the neutrino flavor and energy.

Presented here is the extension of our deep learning efforts for identification of neutrino signal events, final state identification, single particle tagging, and reconstruction using instance segmentation techniques. I will describe the new implementations of modified Convolutional Neural Networks for anti-neutrino events which yield a 14% improvement in efficiency. I will also show the performance of our single particle ID network, data driven performance tests, standard candle measurements, and advances for reconstruction.

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Atmospheric Neutrino Oscillations with IceCube/DeepCore

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Details of the NOvA oscillation analyses

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Details of the T2K oscillation analyses

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Global analysis of neutrino oscillation experiments

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DUNE Oscillation Physics

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Physics potential of Hyper-Kamiokande for neutrino oscillation measurements

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Physics potential of the ESSνSB facility

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Status of ProtoDUNE Experiments at CERN

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Measuring the Leptonic Dirac CP Phase with Muon Decay at Rest

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Sketch of physics case in preparation for the EU Strategy Update

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Cross section issues for the next decade

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Detector concepts for nuSTORM

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Status of consideration of implementation of nuSTORM at CERN

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nuSTORM accelerator concept to serve cross-section programme

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Simulation studies of a detector for nuSTORM

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Daya Bay Reactor Neutrino Experiment

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Starting in 2011, the Daya Bay Reactor Neutrino Experiment observed anti-neutrinos from six nuclear reactors with eight identically designed underground anti-neutrino detectors in three experimental halls, and has accumulated the world's largest dataset of anti-neutrino candidates. The measurement of the neutrino mixing angle theat 13 and the neutrino mass squared difference |Delta m^2 ee|have reached a precision of better than 4%. The large dataset allows study of a variety of topics in neutrino physics, such as absolute reactor flux and spectrum. In this poster, we will present the latest results from Daya Bay on several topics.

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ANNIE Phase II Detector and Event Reconstruction

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The Accelerator Neutrino Neutron Interaction Experiment (ANNIE), deployed on the Booster Neutrino Beam (BNB) at Fermilab, has recently finished the neutron background measurement in the Phase I data taking. The primary physics goal of Phase II is to measure the multiplicity of final state neutrons from neutrino-nucleus interactions in water, which provides a strong handle to study the systematic uncertainties relevant to the neutrino energy reconstruction in the future long baseline oscillation experiments. The ANNIE Phase II detector will use Gadolinium-loaded water to detect the final state neutrons from neutrino interactions. It will also incorporate five Large Area Picosecond PhotoDetectors (LAPPDs) to improve the vertex and track reconstruction capability required by the physics goals. This presentation will give an overview of the Phase II detector upgrade and focus on the event reconstruction capability improved by the LAPPDs.

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The NOvA Test Beam Program

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NOvA is a long-baseline off-axis beam neutrino experiment. By measuring ν_μ disappearance and ν_e appearance at the 14 kiloton NOvA Far Detector, the experiment is addressing outstanding questions in neutrino physics, including the neutrino mass hierarchy and existence of leptonic CP violation. The NOvA Test Beam program, under deployment at the Fermilab Test Beam Facility, will use a scaled-down NOvA detector to sample beams of tagged electrons, muons, pions, and protons in the momentum range of 0.3 to 2 GeV/c. It will further the NOvA physics reach by precisely measuring the detector's muon energy scale and electromagnetic and hadronic response, and provide real data for detailed studies of particle identification techniques. Ongoing efforts on beamline instrumentation, data acquisition, simulation, momentum reconstruction and particle identification are presented. Implications for the neutrino oscillation measurements are discussed.

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Neutrino Physics with Deep Learning on NOvA

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The NOvA experiment has made both νμ disappearance and νe appearance measurements in Fermilab's NuMI beam, and is working on cross section measurements using near detector data. At the core of NOvA's measurements is the use of deep learning algorithms for identification and reconstruction of the neutrino flavor and energy.

Presented here is the extension of our deep learning efforts for identification of neutrino signal events, final state identification, single particle tagging, and reconstruction using instance segmentation techniques. I will describe the new implementations of modified Convolutional Neural Networks for anti-neutrino events which yield a 14% improvement in efficiency. I will also show the performance of our single particle ID network, data driven performance tests, standard candle measurements, and advances for reconstruction.

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Reactor Antineutrino Detection Using CHANDLER : A New Portable Neutrino Detector Tulasi Subedi Abstract CHANDLER

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CHANDLER is a neutrino detection technology to detect reactor antineutrino. It detects the end products (positron and neutron) from inverse beta decay (IBD) reaction, to tag an event. This technology can be used for nuclear non-proliferation and a sterile neutrino search.

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Close

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