The 24th International Workshop on Neutrinos From Accelerators (NuFact 2023)

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Natural Science Lecture Center (building-28), Seoul National University, Korea

Book of Abstracts

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MK Single Pion Production

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I would like to present my recent work at the NuFact workshop in Seoul. https://journals.aps.org/prc/abstract/10.1103/PhysRevC

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 ,
In the recent paper, I extended the model to the transition region between resonance and Deep Inelastic regions (high momentum transfer, Qˆ2, and hadron invariant mass, W) which is extremely important for neutrino oscillation experiments such as DUNE.

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Beyond the Standard Model: Probing Modular Symmetries in High-Energy Neutrino Oscillations with DUNE, T2HK, and T2HKK

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The focus of our study is to investigate neutrino mass models that arise from discrete non-abelian modular symmetry groups. These symmetries offer a promising theoretical approach to understanding neutrino phenomenology and involve multiple free parameters. Specifically, we examine models based on the A_4 modular symmetry and explore how the non-trivial transformation of Yukawa couplings impacts the flavor structure of the neutrino mass matrix. Our analysis demonstrates that the resulting mixing angles and CP-violating phase are consistent with the current oscillation data within a 3σ range.

We assume three such models and evaluate the potential of the DUNE and T2HK/T2HKK experiments to probe these models using best-fit values. Furthermore, we analyze how the determination of CP phase and atmospheric angle values is impacted by these models. To provide a more comprehensive understanding of the implications of our findings, we conduct a comparative study of DUNE and T2HK/T2HKK by performing a comprehensive parameter scan of the CP phase and atmospheric angle, independent of the fit.

Our research offers valuable insights into the impact of discrete non-Abelian modular symmetry groups on neutrino phenomenology. By exploring the implications of these models, we contribute to a deeper understanding of the underlying mechanisms that govern neutrino mass. This work has important implications for the broader field of particle physics and for future experiments seeking to probe the properties of neutrinos.

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Prospects of Neutrino mass ordering with supernova neutrinos in the upcoming long-baseline experiments

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In this paper we study the possibility of determining the neutrino mass ordering sensitivity from the future supernova neutrino events at the DUNE and T2HK detectors. We estimate the expected neutrino event rates from a future supernova explosion assuming GKVM flux model corresponding to different processes that are responsible for detecting the supernova neutrinos at these detectors. We present our results in the form of χ^2, as a function of supernova distance. For a systematic uncertainty of 5\%, our results show that, the neutrino mass ordering can be determined at $5\ \sigma$ C.L. if the supernova explosion occurs at a distance of 44 kpc for T2HK and at a distance of 6.5 kpc for DUNE. Our results also show that the sensitivity of T2HK gets affected by the systematic uncertainties for the smaller supernova distances. Further, we show that in both DUNE and T2HK, the sensitivity gets deteriorated to some extent due to presence of energy smearing of the neutrino events. This occurs because of the reconstruction of the neutrino energy from the energy-momentum measurement of the outgoing leptons at the detector.

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Implications of NSI Effects in Long-Baseline Neutrino Experiments

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The upcoming long-baseline (LBL) neutrino experiments will be sensitive to non-standard interaction effects and can provide information on the unknown oscillation parameter values. We explore the parameter degeneracies that can occur in DUNE, T2HK experiments, and a combination of both due to nonstandard interactions (NSI) arising simultaneously from two different off-diagonal sectors, i.e., $e-\mu$ and $e-\tau$. We derive constraints on both the NSI sectors using the combined NOνA and T2K results. Our analysis reveals a significant impact that dual NSIs may have on the sensitivity of atmospheric mixing angle θ_{23} in the normal ordering (NO) case. Furthermore, when non-standard interaction from the $e-\mu$ and $e-\tau$ sectors are included, we see significant changes in the probabilities for DUNE, T2HK, and the CP asymmetry also exhibits an appreciable difference.

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Vector leptoquark U_3: A possible solution to the recent discrepancy between NOvA and T2K results on CP violation

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In the current epoch of neutrino physics, many experiments are aiming for precision measurements of oscillation parameters. Thus, various new physics scenarios which alter the neutrino oscillation probabilities in matter deserve careful investigation. Recent results from NOvA and T2K show a slight tension on their reported values of the CP violating phase δ_{CP}. Since the baseline of NOvA is much larger than the T2K, the neutral current non-standard interactions (NSIs) of neutrinos with the earth matter during their propagation might play a crucial role for such discrepancy. In this context, we study the effect of a vector leptoquark which induces non-standard neutrino interactions that modify the oscillation probabilities of neutrinos in matter. We show that such interactions provide a

relatively large value of NSI parameter $\varepsilon_{e\mu}$. Considering this NSI parameter, we successfully explain the recent discrepancy between the observed δ_{CP} results of T2K and NOvA. We also briefly discuss the implication of U_3 leptoquark on lepton flavour violating muon decay modes: $\mu \to e\gamma$ and $\mu \to eee$.

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Neutrino Structure Functions from GeV to EeV Energies

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Accurate theory calculations for neutrino-nucleus scattering rates are essential in the interpretation of neutrino experiments, from oscillation measurements to astroparticle physics at neutrino telescopes. In the deep-inelastic (DIS) regime, neutrino structure functions can be reliably evaluated in the framework of perturbative QCD. However, large uncertainties affect these structure functions at low momentum transfer, distorting event rate predictions for energies up to 1 TeV. We present a determination of the neutrino inelastic structure functions valid for all values of Q2, from the resonance region to ultra-high energies. Our approach combines a data-driven machine learning parametrization of neutrino structure functions at low and moderate Q2 values matched to perturbative QCD calculations at large Q2. We compare our results to other calculations in the literature and outline the implications for neutrino telescopes.

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A Scattering and Neutrino Detector at the LHC (SND@LHC)

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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 < ⊠ < 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 a 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 physics programme includes studies of charm production, and lepton universality tests in the neutral sector. 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 250 fb−1. The experiment was recently installed in the TI18 tunnel at CERN and has collected its first data in 2022. A new era of collider neutrino physics has started.

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Update on the Targetry and Beamlines of MELODY

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Since the approval of MELODY in early 2023, the collection of surface muons and pions and the relevant beamlines have been revised.
In this report, we would like to present our latest studies at MELODY: i) For the target station, a) the optimization in terms of yields and material of the rotated target that is currently preferred and combined with the new sideways collection of both muons and (for the future) pions at an angle of 90 deg. and 270 deg. respectively, with respect to the primary protons, b) the cooling and maintenance scenarios, and c) the radiation shielding studies. ii) For the beamlines, the revised layout and optimization of the surface muon beamline including the beam monitoring studies. The decay muon beamline, foreseen as a future upgrade, will also be discussed.

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The MicroBooNE cross section program, with a special focus on the TKI analysis

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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, with eight published measurements and more than thirty ongoing analyses studying a wide variety of interaction modes. This talk provides an overview of MicroBooNE's neutrino cross-section physics program, including investigations of exclusive pion final states and rare processes, novel cross section extraction methods, and measurements with both muon and electron neutrinos from the BNB and NuMI beamlines.

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Distinguishing Non-Standard Interaction and Lorentz Invariance Violation at the future long-baseline experiments

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In the current era of precision measurements, one of the prime objectives of various neutrino oscillation experiments is to look for the signals of sub-leading effects in the three flavour neutrino oscillation framework. It is therefore, crucial to distinguish between the different new physics scenarios so that they their origin and implications can be well understood theoretically. As the two phenomena, Non-standard interactions in neutrino propagation (NSI) and Lorentz invariance violation (LIV) can modify the Hamiltonian of neutrino oscillation in a similar fashion, it is very difficult to distinguish these two effects. The only difference between them lies in the fact that NSI depends on the matter density, whereas LIV is independent of the earth matter effect. Therefore, for a fixed

baseline experiment, where matter density is constant, the theories describing NSI and LIV are exactly equivalent. However, as the present and future bounds of the NSI and LIV parameters are not equivalent, one can distinguish these two scenarios in the long-baseline neutrino experiments depending on their statistics with respect to the present and future bounds of these parameters. In this work, we attempt to differentiate between LIV and NSI in the context of DUNE and P2SO, as these two future experiments are believed to be sensitive to the strongest matter effect and will have very large statistics. Taking LIV in the data and NSI in theory, our results show that, indeed it is possible to have good discrimination between LIV and NSI. The best separation between LIV and NSI at 3σ C.L. is achieved for the parameter $a_{\mu\mu}$ with P2SO. In this case, the value of LIV parameter for which separation is possible, lies within its future bound, if one considers the value of NSI parameter to be constrained by the present experiments. Between DUNE and P2SO, the latter has better sensitivity for such discrimination.

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Present and future constraints on flavor-dependent long-range interactions of high-energy astrophysical neutrinos

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The discovery of new, flavor-dependent neutrino interactions would provide compelling evidence of physics beyond the Standard Model. We focus on interactions generated by the anomaly-free, gauged, abelian lepton-number symmetries, specifically $L_e - L_\mu$, $L_e - L_\tau$, and $L_\mu - L_\tau$, that introduce a new matter potential sourced by electrons and neutrons, potentially impacting neutrino flavor oscillations. We revisit, revamp, and improve the constraints on these interactions that can be placed via the flavor composition of the diffuse flux of high-energy astrophysical neutrinos, with TeV-PeV energies, i.e., the proportion of ν_e, ν_μ, and ν_τ in the flux. Because we consider mediators of these new interactions to be ultra-light, lighter than 10^{-10} eV, the interaction range is ultra-long, from km to Gpc, allowing vast numbers of electrons and neutrons in celestial bodies and the cosmological matter distribution to contribute to this new potential. We leverage the present-day and future sensitivity of high-energy neutrino telescopes and of oscillation experiments to estimate the constraints that could be placed on the coupling strength of these interactions. We find that, already today, the IceCube neutrino telescope demonstrates potential to constrain flavor-dependent long-range interactions significantly better than existing constraints, motivating further analysis. We also estimate the improvement in the sensitivity due to the next-generation neutrino telescopes such as IceCube-Gen2, Baikal-GVD, KM3NeT, P-ONE,
and TAMBO.

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Complementarity of low- and high-energy probes for lepton flavour physics

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The neutrino sector is currently not well constrained and may be hiding new physics beyond neutrino masses. I will consider a model-independent approach using effective field theory and discuss different ways to probe interactions between neutrinos and quarks using a range of different processes from coherent elastic neutrino nucleus scattering (CEνNS) and invisible meson decays to lepton flavour universality violation.

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Search for a muon EDM at PSI using the frozen-spin technique

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Permanent electric dipole moment (EDM) of a fundamental particle breaks both parity (P) and time-reversal (T) symmetries, implying the violation of charge-parity (CP) symmetry, assuming CPT invariance. With the current experimental sensitivities, an observation of a non-zero muon EDM would indicate new CP violating sources from physics beyond the Standard Model. The experiment at the Paul Scherrer Institute (PSI) will search for the muon EDM employing the frozen-spin technique for the first time. The muons will orbit in a solenoid storage ring with the radial electric field applied such that it cancels the g-2 precession. A non-zero EDM would result in the muon spin precession in the plane orthogonal to the muon motion and the signal would manifest as the upstream-downstream (with respect to the magnetic field) asymmetry in the decay positron counts versus time. The experiment is expected to reach the sensitivity of $6 \times 10^{-23} e$ cm using $p = 125$ MeV/c muons, thus improving the current direct limit by more than three orders of magnitude. This talk will summarize the principle, current status and timeline of the experiment at PSI.

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Impact of final-state de-excitation on modeling neutrino-nucleus interactions

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As neutrino oscillation physics enters the precision era, the modeling of neutrino-nucleus interactions constitutes an increasingly challenging source of systematic uncertainty for new measurements. To confront such uncertainties, a new generation of detectors is being developed to measure the exclusive final state of neutrino interaction. Precise simulations of the nuclear effects on the final-state nucleons are needed to fully benefit from the improved detector capabilities.

To address this problem, we focused on the re-interactions of final state nucleons with the nuclear medium (FSI) by comparing NuWro and INCL cascade models and considering the de-excitation model from ABLA. INCL is an evolved nuclear cascade code primarily designed to simulate nucleon-, pion- and light-ion-induced reactions on nuclei. ABLA is a de-excitation code coupled to INCL that can simulate all the particles emitted by de-excitation. This is the first detailed study using the INCL model in the framework of neutrino physics and the first study investigating the effect of de-excitation on the hadronic final state of neutrino interactions. The results feature various novelties, including the production of nuclear clusters (e.g., deuterons, α particles) in the final state and the release of removal energy during the de-excitation stage.

We present a characterization of the hadronic final state after FSI and de-excitation, comparisons to available measurements of transverse kinematic imbalance, an assessment of the observability of nuclear clusters, and the impact of de-excitation on the energy released around the vertex.

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High - Intensity Muon Beams (HIMB) project or how to improve the most intense continuous muon source in the world

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Currently PSI delivers the most intense continuous muon beam in the world with up to a few 10^8 μ+/s. The High Intensity Muon Beam (HiMB) project aims at developing a new target station and muon beam lines able to deliver 10^10 μ+/s, with a huge impact for low-energy, high-precision muon experiments.

While the next generation of proton drivers with beam powers in excess of the current limit of 1.4 MW still requires significant research and development, the focus of HiMB is to improve the surface muon yield with a new target geometry and to increase capture and transmission with a solenoid-based beamline in order reach a total efficiency of approximately 10%.
We present the current status of the HiMB project.

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First commissioning data from the upgraded T2K beamline

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The J-PARC accelerator, serving the long-baseline neutrino oscillation program in Japan, is engaged in a long-term effort to increase the proton beam power from 500kW to 750kW during T2K data-taking, and ultimately more than 1.3 MW for Hyper-Kamiokande.

The T2K beamline underwent major upgrades in view of the increased beam power, and a successful first run was performed in April 2023.
T2K is instrumented with a series of proton beam monitors upstream of the production target, as well as a muon monitor downstream of the decay volume, which measures muons coming from the hadron decays producing neutrinos.

It also has the INGRID on-axis near detector, which monitors the direction and position of the neutrino beam. These detectors can be used together to ensure the correct alignment and the correct operation of the components in the upgraded T2K beamline.

Results of the first commissioning run of the upgraded T2K beamline using these beam monitoring detectors will be presented.

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Tests and assembly of the T2K near detector upgrade

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The near detector of T2K (ND280) is undergoing a major upgrade. A new scintillator tracker, named superFGD, with fine granularity and 3D-reconstruction capabilities has been assembled at JPARC. The new Time Projection Chambers are under development, based on the innovative resistive Micromegas technology and a field cage made of extremely thin composite walls. New scintillator panels with precise timing capability have been built to allow precise Time of Flight measurements.

The detector is currently in assembly phase following a detailed effort of characterization during detector production. The results of multiple tests of the detectors with charged beams, neutron beam, cosmics and X-rays will be presented. Among these results, we could mention the first measurement of neutron cross-section with the superFGD and the first detailed characterization of the charge spreading in resistive Micromegas detectors.

Thanks to such innovative technologies, the upgrade of ND280 will open a new way to look at neutrino interactions: sensitivity results and prospects of physics capabilities will be also shown.

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Experimental proof of principle of the Neutrino Tagging technique at NA62

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The neutrino tagging technique proposes to instrument a neutrino beam line with silicon trackers to kinematically reconstruct properties of individual beam neutrinos produced in $\pi \to \mu\nu_\mu$, K$\to \mu\nu_\mu$ decays. As a result, the initial neutrino flux is precisely determined and the individual neutrino energy can be reconstructed with a resolution better than 1%. Moreover, based on time and angular coincidence, the neutrinos kinematically reconstructed by the trackers can be individually associated to the neutrinos interacting in the neutrino detector, such that the precise measurement of their properties can be used for physics analyses (e.g. oscillations, cross-section). A proof of principle of the method has been performed using the NA62 experiment at CERN as a miniature neutrino experiment: its intense kaon beam copiously produces neutrinos when decaying as K$\to \mu\nu_\mu$, its spectrometers act as tagger for the charged particles, and its electromagnetic calorimeter serves as neutrino detector. A trigger line was deployed in 2022 to collect events in which a neutrino interacted in the calorimeter. This contribution presents the analysis of the data collected in 2022. To avoid potential bias, the analysis was optimized in a phase space region free of neutrino interactions. In the complementary signal region, a fraction of an event is expected. This contribution will reveal the actual content of this signal region.

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Neutrino data for nuclear parton distribution fonction determinations

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Global analyses of nuclear Parton distribution functions (nPDFs) play a crucial role in making precise predictions for a wide range of processes in lepton-nucleus (lA), proton-nucleus (pA), and heavy ion collisions (AA). In this context, the inclusion of neutrino deep inelastic scattering (DIS) data is particularly important as it enables an improved flavour separation of the parton densities. However, over the past two decades several studies have reported tensions when attempting to combine neutrino and charge lepton DIS data. In this talk, we present the recent and detailed study of the compatibility of neutrino DIS data within the nCTEQ frame work based on arXiv:2204.13157.

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Neutrino Mass Ordering using Atmospheric Neutrino Oscillations with IceCube DeepCore

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Neutrino Mass Ordering (NMO) studies explore the unresolved fundamental question of whether the neutrino masses follow a normal ordering (m3>m2>m1) or an inverted ordering (m2>m1>m3). IceCube is an ice-Cherenkov neutrino detector deployed about 1.5 kilometers below the surface of the South Pole. Using DeepCore, a more densely instrumented volume of ice near the bottom of the detector, we study the ordering by a measurement of the oscillation patterns of a 9.28-year sample of atmospheric neutrinos. The main goals of this work include analyzing the NMO at higher neutrino energies relative to Super-Kamiokande and long-baseline experiments as well as observing neutrino-Earth matter effects, both of which will play a distinctive role in NMO global fit studies. Another goal includes preparing for a measurement of the ordering using the superior IceCube Upgrade instrumentation, a fully-funded extension of DeepCore that is estimated to be deployed in the 2025-2026 Antarctic summer.

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Overview of physics results with coherent elastic neutrino-nucleus scattering data

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The detection of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) performed in 2017 and 2021 with cesium iodide and in 2020 with liquid argon by the COHERENT collaboration has paved the way for precision phenomenological measurements of many diverse physical phenomena.
CEνNS is a neutral current process induced by the exchange of a Z boson that permits putting interesting constraints on nuclear physics, beyond the standard model (SM) neutrino electromagnetic properties but it also represents a sensitive probe for non-standard interactions (NSI) that are not included in the SM, induced by yet to be discovered neutral vector and scalar bosons.
Recently, CEνNS has also been observed for the first time using antineutrinos from reactors at the Dresden-II site with a germanium detector called NCC-1701, allowing to obtain more stringent and complementary constraints.

In this talk, I will present a summary of the physics reach of CEνNS, presenting, in particular, the state-of-the-art constraints on neutrino charge radii, milli-charges, and magnetic moments [1] (putting emphasis on the role of elastic neutrino electron scattering in Dark Matter experiments like LZ and XENONnT [2]) as well as new limits on different new physics models involving light vector Z' mediators [3]. The complementarity of CEνNS constraints with nuclear physics with the recent PREX and CREX neutron-skin determinations will also be discussed [4], highlighting the interplay with the weak-mixing angle determination [5].

Finally, I will provide prospects for the future, given the large amount of CEνNS experiments that are currently being proposed or under construction [5].

[1] M. Corona et al. JHEP 09 (2022) 164, Arxiv: 2205.09484
[2] M. Corona et al. Phys. Rev. D 107 (2023) 5, 053001, Arxiv: 2207.05036
[3] M. Corona et al. JHEP 05 (2022) 109, Arxiv: 2202.11002
[4] M. Corona et al. Phys. Rev. C 105 (2022) 5, 055503, Arxiv:2112.09717
[5] M. Corona et al. Arxiv:2303.09360 (2023)

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Recent Developments Regarding the MiniBooNE Anomaly

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The 4.8σ low-energy excess (LEE) of electron-like events observed by MiniBooNE is one of the longest-standing anomalies in particle physics. As the MiniBooNE reconstruction relied on the identification of Cherenkov rings, the excess could come from extra electrons or photons in the detector. This talk covers new developments regarding each hypothesis. The MicroBooNE experiment has recently constrained the level to which excess ν_e interactions from the Booster Neutrino Beam can explain the LEE. We show that the MicroBooNE constraints are significantly alleviated if the LEE comes from $\overline{\nu}_e$ rather than ν_e interactions. This effect is due to a difference in the low-energy suppression of $\overline{\nu}_e$ and ν_e cross sections in carbon v.s. argon. Next, we discuss a model comprised of an eV-scale sterile neutrino and a heavy neutral lepton $\mathcal{N}$ with a transition magnetic moment coupling to active neutrinos, also known as a "neutrissimo". It is shown that the visible decay $\mathcal{N} \to \nu\gamma$ can explain the bulk of the energy and angular distributions of the LEE. New constraints on the neutrissimo model are also derived from MINERνA neutrino electron elastic scattering measurements. While they do not currently rule out the MiniBooNE solution, a dedicated MINERνA analysis would likely be sensitive to the MiniBooNE-preferred region of neutrissimo parameter space.

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Time Slicing of Neutrino Fluxes in Oscillation Experiments at Fermilab

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The upcoming long baseline neutrino experiments have the goal of enhancing proton beam power to a multi-MW scale and utilizing large-scale detectors to address the challenge of limited event statistics. The DUNE experiment at LBNF will test the three neutrino flavor paradigm and directly search for CP violation by studying oscillation signatures in the high intensity ν_μ (anti-ν_μ) beam to ν_e (anti-ν_e) measured over a long baseline.\par
As long baseline neutrino experiments progress into a phase of increased precision, it becomes crucial to minimize systematic errors to a few percent in order to achieve their desired scientific objectives. One of the most demanding contributors to these systematic errors arises from the cross sections of neutrino-nucleus interactions.
During this presentation, a novel approach called the "stroboscopic approach" is introduced as an innovative research and development technique for neutrino beams. By exploiting the correlation between the true neutrino energy and the measured neutrino arrival time, this technique selects different neutrino energy spectra from a wide-band neutrino beam. It uniquely allows access to true energy information at the Far detector, which is not possible from any other existing part of the DUNE experiment.\par
Three different thrusts are necessary for the application of stroboscopic approaches, namely: 1) creation of short (˜300ps) proton bunch length, 2) implementation of fast timing to get equivalent time resolution in the detectors, 3) establishment of synchronization between the time at the detector and time of the bunch-by-bunch proton at the target. This talk will explain how the three different thrusts emerge from the same objective of understanding how the stroboscopic approach brings its own critical contribution to DUNE and US neutrino physics.\par
Obtaining a better understanding of the cross sections is critical for DUNE experiment and neutrino physics as a whole and US accelerator-based neutrino beams will benefit from this novel technique.

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Prompt neutrinos at the LHC and connections to the prompt atmospheric neutrino flux

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The Large Hadron Collider (LHC) can produce huge numbers of neutrinos into the large rapidity region. New experiments at the LHC, the ongoing FASER\nu and SND@LHC and the proposed Forward Physics Facility (FPF) experiments aim to detect such neutrinos, in particular prompt neutrinos which mainly come from charm hadron decays. Prompt neutrinos can be also produced by cosmic ray interactions in the atmosphere which become the main component of the atmospheric neutrino flux at very high energies. Prompt atmospheric neutrinos have not yet been detected and theoretical predictions have large uncertainties, mainly related to charm hadron production. The study of charm production through measurements of prompt neutrinos at the LHC with high statistics will help estimations of the prompt atmospheric neutrino flux. We will present the kinematic regions for prompt neutrinos that can be detected in far-forward neutrino experiments. We discuss the relevance to the prompt atmospheric neutrino flux using collider kinematic variables, the collision energy \sqrt{s} and the center-of-mass rapidity y of the charm hadrons and neutrinos.

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Current Status and Results from the NINJA Experiment

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The NINJA collaboration aims to study neutrino-nucleus interactions in the energy range of hundreds of MeV to a few GeV using an emulsion-based detector. A series of neutrino-nucleus interaction measurements was conducted using the emulsion detector with water and iron targets in the near detector hall of the T2K experiment at J-PARC. The emulsion detector is suitable for precision measurements of charged particles produced in neutrino interactions with a low momentum threshold, especially low momentum protons as low as 200 MeV/c, thanks to its thin-layered structure and sub-μm spatial resolution. Multiplicities and kinematics of muons, charged pions and protons were measured and some significant differences between the data and Monte Carlo prediction were observed. In this talk, current status and the results from the NINJA experiment will be presented.

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Exploring Linear Seesaw with Modular S_3 Symmetry

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We typically prioritize discrete symmetries when exploring neutrino phenomenology. In this context, we examine neutrino masses and mixing within the linear seesaw framework by utilizing a simple permutation group known as S_3 symmetry. To simplify the complexity of vacuum alignments and avoid the need for multiple flavon fields, we incorporate modular symmetries, which prove advantageous. Our aim is to elucidate the effects and significance of the modular S_3 symmetry in explaining viable neutrino mixing consistent with current observations. Furthermore, we discuss the inclusion of a non-zero reactor mixing angle and adjust the model parameters accordingly. Additionally, we provide a brief overview of leptogenesis.

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A monitored neutrino beam for high precision cross section measurements: the ENUBET experiment at CERN

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Monitored neutrino beams represent a powerful and cost effective tool to suppress cross section related systematics for the full exploitation of data collected in long baseline oscillation projects like DUNE and Hyper-Kamiokande. In the last years the NP06/ENUBET project has demonstrated that the systematic uncertainties on the neutrino flux can be suppressed to 1% in an accelerator based facility where charged leptons produced in kaon and pion decays are monitored in an instrumented decay tunnel. In this talk, we will present the final results of this successful R&D programme. The collaboration is now working to provide the full implementation of such a facility at CERN in order to perform high precision cross section measurements at the GeV scale exploiting the ProtoDUNEs as neutrino detectors. This contribution will present the final design of the ENUBET beamline that allows to collect $\sim 10^4$ ν_e and $\sim 6\times 10^5$ ν_μ charged current interactions on a 500 ton LAr detector in about 2 years of data taking. The experimental setup for high purity identification of charged leptons in the tunnel instrumentation will be described together with the framework for the assessment of the final systematics budget on the neutrino fluxes, that employs an extended likelihood fit of a model where the hadro-production, beamline geometry and detector-related uncertainties are parametrized by nuisance parameters. We will also present the results of a test beam exposure at CERN-PS of the Demonstrator: a fully instrumented 1.65 m long section of the ENUBET instrumented decay tunnel. Finally the physics potential of the ENUBET beam with ProtoDUNE-SP and plans for its implementation in the CERN North Area will be discussed.

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Neutrino Interaction Measurement Capabilities of the SBND Experiment

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The Short-Baseline Near Detector (SBND) is a 100-ton scale Liquid Argon Time Projection Chamber (LArTPC) 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 be filled with liquid argon in fall 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 LArTPC 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 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 program ahead.

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Status of the Short-Baseline Near Detector at Fermilab

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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 anticipated to begin operation later this year. 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.

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Studying Neutrino-Nucleus Interactions at SBND with Muon Neutrino Charged-Current Events with no Pions in the Final State

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The Short-Baseline Near Detector (SBND), a liquid argon time projection chamber (LArTPC) located at Fermilab, will soon start collecting over a million neutrino events per year. For SBND and other neutrino experiments like DUNE, modeling neutrino-nucleus interactions with heavy nuclei at the few-GeV energy range is a significant challenge. In this range, neutrinos scatter on heavy nuclei through multiple interaction modes, and the final states are convoluted with various nuclear effects. Improved understanding of these interaction processes will broadly impact future oscillation measurements as well as exotic searches performed at neutrino facilities. This poster presents a study on events with a muon and no pions in the final state, the dominant exclusive event topology at SBND. We demonstrate the capabilities of SBND to provide high-statistics, high-purity data on this channel, and discuss how the unique features of this channel will lead to a better understanding of neutrino-nucleus interactions.

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Exploring new-physics effects of scalar NSI at long baseline experiments

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The experimental observation of the phenomena of neutrino oscillations was the first firm experimental evidence of physics beyond the Standard Model (SM). The SM of particle physics needs an extension to explain the neutrino masses and mixing. The models describing beyond SM physics usually comes with some additional unknown couplings of neutrinos termed as Non Standard Interactions (NSIs). The idea of NSI was initially explored by Wolfenstein [1], where he studied how a vector mediated NSI can introduce matter effects in neutrinos. Apart from vector NSI, there is also an interesting possibility of neutrinos coupling with matter fermions via a scalar, called scalar NSI [2, 3]. Unlike the vector NSI, the effect of scalar NSI appears as a medium dependent correction to the neutrino mass term, which may offer unique phenomenology in neutrino oscillations.

In this work, we studied the impact of scalar NSI on the measurement sensitivities of oscillation parameters at three upcoming long-baseline (LBL) experiments: DUNE, [4], T2HK [5] and T2HKK [6]. The presence of scalar NSI may significantly impact the neutrino oscillation probabilities as well as the event rates at the detectors. We show the scalar NSI parameters can alter the physics sensitivities of these experiments. We then perform a synergy study among the LBL experiments (DUNE+T2HK, DUNE+T2HKK) which may offer a better capability of constraining the scalar NSI parameters as well as an improved sensitivity towards CP-violation and mass hierarchy [7]. We also probe scalar NSI to constrain the absolute masses of neutrinos via neutrino oscillation experiments.
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Recent Results on Indirect Dark Matter Searches with IceCube

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Although the existence of dark matter has been well established by numerous observations, its nature remains unknown. Dark Matter could be detected indirectly through the observation of neutrinos produced in self-annihilations or decays of dark matter. Objects with large dark matter accumulations such as galaxy clusters or the Galactic dark matter halo are primary targets. Searches for such signals conducted with the IceCube Neutrino Telescope have resulted in some of the most stringent constraints on the lifetime of dark matter in particular in the TeV - PeV mass range. We present searches for neutrinos from dark matter decay with IceCube, that are conducted in a model independent way assuming a 100% branching ratio into a pair of Standard Model particles. The decay channels considered for these works include $\nu\bar{\nu}$, $\tau^+\tau^-$, W^+W^-, $b\bar{b}$. Current constraints and sensitivities are reviewed.

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First results from a relativistic mean field theory implemented in the NEUT neutrino interaction event generator

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Neutrino oscillation experiments, such as the Tokai to Kamioka (T2K) experiment, are limited by their simulation of accurate neutrino-nucleus interactions. More in-depth theoretical knowledge of neutrino-nucleus interactions are paramount; however, implementing such knowledge in existing event generator frameworks is just as imperative. To evaluate neutrino-nucleus interactions a general framework for the relativistic nuclear many-body problem is required; this framework can be calculated to arbitrary accuracy and compared with experimental measurements.

A relativistic nuclear model containing interacting nucleons with mesons was proposed by Walecka [J.D. Walecka, Annals Phys. 83 (1974) 491-529] and is based on quantum field theory. The model is complex and computationally expensive; however, it can be approximated at higher densities by using a mean field approach in which the meson field operators are replaced by their respective expectation values. The resulting model, relativistic mean field theory (RMF), can be used to describe medium to high density nuclei through Dirac-Hartree calculations [C.J. Horowitz, Brian D. Serot, Nucl. Phys.A 368 (1981) 503-528] of the nuclear bound state. This method can be exactly solved for spherically symmetric nuclei such as ^{12}C, ^{16}O and for some nearly-spherically symmetric nuclei such as ^{40}Ar—the target nuclei used in neutrino experiments. The RMF model [R. González-Jiménez *et al.*, Phys. Rev. C 100 (2019) 4, 045501] [R. González-Jiménez *et al.*, Phys. Rev. C 101 (2020) 1, 015503] has already been used to evaluate electron and neutrino scattering on different nuclei. The RMF bound state model can then be coupled with the nucleon scattered state (the solution of the Dirac equation with a complex optical potential) to predict the hadronic current in lepton-nucleus scattering.

This talk presents the first work in implementing an RMF neutrino interaction model into the NEUT neutrino interaction event generator framework. This can provide a first glimpse into calculating an exclusive cross section using an neutrino interaction event generator and can provide the T2K experiment with a more theoretically robust model upon which to study systematic uncertainties.

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Measurement of the inelasticity distribution of neutrino-nucleon interactions for 100 GeV < E_nu < 1 TeV with IceCube DeepCore

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IceCube DeepCore, a sub-array of the IceCube neutrino observatory, has a high-density configuration and it is sensitive to neutrinos with energies above a few GeV. In this contribution, we present a measurement of the shape of differential cross section as a function of inelasticity for neutrino-nucleon interactions in the energy range from 100 GeV to 1 TeV. The measurement is based on a high-purity sample of starting muon-neutrino events from charge interactions detected by IceCube DeepCore over a period of 9.2 years. Our measurement bridges a critical gap between the prior IceCube result and accelerator differential cross section measurements. We compared our results with predictions using different combinations of available flux and cross section models.

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Multinucleon knock-out in neutrino-nucleus scattering

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The precise measurement of neutrino properties is among the highest priorities in fundamental particle physics. Accelerator-based neutrino experiments provide a unique framework for such studies, providing oscillation measurements and hints of the CP violation in the leptonic sector. However, since these experiments rely on the interaction of neutrinos with bound nucleons inside atomic nuclei, understanding the hadronic and nuclear physics of these interactions constitutes a challenging source of uncertainty. Modeling neutrino-nucleus scattering processes is a complex many-body problem, traditionally performed in the independent-particle picture, focusing on the quasielastic neutrino-nucleon interactions or the excitation of nucleon resonances. Improving our knowledge of such cross sections to the required percent levels involves conducting research beyond the first approximation, incorporating the effects of nucleon correlations and multinucleon knock-out processes.
The presented research involves a novel, multidirectional approach to tackling these problems by combining the theoretical experiences of the Ghent group and the Monte Carlo neutrino event generator NuWro. The nuclear physics of Ghent involves a non-relativistic, mean-field-based model for both the initial and final hadronic states. On top of that, we add dynamically generated short-range nucleon correlations and explicit two-body dynamics with meson-exchange currents involving isobar degrees of freedom. This framework, exhaustively compared against electron scattering, provides predictions of inclusive, semi-inclusive, and exclusive cross sections for neutrino-nucleus interactions leading to 1-particle-1-hole and 2-particle-2-hole final states. Together with auxiliary advancements in other aspects of Monte Carlo simulations, we will present the implementation of the obtained two-nucleon knock-out model in NuWro and compare it to experimental neutrino data, therefore completing the bridge between the theoretical and experimental sides of accelerator-based neutrino research.

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Operation and results of the FASERnu detector

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FASER, the ForwArd Search ExpeRiment, at the CERN LHC, is designed to search for new, light, weakly-interacting particles, and investigate high-energy collider neutrino interactions in the TeV regime, extending current cross-section measurements. Located 480 m downstream from the ATLAS IP, it is aligned with the collision axis line-of-sight, covering a previously unexplored pseudorapidity range of $\eta > 8.8$. In March 2023, the FASER collaboration announced the first direct observation of neutrino interactions at a particle collider experiment using the active electronic components of the FASER detector. FASER is composed of a main electronic detector, sitting behind the passive FASERν neutrino detector, made up of 730 alternating emulsion films and tungsten plates, resulting in a 1.1 tonne target mass. The FASERν detector achieves sub-micron position resolution, allowing for all three neutrino flavours to be distinguished by their vertex topology in CC interactions. Due to the track occupancy in emulsion, three data-taking periods are carried out per year, each module requiring assembly and development campaigns. FASER plans to run throughout the LHC Run3, collecting $250\ \text{fb}^{-1}$ of data. In this presentation, recent FASER results, as well as the status of data taking and analysis for FASERν, will be presented.

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Deep Learning applications to the event reconstruction in JUNO

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Jiangmen Underground Neutrino Observatory (JUNO), located in the southern part of China, will be the world's largest liquid scintillator (LS) detector upon completion. Equipped with 20 kton LS, about 17612 20-inch PMTs and 25600 3-inch PMTs in the central detector (CD), JUNO will provide a unique apparatus to probe the mysteries of neutrinos, particularly the neutrino mass ordering puzzle. One of the main challenges for JUNO is the high-precision event reconstruction. In recent decades Deep Learning has been more and more widely used in various neutrino experiments. If each PMT is viewed as a pixel, the JUNO CD can be regarded as a large spherical camera, providing a perfect scenario for the application of Deep Learning. This talk will present a few Deep Learning applications to the event reconstruction in JUNO. These Deep Learning based methods not only provide alternative approaches complementary to the traditional ones, but also demonstrate huge potential on enhancing the performance of the JUNO detector.

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The NEUT Generator: Status and Plans

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The NEUT generator has a long, storied history. Originally written to predict neutrino induced backgrounds for the Kamioka Nucleon Decay Experiment (Kamiokande), it is now relied upon by T2K to simulate signal and background interactions for their oscillation and neutrino scattering cross section measurements. Looking to the future, the next-generation Hyper-Kamiokande experiment expects to rely on NEUT predictions for their flagship precision CP violation measurements.

This talk will introduce recent model development in NEUT in the context of comparisons to cross-section measurements. It will also discuss ongoing modernisation efforts for both HyperK and better compatibility with other tools that will be developed by the neutrino-scattering community in the build up to next-generation experiments and their modelling precision and tooling needs.

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Highlights from the Fermilab Workshop on Neutrino Event Generators

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Simulations of neutrino-nucleus scattering are a critical input to oscillation analyses and various other investigations in high-energy physics. Achieving the physics goals of future experiments will require substantial improvements to the precision of these simulations. In March of this year, a

workshop was held at Fermilab that examined several major topics related to future development of neutrino event generators. These included streamlining implementation of theory enhancements, standardizing event formats and interfaces to beam simulations, extending tools for model comparisons to neutrino and electron cross-section data, and quantifying systematic uncertainties. This talk will present highlights from the workshop proceedings and the outlook for the future of the field.

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Study of Beam Effects for Muon Entrance Detector for the muEDM Experiment at PSI

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The proposed muEDM experiment at the Paul Scherrer Institute (PSI) in Switzerland is designed to search for a muon EDM with a sensitivity of 6×10ˆ(-23) e·cm. It leverages the frozen-spin technique, which cancels the muon's anomalous precession within a compact storage solenoid. This approach considerably enhances the sensitivity of the search compared to the parasitic method using a storage ring at BNL/FNAL. For an EDM measurement, it is crucial to confine muons within the central region of the solenoid. This is accomplished using a fast entrance detector that generates a signal to initiate a pulsed magnetic kick, thereby halting the muon's longitudinal motion as it enters the central region. Equipped with a thin scintillator and four wall scintillators, this detector identifies incoming muons and rejects events that surpass the solenoid's acceptance. During a beam test at PSI in December 2022, we tuned the 27.5 MeV/c muon beam at piE1 to two focal positions and recorded 7×10ˆ5 muon events. Prior to data collection, we carried out beam profiling to extract the Twiss parameters and emittance for these beam tunes. We incorporated these beam properties into a Geant4 simulation, which enabled us to compare the proportions of various muon scattering scenarios with those observed in the experimental data.

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Impact of the near detector on the T2K oscillation analysis

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T2K is a long baseline neutrino experiment which exploits a neutrino and antineutrino beam at J-PARC to perform precision measurements of atmospheric parameters $\Delta m^2_{32}, \sin^2(\theta_{23})$ and to search for CP-violation. The main systematic uncertainties limiting the precision will be described, as well as, the role of the near detector to constrain such systematic uncertainties.

The most challenging of such systematic uncertainties is related with the modelling of few-GeV neutrino-nucleus interactions. In particular, in the latest oscillation analysis, new samples with proton and photon tagging at the near detector have been implemented to improve the control and tuning of such uncertainties. To attack this problem, the T2K experiment is also 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.

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T2K latest oscillation results

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T2K is a long baseline neutrino experiment which exploits a neutrino and antineutrino beam produced at the Japan Particle Accelerator Research Centre (J-PARC) to provide world-leading measurements of the parameters governing neutrino oscillation. Neutrino oscillations are measured by comparing neutrino rates and spectra at a near detector complex, located at J-PARC, and at the water-Cherenkov far detector, Super-Kamiokande, located 295 Km away.

The latest T2K results include multiple analysis improvements, in particular a new sample is added at the far detector requiring the presence of a pion in muon-neutrino interactions. It is the first time that a pion sample is included in the study of neutrino disappearance at T2K and, for the first time, a sample with more than one Cherenkov ring is exploited in the T2K oscillation analysis, opening the road for future samples with charged- and neutral-pion tagging. The inclusion of such a sample assures proper control of the oscillated spectrum on a larger neutrino-energy range and on subleading neutrino-interaction processes.

T2K is also engaged in a major effort to perform a joint fit with the Super-Kamiokande neutrino atmospheric measurements and another joint fit with NOvA. Such combinations allow to lift the degeneracies between the measurement of the CP-violating phase δ_{CP} and the measurement of the ordering of the neutrino mass eigenstates. Results and prospects of such joint fits will be discussed.

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T2K flux prediction and tuning

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T2K is a long baseline neutrino experiment which exploits a neutrino and antineutrino beam at J-PARC, which is produced by a proton beam impinging on a graphite target, a flux of pions and kaons are produced and neutrinos are produced by their disintegration.

A very detailed simulation of the beamline allows to predict the rate and energy of produced neutrinos, but still large uncertainties related with the nuclear models to describe the hadron interactions in the target affect such predictions. To improve the precision, the flux simulation is tuned using the results of a dedicated hadron production experiment at CERN: NA61/SHINE. Notably, T2K has obtained a major improvement in the flux uncertainties of the latest oscillation analysis by implementing the constraints coming from a new NA61/SHINE analysis of data taken with a replica of the T2K target. In parallel, the simulation of the material in the beamline has been further refined.

The impact of replica-target data, the improved simulation and the impact on the oscillation analysis will be described, together with prospects for further future improvements.

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Status of Mu3e Phase 1

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The Mu3e experiment will search for the charged lepton flavour violating decay $\mu \rightarrow e^+e^-e^+$ and is based at the Paul Scherrer Institute (PSI). It aims to achieve a sensitivity of one in $\mathcal{O}(10^{15})$ moun decays in phase 1 and one in 10^{16} muon decays in phase 2, which is four orders of magnitude more sensitive than the previous measurement conducted by the SINDRUM experiment. Any observation of this decay would be a clear sign for new physics, since it is highly suppressed in the Standard Model to a branching ratio of below $\mathcal{O}(10^{-54})$.

The Mu3e detector will use four layers of thin Mupix sensors (high voltage monolithic active pixel sensors, HV-MAPS) to track electrons and positrons. A time resolution of O(100ps) will be provided by scintillating tile and fibre detectors, which are coupled to SiPMs and read out by the Mutrig chip. A FPGA-based, triggerless DAQ system will collect data from these detectors, which will then be reconstructed in a GPU filter farm.

With Mupix11 and Mutrig3 the sensor developement for phase 1 has concluded and the collaboration has performed engineering runs with a fist prototype of the inner detector region in order to validate a variety of systems and to identify potential issues. With the experience gained from the engineering runs the collaboration is now in the process of constructing the phase 1 detector.

The talk will present the design of the detecor and readout system and discuss the ongoing activities for Mu3e phase 1.

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DUNE: Long-Baseline Oscillation Sensitivity

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The Deep Underground Neutrino Experiment (DUNE) is a next generation long baseline neutrino experiment for oscillation physics and proton decay studies. The primary physics goals of the DUNE experiment are to perform neutrino oscillation physics studies, search for proton decay, detect supernova burst neutrinos, make solar neutrino measurements and BSM searches. The liquid argon prototype detectors at CERN (ProtoDUNE) are a test-bed for DUNE's far detectors, which have operated for over 3 years, to inform the construction and operation of the first two and possibly subsequent 17-kt DUNE far detector LArTPC modules. Here we introduce the DUNE and protoDUNE experiments and physics goals as well as discussing recent progress and results.

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The DUNE Near Detector Suite

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DUNE will be a next-generation experiment aiming to provide precision measurements of the neutrino oscillation parameters. It will detect neutrinos generated in the LBNF beamline at Fermilab, using a Near Detector (ND) situated near the beam target where the neutrinos originate and a Far Detector (FD) located 1300 km away in South Dakota. A comparison of the spectra of neutrinos measured at the FD and the ND will allow for the extraction of oscillation probabilities from which the oscillation parameters can be inferred. The specific role of the ND will be to serve as the experiment's control: it will establish the no oscillation null hypothesis, measure and monitor the beam, constrain systematic uncertainties, and provide essential measurements of the neutrino interactions to improve models. The ND complex will include three primary detector components: a liquid argon TPC called ND-LAr, a high-pressure gas TPC called ND-GAr and an on-axis beam monitor called SAND. The three detectors will serve important individual and overlapping functions, with ND-LAr and ND-GAr also able to move transverse to the beam's axis via the DUNE-PRISM program. The overall design of the ND and its physics goals will be discussed in this talk.

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Atmospheric neutrino oscillations in JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose experiment currently under construction in southern China. It consists of a 20 kton liquid scintillator detector, whose main physics goal is to determine the neutrino mass ordering (NMO). While its main sensitivity is from reactor neutrino oscillations in vacuum, atmospheric neutrino oscillations in JUNO, via matter effects, can potentially provide an independent sensitivity to NMO, and increase JUNO's total sensitivity in a combined analysis. This talk reports the recent progress made by JUNO towards this goal, including the reconstruction of atmospheric neutrino's energy and directionality, flavor and neutrino/anti-neutrino identification, and background rejection. A preliminary discussion on sensitivity is also presented.

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Beyond the Standard Model Searches with the Short Baseline Near Detector

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The Short-Baseline Near Detector (SBND) is a 112-ton liquid argon time projection chamber (LArTPC) detector located 110-meters downstream the Booster Neutrino Beam target at Fermilab. As the near detector of the Short-Baseline Neutrino Program, SBND is especially sensitive to any new particles produced in the beam. In addition to the excellent spatial and energy resolution of the LArTPC technology, SBND features photon detection and cosmic–ray tagger systems achieving ns-time resolution. In this talk, we will review SBND's capabilities and prospects for searches for Beyond Standard Model physics such as heavy neutral leptons, sub-GeV dark matter, and dark neutrinos.

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Detecting Charged-Current Neutrino-Nucleus Interactions on Oxygen in a Heavy Water Cherenkov Detector

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At Oak Ridge National Laboratory (ORNL), the COHERENT collaboration has been building a heavy water Cherenkov detector to measure the neutrino flux coming from the Spallation Neutron Source (SNS). This detector is a steel cylinder filled with light water with an inner acrylic vessel holding heavy water and twelve PMTs lining the inside of the top lid. It began accumulating statistics in summer 2022 with light water only, since the inner acrylic tank and heavy water were not installed until summer 2023. The detector is expected to be fully completed and taking measurements in the summer of 2023. Although this heavy water Cherenkov detector was built primarily to measure the SNS neutrino flux, it can also be used to measure the cross section of neutrino-nucleus charged-current interactions on oxygen nuclei. Charged-current 16O(ν_e, e−)X reactions produce recoiling electrons that will emit Cherenkov radiation within the detector with an energy threshold of about 5 MeV, well within the energy range of electron neutrinos created at SNS. This charged-current reaction in oxygen has never been measured and has implications for supernovae neutrino detection and testing nuclear physics theories. This presentation describes methodology for detecting and measuring the cross section and event rate of this charged-current interaction between electron neutrinos and oxygen nuclei.

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First Measurement of Double-Differential Charged Current muon neutrino–Argon Scattering Cross Sections In Kinematic Imbalance Variables With The MicroBooNE Detector

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Making high-precision measurements of neutrino oscillation parameters requires an unprecedented understanding of neutrino-nucleus scattering. In this work, we present 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, these variables 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.

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Development of a muon entrance detector for the muEDM experiment at PSI

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The muEDM experiment, currently under development at the Paul Scherrer Institute (PSI) in Switzerland, aims to probe the muon electric dipole moment (EDM) using the frozen-spin technique within a solenoidal storage ring. This experiment seeks to achieve a muon EDM sensitivity of 6×10⁻²³ e·cm, which is three orders of magnitude more precise than the current limit set by the BNL Muon g-2 collaboration. The experiment proceeds by injecting a muon into a solenoid via a superconducting channel. The muon then transverses an entrance detector which, upon detecting the muon, swiftly triggers a pulsed magnetic field to confine the muon within the solenoid's central region. This entrance detector has been designed to reject muons that exceed the solenoid's storage acceptance without causing notable multiple scatterings. We have developed a prototype detector equipped with a thin scintillator for identifying incoming muons, supplemented by four wall scintillators acting as veto detectors. These scintillators are light-readout using silicon photomultiplier. We evaluated the performance of the prototype using 27.5 MeV/c muons at PSI's <i>pi;E1</i> beamline. This poster presents an overview of the prototype detector, discusses measured relative event rates for varying event topologies, and illustrates the distribution of detected photoelectrons for the veto detectors.

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DUNE Vertical Drift LArTPC design

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The Deep Underground Neutrino Experiment (DUNE) is a long-baseline neutrino-oscillation experiment aiming at measuring CP-violating phase and neutrino mass ordering. The far detector consists of four 17-kt modules based on Liquid Argon Time Projection Chamber (LArTPC) technology.

The recently proposed Vertical Drift (VD) concept has been selected as the design of the second module. This concept uses a novel perforated-PCB anode design, which considerably simplifies the TPC construction compared to the standard wired-based anodes with similar calorimetry and tracking efficiencies.

A VD-prototype, so-called Module-0, is currently under final assembly at the CERN Neutrino Platform and is foreseen to take cosmic and beam data early 2024. The Module-0 is equipped with four anode planes, or Charge-Readout Plane (CRP), which have all been operated in a dedicated full-scale cryostat with cosmic data over the past year.

This talk will introduce the LArTPC Vertical Drift concept and present the performance results from the CRP full-scale data campaign. The status and the preparation work for the upcoming Module-0 data will be discussed, such as the plans towards the second DUNE far detector module.

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KM3NeT/ORCA: Updates of neutrino oscillation measurement

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The KM3NeT collaboration is building two neutrino detectors in the Mediterranean Sea. The KM3NeT/ORCA detector has been optimized for the detection of atmospheric neutrinos with energies between few GeV and 100 GeV. Among the primary goals are the measurement of the neutrino oscillation parameters and the determination of the neturno mass ordering. A correct interpretation of the measurements requires the understanding of the different sources of systematic uncertainties. This talk addresses the uncertainties associated to neutrino interaction models, which are encoded in the so-called neutrino MC generators. In particular, the differences between GENIE, the neutrino generator used by KM3NeT and the GiBUU generator are explored at the level of systematic uncertainties and their impact on sensitivity estimates. In this contribution an overview of the recent updated results from KM3NeT/ORCA and the neutrino generator environment for Monte-Carlo simulations in KM3NeT will be presented.

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Investigation of scalar Non-Standard Interactions at P2SO and DUNE

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Neutrinos can interact with some scalar fields through some unknown couplings referred as scalar non-standard interaction (SNSI). Unlike vector NSI, SNSI parameters do not appear as potential term in neutrino oscillation rather appeared as a correction to neutrino mass term. Significant effects of SNSI parameters on neutrino oscillation can be observed at neutrino long baseline experiments. For the first time, we have obtained bounds on the diagonal SNSI parameters from the two longest baseline experiments DUNE (1300 KM) and P2SO (2595 KM). Our findings indicate that P2SO provides tighter constraints on the diagonal SNSI parameters compared to DUNE, except for η_{ee}. We found that the mass hierarchy and CPV sensitivities are mostly affected by η_{ee} compared to $\eta_{\mu\mu}$ and $\eta_{\tau\tau}$. On the other hand octant sensitivity is mostly affected by $\eta_{\mu\mu}$ and $\eta_{\tau\tau}$.

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Classification of muon- and electron neutrino events for the ESSnuSB Near Detector using Graph Neural Networks

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Accurate and fast event reconstruction is central for the design and performance of the ESSnuSB detectors. While precise, the currently proposed likelihood-based method for event reconstruction is computationally expensive. In recent years, machine learning methods have been implemented for reconstruction in several high energy physics experiments, including neutrino experiments, enabling fast reconstruction without reducing performance and in some cases even improving it.
In this work, we investigate the use of Graph Neural Networks (GNNs) for classification of muon and electron events and muon- and electron neutrino charged current events in the Near Detector of the proposed ESSnuSB experiment. We demonstrate that the accuracy of the GNN method is comparable to that of the likelihood method, and that the GNN can even learn the signatures of, and accurately identify, complex events that are currently discarded, while providing a factor 104

increase in reconstruction speed. Furthermore, we study the performance of the GNN by investigating the relation between event signatures and reconstruction performance.
Using the GNN based method will enable fast event reconstruction when making changes to the detector design, and will thus allow for easier investigation of different detector designs. Eventually, the GNN could also be used for regression tasks, such as energy reconstruction. In this talk, we will present the method and results of training and running a GNN on simulated events for the ESSnuSB detectors, and compare the performance and reconstruction speed to the likelihood-based method.

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Probing the reactor neutrino flux below the IBD threshold with CEνNS

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Most antineutrinos produced in a nuclear reactor have energies below the inverse beta decay (IBD) threshold, and have not yet been detected. We show that a coherent elastic neutrino-nucleus scattering (CEvNS) experiment with an ultra-low energy threshold like NUCLEUS can measure the flux of reactor neutrinos below the IBD threshold. Using a regularized unfolding procedure, we find that a meaningful upper bound can be placed on the low energy flux with CEvNS. However, it is difficult to establish the existence of the neutron capture component.

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Recent developments in GENIE

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The international GENIE Collaboration maintains and develops an extensive software suite to meet the simulation needs of the broad neutrino community. GENIE develops a universal event generator simulating neutrino interactions from MeV to PeV energy scales, and a global analysis of neutrino scattering data used for model characterization, tuning and uncertainty evaluations. In recent years, there were significant advances towards a) the construction and characterisation of several alternative comprehensive neutrino interaction models in the GeV energy range, b) the tuning and evaluation of uncertainties for key modelling elements, c) the implementation of more rare neutrino scattering processes, d) the development of extensions for low and ultra high energy neutrinos, e) the validation and improvement of complementary electron scattering simulations, and f) the implementation within GENIE of BSM simulations, such as the simulation of dark neutrinos, boosted dark matter and heavy neutral leptons. This talk presents selected highlights from these ongoing developments.

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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 10ˆ4 TeV. While muon-to-electron-conversion is permissible in an extension of the standard model through neutrino oscillations, the rate is extremely low at about one event in 10ˆ52. 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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First measurement of η production in neutrino interactions on argon with the MicroBooNE experiment

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The modeling of resonant neutrino interactions on argon is a critical aspect of the neutrino oscillation and beyond the standard model physics programs being carried out by the DUNE and Short Baseline Neutrino experiments. Resonant interactions are typically studied in events with pions in the final state. The measurement of η production provides a powerful new probe of resonant interactions, complementary to pion channels. This talk will present the first measurement of the flux-integrated $\nu_\mu + \mathrm{Ar} \to \eta + x$ cross-section with the MicroBooNE experiment. How this rare signature is identified, and the implications of measuring η production for accelerator neutrino experiments more broadly will be discussed.

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Sterile Neutrino Search at MicroBooNE using both the BNB and NuMI Beams

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The MicroBooNE experiment employs an 85-ton active volume liquid argon time projection chamber to detect neutrinos from both the on-axis Booster Neutrino Beam (BNB) and off-axis Neutrinos at the Main Injector (NuMI) beam. This work investigates short baseline neutrino oscillations in a 3+1 sterile neutrino model and compares our results to previous anomalies found in experiments such as LSND, Neutrino-4, and gallium anomalies. To achieve our goal, we utilize high-performance charged current electron neutrino and muon neutrino selections. In this presentation, we will detail our initial results on this sterile neutrino search from MicroBooNE using the BNB beam. Additionally,

we will examine the impact of a degeneracy resulting from the cancellation of ν_e appearance and disappearance, and demonstrate that combining data from the BNB and NuMI beams, which have substantially different ν_e/ν_μ ratios, can break this degeneracy.

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MicroBooNE's Search for Anomalous Single-Photon Production

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The MicroBooNE experiment is an 85-ton active volume liquid argon time projection chamber (LArTPC) neutrino detector situated in the Fermilab Booster Neutrino Beam (BNB). Leveraging the unique capabilities of the LArTPC technology to distinguish photons from electron electromagnetic showers, MicroBooNE has achieved the world's most sensitive search for neutrino-induced single-photon production. In this talk, we will present a comprehensive overview of these results, as well as recent advancements in our search for single-photons as an explanation for the MiniBooNE Low Energy Excess. These include a more model-independent approach utilizing inclusive photon searches, as well as a targeted search for NC coherent-like single-photon production. Moreover, we will introduce a new direction of focused searches aimed at exploring "Beyond the Standard Model" scenarios, which involves investigating exotic e+e- pair production that could be attributed to neutrinos acting as a portal to a potential "Dark Sector" of new physics.

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ProtoDUNE-SP's performance, physics status, and future plans

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The ProtoDUNE-SP detector is a single-phase liquid argon time projection chamber measuring 7.2 × 6.1 × 7.0 m^3 in active volume. It is designed as a test bed and full-scale prototype for the elements of the first far detector module of the Deep Underground Neutrino Experiment (DUNE). Located at the CERN Neutrino Platform, the detector was exposed to a tagged and momentum-analyzed particle beam with momentum settings ranging from 0.3 GeV/c to 7 GeV/c and collected more than four million beam events. Additionally, the detector operated for approximately two years, continuously collecting cosmic ray events. We present the performance of the detector which has met or surpassed the specifications set for the DUNE far detector. The status of physics analyses including hadron-Ar cross sections and measurements of liquid argon properties will be summarized. Talk will conclude with plans for the coming Run2 with ProtoDUNE-HD (horizontal drift).

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Rescuing leptogenesis parameter space of inverse seesaw in standard and nonstandard cosmology

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The generic inverse seesaw (ISS) framework is unable to produce an adequate amount of lepton asymmetry, which consequently fails to generate the observed baryon asymmetry of the Universe (BAU). This happens due to mainly two reasons, (i) partial cancellation of the lepton asymmetries among the pseudo-Dirac pairs, and (ii) strong wash out caused by the inverse decays. In this work we offer two possible resolutions to overcome the above mentioned challenges considering a (3,3) ISS framework. Our first proposal is based on the assumption of a non-standard cosmological era in the pre-BBN epoch, that triggers a faster expansion of the Universe, thereby reducing the washout by several orders of magnitude. The second proposition is an alternative of first which considers a non-degenerate right handed neutrino mass spectrum, resulting into a larger order of lepton asymmetry that survives the impact of strong washout to account for the observed BAU. The viable parameters space, as obtained can be tested at present and future Lepton Flavour Violation experiments e.g. MEG and MEG II.

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Machine learning approach for the directional reconstruction of atmospheric neutrinos in JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation large (20 kton) liquid-scintillator neutrino detector, which is designed to determine the neutrino mass ordering from its precise reactor neutrino spectrum measurement. Moreover, high-energy (GeV-level) atmospheric neutrino measurements could also improve its sensitivity to mass ordering via matter effects on oscillations, which depend on the directional (zenith angle) resolution of the incident neutrino. However, large unsegmented liquid scintillator detectors like JUNO are traditionally limited in their capabilities of measuring event directionality.
This poster presents a machine learning approach for the directional reconstruction of atmospheric neutrinos in JUNO. In this method, several features relevant to event directionality are extracted from PMT waveforms and used as inputs to the machine learning models. Three independent models are used to perform reconstruction, each with its own unique approach for handling the same input features. The results are make use of simulated data based on the GENIE generator, and an independent sample simulated with an alternative generator is also used to check the robustness of this approach.

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Modeling quasielastic and pion production on the nucleus

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I will discuss some nuclear effects affecting neutrino-nucleus cross sections at energies of interest for neutrino-oscillation experiments. Pauli blocking, binding energies, effects beyond the impulse approximation, and final state interactions are investigated, with focus on the differences between a quantum mechanical approach and the models and methodology found within Monte Carlo neutrino event generators. The results I will presennt are mainly based on our recent works: PRL 123, 052501 (2019); PRC 100, 045501 (2019); PRC 105, 025502 (2022); PRC 105, 054603 (2022); Phys. Rev. D 106, 113005 (2022); arxiv:2203.09996; arxiv:2304.01916; and some ongoing projects.

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Determination of the Argon spectral function from (e,e'p) data

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I will outline the conceptual framework supporting the interpretation of the 40Ar(e,e'p) cross sections–recently measured at Jefferson Lab by the E12-14-012 Collaboration—in terms of the spectral functions describing the energy and momentum distribution of protons in the target nucleus. The key underlying assumptions and their validity in the kinematical setup of the Jefferson Lab experiment will be discussed, and the results of the analysis will be illustrated highlighting their relevance for ongoing and
future neutrino oscillation programs.

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The CUPID neutrinoless double-beta decay experiment

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Neutrinoless double-beta decay (0νββ) is a key process to address some of the major outstanding issues in particle physics, such as the lepton number conservation and the Majorana nature of the neutrino. Several efforts have taken place in the last decades in order to reach higher and higher sensitivity on its half-life. The next-generation of experiments aims at covering the Inverted-Ordering region of the neutrino mass spectrum, with sensitivities on the half-lives greater than 1E27 years. Among the exploited techniques, low-temperature calorimetry has proved to be a very promising one, and will keep its leading role in the future thanks to the CUPID experiment. CUPID (CUORE Upgrade with Particle IDentification) will search for the neutrinoless double-beta decay of 100Mo and will exploit the existing cryogenic infrastructure as well as the gained experience of CUORE, at the Laboratori Nazionali del Gran Sasso in Italy. Thanks to 1596 scintillating Li2MoO4 crystals, enriched in 100Mo, coupled to 1710 light detectors CUPID will have simultaneous readout of heat and light that will allow for particle identification, and thus a powerful alpha background rejection. Numerous studies and R&D projects are currently ongoing in a coordinated effort aimed at finalizing the design of the CUPID detector and at assessing its performance and physics reach.
In our talk, we will present the current status of CUPID and outline the forthcoming steps towards the construction of the experiment.

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Multi-Calorimetry in Light-based Neutrino Detectors

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Neutrino detectors are amongst the largest ever built photonics systems, where the neutrino detection is inexorably linked to the challenging detection of scarce photons. The tremendous progresses in neutrino physics over past several decades are inseparable from the evolution of the detector photonics interfaces to yield ever higher precision and richer detection information. The measurement of the energy of neutrinos, referred to as calorimetry, is required today to be controlled to the per-mille level precision, thus leading to further innovation in specialized photonics. In this talk, a novel design, with the publication to be released soon, is presented that detectors can be endowed with multiple photonics interfaces for simultaneous multiple light detection to yield high-precision calorimetry. This multi-calorimetry approach opens the novel notion of dual calorimetry detectors as an evolution from the single calorimetry setups used for most experiments so far. The dual calorimetry design exploits unique response synergies, including correlations and cancellations, to yield the unprecedented mitigation of today's dominant response systematic effects. The dual calorimetry design has been adopted by JUNO experiment and could shed light on the design of future neutrino detectors.

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Constraining Lorentz Invariance Violation with Future Long-Baseline Experiments

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Unified theories such as string theory and loop quantum gravity allow the Lorentz Invariance Violation (LIV) at the Planck Scale ($M_P \sim 10^{19}$ GeV). Using an effective field theory, this effect can be observed at low energies in terms of new interactions with a strength of $\sim 1/M_P$. These new interactions contain operators with LIV coefficients which can be CPT-violating or CPT-conserving. In this work, we study in detail how these LIV parameters modify the transition probabilities in the next-generation long-baseline experiments, DUNE and Hyper-K. We evaluate the sensitivities of these experiments in isolation and combination to constrain the off-diagonal CPT-violating ($a_{e\mu}$, $a_{e\tau}$, $a_{\mu\tau}$) and CPT-conserving ($c_{e\mu}$, $c_{e\tau}$, $c_{\mu\tau}$) LIV parameters. We derive approximate compact analytical expressions of appearance ($\nu_\mu \to \nu_e$) and disappearance ($\nu_\mu \to \nu_\mu$) probabilities in the presence of these LIV parameters to explain our numerical results. We explore the possible correlations and degeneracies between these LIV parameters and the most uncertain 3ν oscillation parameters, namely, θ_{23} and $\delta_{\rm CP}$. We find that for non-maximal values of θ_{23} ($\theta_{23} \neq 45°$), there exist degenerate solutions in its opposite octant for standalone DUNE and Hyper-K. These degeneracies disappear when we combine the data from DUNE and Hyper-K. In case of no-show, we place the expected upper bounds on these CPT-violating and CPT-conserving LIV parameters at 95\% C.L. using the standalone DUNE, Hyper-K, and their combination. We observe that due to its access to a longer baseline and multi-GeV neutrinos, DUNE has a better reach in probing all these LIV parameters as compared to Hyper-K. Since the terms containing the CPT-conserving LIV parameters are proportional to neutrino energy in oscillation probabilities, Hyper-K is almost insensitive to the CPT-conserving LIV parameters because it mostly deals with sub-GeV neutrinos.

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Performance and Testing of the JUNO 20-inch PMTs

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The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator detector scheduled to come online in 2024. The scintillator volume is observed by approximately 17 000 large 20"PMTs and 25 000 small 3"PMTs. The performance of the PMTs is essential to reach the scientific goals, especially for oscillation physics. I will review the system of the large PMTs. Prior to installation, the PMTs have gone through intensive tests. I will describe the tests and the performance expected from the tests.

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Status of the RENO experiment

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The RENO experiment has precisely measured the amplitude and frequency of reactor antineutrino oscillation at Hanbit Nuclear Power Plant since Aug. 2011. The 2018 publication reported the measured oscillation parameters based on 2200 days of data. After that, additional 1600 days of data has been acquired with one or two operating reactors, which yields relatively lower antineutrino flux. This presentation reports the current status and analyses which has been performed.

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Dirac-Majorana neutrino type conversion induced by an oscillating scalar dark matter

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Some properties of a neutrino may differ significantly depending on whether it is Dirac or Majorana type. The type is determined by the relative size of Dirac and Majorana masses, which may vary if they arise from an oscillating scalar dark matter. We show that the change can be significant enough to convert the neutrino type between Dirac and Majorana while satisfying constraints on the dark matter. It predicts periodic modulations in the event rates in various neutrino phenomena. As the energy density and, thus, the oscillation amplitude of the dark matter evolves in the cosmic time scale, the relative size of Dirac and Majorana masses changes accordingly. It provides an interesting link between the present-time neutrino physics to the early universe cosmology including the leptogenesis. This talk is based on the recent paper (arXiv:2305.16900) by YeolLin ChoeJo, Yechan Kim, and Hye-Sung Lee.

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COMET Muon conversion experiment at J-PARC

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COMET is an experiment at J-PARC, Japan, which will search for neutrinoless conversion of muons into electrons in the field of a nucleus ($^{-} + N \rightarrow e^{-} + N$); a lepton flavor violating process. Recent progresses in facility and detector development are presented, aiming for the experimental sensitivity of the order of 10^{-15} for Phase-I and 10^{-17} or beyond for Phase-II experiment. A schedule and preparation status to start the Phase-I experiment in 2025 will be discussed.

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Two-Nucleon Emission in Quasielastic Neutrino and Electron Scattering induced by short-range correlations

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Status of the Measurement of Neutrinos Elastically Scattering Off Electrons in the NOvA Near Detector

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Neutrinos elastically scattering off atomic electrons is a purely leptonic process whose cross section can be precisely calculated in the standard model. A measurement of this process can provide an *in-situ* constraint to the absolute neutrino flux in an accelerator-based ν_μ beam. NOvA is a long-baseline neutrino experiment optimized to observe the oscillation of ν_μ to ν_e. It consists of a near detector located 1 km downstream of the neutrino production target at Fermilab and a far detector located 810 km away in Ash River, Minnesota. This talk presents the status of the neutrino-electron elastic scattering measurement using the NOvA near detector, including strategies for selecting the signal, as well as the prospect of reducing the flux uncertainty.

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Revisiting target mass corrections in lepton-nucleus deeply inelastic scattering

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In this talk we revisit so-called target mass corrections (TMCs) to nuclear structure functions in lepton-nucleus deeply inelastic scattering (DIS), which account for the fact that the masses of nuclei are not guaranteed to be small compared to momentum transfers in DIS. We present several findings, including: (i) that nuclear parton distribution functions can be expressed directly in terms of partonic degrees of freedom in the OPE (the intermediate picture of "bound nucleons" is not necessary); (ii) that nuclear TMCs can be expressed in a way that is universal for all nuclei and readily implemented in numerical codes; (iii) the numerical impact in DIS cross sections.

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Light mesons from light heavy neutrinos at the LHC

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In the context of the Phenomenological Type I Seesaw, we investigate the LHC's sensitivity to exclusive, mesonic decay modes of long-lived, light (Dirac and Majorana) heavy neutrinos N when they are produced in the decays of $W^{\pm}$ bosons. We present a new framework that combines massless QCD to describe N's production up to NLO in QCD via weak bosons with a low-energy effective field theory to describe N's decays to mesons. We provide a prescription for fast, numerical determination of N's partial and total widths for any mass and accounts for mesonic decay modes.

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Impact of of light sterile neutrino at the long-baseline experiment options at KM3NeT

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We have studied the capability of different long-baseline experiment options at the KM3NeT facility i.e., P2O, Upgraded P2O and P2SO to probe the light sterile neutrino and compare their sensitivities with DUNE. The P2O option will have neutrinos from a 90 KW beam at Protvino to be detected at the ORCA detector, the Upgraded P2O will have neutrinos from the upgraded 450 KW beam to be detected at the ORCA detector and the option P2SO will have neutrinos from a 450 KW beam to be detected at the upgraded Super-ORCA detector. All these options will have a baseline around 2595 km. Our results show that the experiments at the KM3NeT (DUNE) would be more sensitive if the value of Δm^2_{41} is around 10 (1) eV^2. Our results also show that the role of near detector is very important for the study of sterile neutrinos and addition of near detector improves the sensitivity as compared to only far detector for 3+1 scenario. Among the three options at KM3NeT, the sensitivity of P2O and upgraded P2O is limited and sensitivity of P2SO is either comparable or better than DUNE.

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Deep Learning Reconstruction at DUNE Far Detector

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DUNE, the flagship next-generation neutrino experiment in the United States, is designed to decisively measure neutrino CP violation and the mass hierarchy. Its far detector modules utilize Liquid Argon Time Projection Chamber (LArTPC) technology, which provides exceptional spatial resolution and the potential to accurately identify final state particles and neutrino events. However, this enhanced spacial resolution exposes fine details of the neutrino interactions and their final states, which need to be harnessed during event reconstruction to fully utilize the potential of the detector technology. Fortunately, deep learning techniques, in particular convolutional neural networks (CNNs), offer a promising solution. These methods allow the direct reconstruction of neutrino events from images representing interactions. In this talk I will describe the development of deep learning based reconstruction methods at DUNE. I will also discuss the application of deep learning methods to data from the DUNE prototype detector ProtoDUNE at CERN.

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The Forward Liquid Argon Experiment at the Forward Physics Facility for High Energy Neutrino and Dark Matter Searches at LHC

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The Forward Physics Facility (FPF) is a proposed program to build an underground cavern with the space and infrastructure to support a suite of far-forward experiments at the Large Hadron Collider during the High Luminosity era (HL-LHC). The Forward Liquid Argon Experiment (FLArE) is a Liquid Argon Time Projection Chamber (LArTPC) based experiment designed to detect very high-energy neutrinos and search for dark matter in FPF, 620 m from the ATLAS interaction point in the far-forward direction, and will collect data during HL-LHC. With a fiducial mass of 10 tonnes, FLArE will detect millions of neutrinos at the highest energies ever detected from a human source and will also search for Dark Matter particles with world-leading sensitivity in the MeV to GeV mass range. The LArTPC technology used in FLArE is well-studied for neutrino and dark matter experiments. It offers excellent spatial resolution and allows excellent identification of individual particles. In this talk, I will overview the physics reach, preliminary design, and status of FPF and FLArE.

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High-Power Targetry R&D for Next-Generation Accelerator Facilities

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As next-generation accelerator target facilities, for Neutrino Program such as the Long-Baseline Neutrino Facility (LBNF) or Muon Program such as Mu2e-II at Fermilab, become increasingly more powerful and intense, high power target systems face key technical challenges. Beam-intercepting devices such as beam windows and secondary particle-production targets are continuously bombarded by high-energy high-intensity pulsed proton beams to produce secondary particles for several High Energy Physics (HEP) experiments. Energy deposition from the primary beam induces near instantaneous heating (thermal shock) and microstructural changes (radiation damage) in the beam-intercepting materials. Both thermal shock and radiation damage ultimately degrade the performance and lifetime of targets and have been identified as the leading cross-cutting challenges of high-power target facilities. Several facilities have already had to limit their beam power because of the survivability of their targets and windows, rather than as a limitation of the accelerators themselves. As beam power in next-generation multi-megawatt accelerator target facilities continue to increase, there is a pressing need to address the material challenges to avoid limiting the scope of future HEP experiments.
After presenting the high power Targetry challenges facing next generation accelerators, I will highlight the most recent activities within the framework of RaDIATE collaboration and the critical materials R&D needs to address the challenges of multi-MW targets.

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Advanced Material Development for Next Generation Accelerators

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Beam-intercepting devices face challenges of beam-induced thermal shock and radiation damage effects. Efficient cooling systems are needed to remove heat as beam power increases. Development of novel materials capable of sustaining increased beam power and intensity is crucial for future multi-MW target facilities. In this talk, several promising novel materials will be discussed, including High Entropy Alloys (HEAs), Nanofibers, SiC-SiC composites, and Toughened Fine-Grained Recrystallized (TFGR) tungsten. These materials offer potential solutions for the challenges faced by next-generation accelerator facilities. HEAs, for instance, demonstrate enhanced radiation tolerance compared to conventional alloys, making them valuable for high-energy physics (HEP) applications. Nanofibers, known for their thermal shock and radiation damage tolerance, are being investigated as target materials, with their numerous grain boundaries and free surfaces acting as sinks to irradiation-induced defects. Initial studies show promising potential for nanofibers in future target materials. Another material known as SiC-SiC composite is being explored as an alternative to graphite in proton beam target applications. SiC-SiC composites exhibit superior oxidation resistance compared to graphite, reducing the need for extensive oxidation prevention measures. Preliminary findings suggest that SiC-SiC composites offer promising potential for improved performance and simplified maintenance in high-power accelerator facilities. TFGR (Toughened Fine-Grained Recrystallized) tungsten is being investigated as a next-generation target material due to its potential to offer 10 times higher muon/neutron brightness compared to current materials. Although tungsten has inherent brittleness at low temperatures, this challenge can be overcome through the application of various metallurgical techniques. The exploration of TFGR tungsten presents an opportunity to enhance the performance and efficiency of muon/neutron generation while addressing the brittleness issue associated with tungsten. In conclusion, the exploration of novel materials such as High Entropy Alloys, Nanofibers, SiC-SiC composites, and TFGR tungsten offers promising solutions for the challenges faced by beam-intercepting devices. Further research and development in these areas are essential to enhance the performance and reliability of next-generation accelerator facilities.

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Fluor wavelength classification of liquid scintillator using images acquired by CMOS image sensor and deep convolutional neural network

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This paper attempts to perform spectral discrimination of fluorescence images of liquid scintillators acquired by complementary metal oxide semiconductor (CMOS) image sensors using the discriminative ability of deep convolutional neural networks without any special effort. As semiconductor fab-processing technology has advanced, so has the processing technology of optical elements in image sensors. There is a trade-off between the pixel size of an image sensor and the signal-noise ratio and high color reproduction. Manufacturers of commercial complementary metal oxide semiconductor (CMOS) image sensors do not provide users with spectral response data for their CMOS sensors. We generated training images with a light-emitting diode module programmable on a single-board computer. We demonstrated the feasibility of inferring the spectral response backward from the discriminant values of a deep convolutional neural network. As a follow-up to the previous study, considering the operational characteristics of neutrino experiments, the feasibility of implanting a deep convolutional neural network for monitoring the attenuation distance and spectral response of light in a liquid scintillator was confirmed in terms of supervised learning. In the future, we will optimize efficient transformer implantation with limited computational resources for the characteristics of the Internet of Things.

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The Camera System for the IceCube Upgrade: Introduction to Its Purpose and Production.

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The IceCube Neutrino Observatory is the largest neutrino telescope located deep within the South Pole ice. Currently, an upgrade with denser spaced sensors is being built and one of the goals of the IceCube Upgrade is a precise characterization of the optical properties of the Antarctic ice, which is the source of the largest systematic uncertainty for most IceCube analysis. Calibration devices replying on LED flashers and lasers were used to calibrate the detector's geometry, infer ice properties and determine the stratigraphy of the ice at the IceCube detector site. For the IceCube Upgrade, uniform light sources, and a novel camera-based calibration system will be added for even more precise calibration. The IceCube Upgrade Camera system, developed with the goal of measuring ice properties and observing the refrozen ice in the drill holes, will be integrated into every newly designed Digital Optical Modules (DOMs).

In parallel to the production and integration of these cameras, detailed measurement plans are being developed and simulation studies are being conducted. In this presentation, the objectives and plans for studying the detector medium using the IceCube Upgrade Camera system will be introduced. In addition, details on the device's hardware specifications and performance tests will be included. This novel calibration system will provide a better understanding of the properties of glacier ice and enable more accurate measurements of neutrino events in the IceCube Upgrade.

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Signal Processing in SBND with WireCell

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The Short Baseline Near Detector (SBND), a 112 ton liquid argon time projection chamber (LArTPC), is the near detector of the Short Baseline Neutrino Program at Fermilab. In a LArTPC, ionization electrons from a charged particle track drift along the electric field lines, inducing bipolar signals on the induction planes, and a unipolar signal collected on the collection plane. In this talk, I present the techniques by which the final digitized waveforms, comprising of the original ionization signal convoluted with detector field response and electronics response as well as noise is processed to recover the original ionization signal in charge and time. The implementation of a 2D deconvolution (in time and wire dimensions) is introduced as a natural complement to the inter-wire and intra-wire induction field ranges and contours inherent to LArTPC signals. I also introduce a deep neural network (DNN) in LArTPC signal processing, to improve traditional signal region of interest (ROI) detection, as well as a novel 3-D tomographic imaging method for further reconstruction, which enables the true power of 3D tracking calorimetry in LArTPCs.

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Searching for physics beyond the Standard model with the MEG II experiment at PSI

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The MEG experiment at Paul Scherrer Institut (Zurich –Switzerland) established in 2016 the best current upper limit of 4.2×10^{-13} on the branching ratio of the $\mu- > e\gamma$ decay. The search for this decay represents an extremely powerful tool to look for possible extensions of the Standard Model since its existence would unambiguously represent a sign of new physics.

To further enhance sensitivity by one order of magnitude, an upgraded apparatus (MEG II) was conceived and constructed in subsequent years.
Following an engineering run in 2020 with a reduced set of electronic channels, MEG II commenced physics data acquisition in the summer of 2021 and is currently in operation. An overview of the sub-detectors' performances and of the analysis status will be presented. MEG II aims to continue data taking until 2026, striving to achieve its ultimate goal.

This talk will further highlight the status and perspectives of MEG II searches for other exotic phenomena, including the exploration of a potential 17.6 MeV particle originating from the $^7Li(p,)^7Be$ reaction.

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ANNIE: the Accelerator Neutrino Neutron Interaction Experiment

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The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) is a Gadolinium-loaded water Cherenkov detector placed in the Booster Neutrino Beam (BNB) at the Fermi National Accelerator Laboratory, USA. The primary physics goal of ANNIE is to perform neutrino cross-section measurements that will constrain systematic uncertainties in the next generation of long-baseline neutrino experiments. The first measurement will be the multiplicity of final-state neutrons from neutrino-nucleus interactions in water. Alongside these measurements, ANNIE has achieved the first ever deployments of two novel detector technologies in a neutrino beam: Large Area Picosecond Photodetectors (LAPPDs) and Water-based Liquid Scintillator (WbLS). LAPPDs are micro-channel-plate-based devices that provide timing resolution of ˜100 picoseconds and sub-centimeter spatial resolution. WbLS combines the low attenuation and Cherenkov production of pure water with the high light-yield and low detection threshold of liquid scintillator. This talk will discuss the status of ANNIE's physics and R&D measurements.

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Measurement of the magnetic field in the Fermilab Muon g−2 experiment

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The Muon g-2 experiment at Fermilab measures the muon magnetic-moment anomaly, $a_\mu = (g-2)/2$, with the ultimate goal of 140 parts per billion (ppb) precision. This requires determining the absolute magnetic field, averaged over space and time, experienced by the muons, expressed as the nuclear magnetic resonance frequency of protons in a spherical pure water sample at a specified reference temperature. A chain of calibrations and measurements maps and tracks the magnetic field providing the muon-weighted average field with precision better than 60 ppb. This talk will present the principles, practical realizations, and innovations incorporated into the measurement and analysis of the magnetic field for the 2019-20 data sets.

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Measurement of the muon anomalous precession frequency ω_a in the Fermilab muon g−2 experiment

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The Fermilab Muon g-2 experiment was designed to measure the muon's anomalous magnetic moment $a_\mu = (g-2)/2$ to 140 parts per billion. The value of a_μ is proportional to the difference frequency $\omega_a = \omega_s - \omega_c$ between the muon's cyclotron frequency and spin precession frequency in the uniform magnetic field of the g-2 storage ring. The frequency ω_a is extracted from the time distribution of the mu-decay positrons recorded by 24 electromagnetic calorimeters positioned around the inner circumference of the storage ring. We will discuss the various approaches to the frequency determination including the reconstruction and fitting of time distributions, fitting of time distributions, and procedures for handling the effects of gain changes, positron pileup and beam dynamics. We also discuss the data consistency checks and the strategy for the averaging of the ω_a across the different analyses.

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Beam dynamics corrections to measurements of the muon anomalous magnetic moment

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The Muon g-2 experiment at Fermilab is making progress towards its physics goal of measuring the muon anomalous magnetic moment with the unprecedented precision of 140 parts per billion. In April 2021 the collaboration published the first measurement, based on the first year of data taking. The second result is based on the second and third years of data taking combined. In this talk, we discuss the corrections to the anomalous spin precession signal due to beam dynamics effects being used to determine the anomalous spin precession frequency for the second result.

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The NuMI Flux at ICARUS

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ICARUS is a 430 t liquid argon time projection chamber, neutrino detector located at Fermi National Accelerator Laboratory and serves as the far detector for the Short Baseline Neutrino program. The ICARUS detector lies 795 m downstream and 5.7° above the Neutrinos at the Main Injector (NuMI) neutrino beam. At this large off-axis angle, ICARUS has a unique opportunity to measure a variety of electron and muon (anti-)neutrino interaction rates with argon nuclei, which will be an important input to the Deep Underground Neutrino Experiment. These measurements rely on detailed predictions of the (anti)neutrino fluxes and their related uncertainties to accurately extract the cross sections and estimate uncertainties. In many cases flux uncertainties can dominate the measurement error budget, and thus must be well understood and well characterized.
The authors will present the predictions for the NuMI flux at ICARUS along with corrections and estimated uncertainties. The uncertainties have two main sources: hadron production uncertainties, which are characterized using the Package to Predict the Flux (PPFX), and beamline uncertainties which are explored by alternate model configurations. Detailed breakdowns of the flux components by hadron production channel will be shown, as well as studies that elucidate how flux uncertainties evolve with large off-axis angles. Data products used for analyses, including covariances between various fluxes and PCA of the flux uncertainties will also be shown.

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Electrons For Neutrinos: The Next Generation

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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. In this talk we will summarize new results and analyses underway measuring proton transparency, a crucial diagnostic observable for event generators' intranuclear cascade models, as well as a new exclusive $1p1\pi$ analysis. We will also discuss new data taken in 2022 with beams at the same energy region and similar nuclear targets as expected in the next generation of accelerator based neutrino oscillation experiments.

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Implementation of the Spectral Function in GENIE

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The neutrino community is at an exciting time where new data with higher precision than ever is challenging the empirically based models which have been developed over the last several decades. Understanding this new data requires state of the art theory, leveraging collaboration between the nuclear physics, electron scattering, and neutrino community. One such state of the art model, the Spectral Function + Extended Factorization scheme, provides a unified approach to lepton-nucleus scattering and can incorporate the entire spectrum of interaction mechanisms from Quasi-elastic to Deep Inelastic scattering. Additionally, Spectral Functions derived from Quantum Monte Carlo methods allow for a concrete estimation of the theoretical error inherent to the factorization scheme.

In this talk I will summarize efforts to include the SF formalism in the GENIE neutrino event generator, starting with Quasi-elastic scattering and plans for other interaction mechanisms in the future. Validation against semi-exclusive electron and neutrino scattering data will be included highlighting the strengths of the SF approach relative to other models.

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Invisible Workers in Science

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Why do we remember some scientists while forgetting others who participated in the same scientific work? Moving away from prominent scientists and focusing on the invisible workers can highlight the role of gender, race, and class in scientific knowledge-making. Using Mount Wilson Observatory at the turn of the twentieth century as an example, I point out how scientists in positions of power, such as observatory directors, enforced gender division among the scientists. Through examples in modern science, I point out how taking into account the contribution made by these forgotten scientists can enrich our understanding of science and provide insights into creating a more equitable environment.

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Study of Neutrino Interactions by the COHERENT collaboration

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COHERENT collaboration at the Spallation Neutrino Source (SNS) at ORNL utilizing intensive low energy neutrino flux to measure various neutrino interactions. Range of interest is from Coherent Elastic Neutrino Scattering (CEvNS) up to nuclear charge current and neutral current interactions of interest for the support of Supernova neutrino detection in large detectors. We will review present status, latest results, and future plans of the collaboration. We will discuss perspectives of expansion as well the existing neutrino program at the SNS in the near future.

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Status of ICARUS at the Fermilab Short-Baseline Neutrino Program

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ICARUS is a liquid argon time projection chamber (LArTPC) neutrino detector situated at the intersection of two neutrino beams at Fermilab. As part of the Short-Baseline Neutrino (SBN) program, it will search for neutrino oscillations in the Booster Neutrino Beam (BNB). The search will test past anomalous results in neutrino physics such as the LSND, MiniBooNE, and reactor anomalies which could be explained by the existence of a sterile neutrino. Beyond oscillation physics, ICARUS will also perform measurements of neutrino cross sections and search for Beyond Standard Model (BSM) physics with the Neutrinos at the Main Injector (NuMI) beam. ICARUS has been installed at Fermilab since 2020 and began its physics data taking in June 2022. In this presentation, preliminary technical results and detector physics measurements from ICARUS data with the BNB and NuMI beams are presented. Progress on the program of ICARUS oscillation, cross section, and BSM physics is shown. These results demonstrate the capability of ICARUS to select and reconstruct neutrino events. The preliminary detector physics measurements also have relevance for the larger program of LArTPC neutrino physics experiments.

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Polarization effects in weak elastic Neutral Current with Non Standard Interactions

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New physics beyond the Standard Model (SM) may appear in the form of unknown couplings, typically termed non-standard neutrino interactions (NSIs) can manifest in neutrino interactions. To explain such a process, NSI offers a general “Effective Field Theory”(EFT)-style framework. While the elements of a given model may differ in weak interactions, they are broadly categorized as charge current (CC) NSI and neutral current (NC) NSI. Many authors have previously studied NSI in the

weak sector. However, most studies focused on neutrino oscillation, their masses, and their electromagnetic properties; the effects of NSI in $\nu - N$ interactions are still unexplored. Recently, Papoulias et al. studied the effects of NSI in $\nu - N$ elastic cross-section. In this work, we examine polarisation observables to see the effects due to NSI in neutral current elastic scatterings. The longitudinal and transverse polarisation shows a substantial deviation from the Standard Model(SM) predictions, though the model dependence is there. Thus, non-zero NSI couplings can be measured through experiments that measure the spin-asymmetry, which shows deviation from SM results.
Additionally, measurement of the polarization of the final proton in NC elastic scattering within the framework of NSI gives additional information about the strange axial form factor(g_A^s), which contributes to the accurate determination of the electromagnetic structure of the proton. Strange quarks also contribute to other observables, such as the nucleon's spin, mass, and internal momentum distributions. The contribution of strange quarks in the region of few GeV neutrino energy by switching off NSI is also examined.

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3-inch PMTs and electronics system in JUNO

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25600 3-inch PMTs (SPMTs) were designed in the JUNO detector together with 20012 20-inch PMTs (LPMTs). The SPMT system can enhance the detector's performances such as calibrating charge nonlinearity of LPMTs and thus improving the energy resolution. Signals of SPMTs are read out by the frontend electronics contained in 200 underwater boxes through 1600 customized multichannel connectors. All of SPMTs and electronics have been produced, integrated and tested. 5% of them have been installed in the 700-m underground JUNO detector and verified with a dedicated light-off test. In this talk, we will report the design of the SPMT system, mass production and performances of SPMTs and electronics, as well as the latest progress of SPMT installation and commissioning.

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Status of the ultra-slow muon beamline at J-PARC MUSE

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The ultra-slow muon (USM) beamline at J-PARC MLF MUSE provides a low-energy muon beam through laser ionization of thermal muonium in a vacuum. When a muon beam irradiates a hot tungsten foil at 2000 K, muonium atoms are emitted with an energy of 0.2 eV. The atoms can be ionized by two synchronized laser beams with wavelengths of 122 nm and 355 nm [1]. Low-energy muons with adjustable energies are valuable for materials science of surface and interface. Furthermore, USM is essential for applications requiring low-emittance muons, such as the muon g-2/EDM experiment at J-PARC [2] and transmission muon microscope [3]. The facility consists of an intense surface muon beamline, muonium production target, ionization laser, and transport optics. The commissioning of the USM beamline is in progress and has achieved sufficient beam specifications for muon spin spectroscopy with thin film samples [4]. In this contribution, we will report on an overview of the facility, its present status, and the results obtained from recent commissioning.

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[2] M. Abe et al., PTEP 053C02 (2019).

[3] Y. Miyake et al., Microscopy 67, i3 (2018).
[4] S. Kanda et al., J. Phys. Conf. Ser. 2462, 012030 (2023).

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The spectrum analysis of light emitted by LED using a CMOS RGB-based image sensor and feasibility study for its application

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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.

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Physics Opportunities at a PIP-II Beam Dump Facility and Beyond

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The accelerator complex at Fermilab is currently undergoing improvements which will increase the available beam power to the complex and is known as Proton Improvement Plan-II (PIP-II). The PIP-II Linac is slated for operation near the end of this decade and will be the main proton driver for Fermilab experiments moving forward and provide the beam to LBNF/DUNE. However, the DUNE physics program requires only ~1% of the available protons provided by PIP-II. The Accelerator Complex Enhancement, or ACE, will provide further upgrades in the 2030s in the form of increased power to LBNF along with a replacement for the Fermilab Booster which could also include an accumulator ring. A workshop was recently held at Fermilab in order to explore the physics possible when PIP-II is coupled with a fixed target or beam dump. The beam dump scenario provides an exciting opportunity to search for dark sector physics across detector threshold energy scales with examples being accelerator-produced dark matter, active-to-sterile neutrino oscillations, millicharged particles, and axion-like particles, which can be produced in the proton collisions with a fixed target. Additionally, experiments located at a PIP-II facility that is coupled to an accumulator ring would also be able to study coherent elastic neutrino-nucleus scattering, or CEvNS. In this talk, I will summarize the physics possible at a PIP-II beam dump facility and sensitivities to different dark sector physics and other beyond the Standard Model searches with detector concepts spanning from an eV-scale to MeV-scale detection threshold.

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New Physics searches using ProtoDUNE and the CERN SPS accelerator

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The exquisite capabilities of liquid Argon Time Projection Chambers make them ideal to search for weakly interacting particles in Beyond the Standard Model scenarios. Given their location at CERN the ProtoDUNE detectors may be exposed to a flux of such particles, produced in the collisions of 400 GeV protons (extracted from the Super Proton Synchrotron accelerator) on a target. Here we point out the interesting possibilities that such a setup offers to search for both long-lived unstable particles (Heavy Neutral Leptons, axion-like particles, etc) and stable particles (e.g. light dark matter, or millicharged particles). Our results show that, under conservative assumptions regarding the expected luminosity, this setup has the potential to improve over present bounds for some of the scenarios considered. This could be done within a short timescale, using facilities that are already in place at CERN, and without interfering with the experimental program in the North Area.

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Status of JSNSˆ2 and JSNSˆ2-II

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The JSNS² (J-PARC Sterile Neutrino Search at the J-PARC Spallation Neutron Source) is an experiment with a neutrino detector utilizing a 3GeV proton beam on a mercury target in the J-PARC Materials and Life Science Experimental Facility. The primary goal of the JSNS² experiment is to search for the sterile neutrino with Δm² ˜ 1eV by measuring a neutrino oscillation at a short baseline of 24m, providing a direct test of the LSND anomalies. The JSNS² experiment started commissioning in 2020 and continued physics data collection in 2023. A new far detector for JSNS²-II, which is the 2nd phase of the experiment using two detector is under construction at a distance of 48m from the source to increase the sensitivity of the sterile neutrino search. In this talk, we summarize the recent status of JSNS² and JSNS²-II.

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Uniform beam simulation technique for NuMI beam scans and ML studies at Fermilab

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Fermilab's neutrino facilities, including NuMI and the upcoming LBNF, use proton beams to produce positively and negatively charged pions and kaons. Detailed simulations are necessary to study particle interactions and beam propagation. To efficiently analyze beam scan effects, we propose a method for generating multiple simulation samples with high statistics. By simulating a single sample with a uniform distribution for each beam parameter, simulation time and computing resources

can be significantly reduced. We calculate Gaussian weights and apply them to post-processing measurements. The alignment of the primary proton beam, target, and focusing horn has a significant impact on the neutrino energy spectrum, and changes in beam parameters can be estimated by scanning the proton beam across the target. Muon monitors detect and respond to these changes, and comparing beam scan data with simulations establishes a correlation between the two. This combined approach also offers valuable beam diagnostics. Our simulation technique allows users to generate as many random beam simulations as needed for beam scan studies and can be applied to a wide range of machine learning algorithms.

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Prospects for physics with the T2K ND280 Upgrade

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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 cm3 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.

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Quantifying the second resonance effect in neutrino-Argon interaction using DUNE Near Detector

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Heavy nuclear targets are used in neutrino oscillation experiments to boost the statistics of neutrino interactions. The complex nuclear environment contributes to the systematic uncertainty as the inevitable nuclear effects. Inadequate knowledge of the neutrino interaction with the nuclear target along with the imperfect reconstruction of neutrino energy seeds uncertainty in the cross-section. Uncertainty in the cross-section propagates as a systematic uncertainty in the determination of the neutrino oscillation parameters. For precision physics, future neutrino oscillation experiments will require understanding of the neutrino nucleus-interaction and neutrino energy reconstruction with a high level of accuracy. In this work, we aim to quantify the second resonance contributions to the neutrino interaction in Argon for reducing systematic uncertainties in the physics predictions for the DUNE Near Detector (ND). We present the results as the ratio distribution of $\frac{d\sigma}{dQ^2}$ for $\Delta(1232)$ resonance and the extended analysis to the second resonance region $P_{11}(1440)$, $D_{13}(1520)$, and $S_{11}(1535)$. This inclusion shows a significant contribution to the total cross-section compared to the case where only the $\Delta(1232)$ resonance is considered.

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Exploring the focusing mechanism of the horn magnets of the Fermilab main injector facility

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Neutrinos at the Main Injector (NuMI) is a project at Fermilab that provides an intense beam of neutrinos used by a number of experiments. NuMI creates a beam of pions that decay into neutrinos, muons, and other particles. Muons are registered by the muon monitors. Magnetic horns are the key elements of the NuMI beam line. This work uses the muon beam profile observed at the muon monitors to study the NuMI horn focusing mechanism. It is found that the horn magnet generates dipole and quadrupole fields to focus pions. This suggests that the optics of the horn magnet are predominantly linear. Our study shows that the muon beam profile accurately detects the horn current within ±0.05%.

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Status of the DeeMe experiment to search for the muon to electron conversion at J-PARC MLF

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The DeeMe experiment is planned at J-PARC MLF H-Line.The experiment aims to search for the muon to electron conversion in the nuclear field, which is one of the charged lepton flavor violating processes that are forbidden in the Standard Model and expected to be highly sensitive to search for new physics.The DeeMe experiment will be the first search with using muonic carbon atoms.We aim to search with a single event sensitivity of $\mathcal{O}(10^{-13})$.DeeMe spectrometer commissioning and performance tests are underway.In this presentation, we will describe the overview and current status of the DeeMe experiment.

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Machine learning algorithms based on muon monitor data and simulation

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With the Main Injector Neutrino Oscillation Search (MINOS) experiment decommissioned, muon and hadron monitors became an important diagnostic tool for the NuMI Off-axis v_μ Appearance (NOvA) experiment at Fermilab to monitor the Neutrinos at the Main Injector (NuMI) beam. The goal of this study is to maintain the quality of the monitor signals and to establish correlations with the neutrino beam profile. By combining individual pixel information from muon monitors and pattern recognition algorithms, we use simulation results and measurement data to build machine learning-based predictions of the muon monitor response and neutrino flux. A new improved simulation allows us to generate high statistics data samples as the training material for machine learning (ML). The model is trained using simulation results with different beam configurations. ML predictions can be used to monitor beamline issues in the future. The plan is to implement the ML model predictions for daily NuMI beamline data monitoring and catching common failure modes.

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Sensitivity study for the nucleon decay with background reduction for the atmospheric neutrino interaction in the Super-Kamiokande

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It is crucial to understand the atmospheric neutrino interaction (ATM-ν) in order to search for the nucleon decay (NDK) in the Super-Kamiokande (SK). In this poster, neutron tagging for ATM-ν background reduction will be introduced and sensitivity obtained by spectrum analysis for π momentum distributions from ATM-ν background and NDK signal MC will be reported using improved SK-4 MC processes such as vector generation and event reconstruction.

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

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The RENO experiment reports the separated reactor antineutrino spectra of 235U and 239Pu from the data sets of 2500 days of near data. As the fission fractions changes as the fuel cycle evolve, the contribution from different fissile isotopes to the measured spectrum can be identified. The separated prompt spectra are unfolded to antielectron neutrino spectra where the detector effect is nearly removed. The IBD yield of 235U(239Pu) is measured as 6.17 ± 0.02(4.19 ± 0.24) cm2/fission. The separated spectra of 235U show clear excess in 5 MeV (6 MeV) of prompt (neutrino) energy region with the 3.9σ of significance, while excess in 239Pu is milder than 235U and consistent with the Huber model with 1.1σ significance.

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Investigating Lorentz Invariance Violation with the long baseline experiments P2O and DUNE

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One of the basic foundations of quantum field theory is Lorentz invariance. The spontaneous breaking of Lorentz symmetry at a high energy scale can be studied at low energy extensions like the Standard model in a model-independent way through effective field theory (EFT). The present and future Long-baseline neutrino experiments can give a scope to observe such a Planck-suppressed physics of Lorentz invariance violation (LIV). In this talk, I will discuss how two future long baseline proposals DUNE and P2O can explore the LIV physics efficiently. We illustrate how the individual LIV parameters affect neutrino oscillations at P2O and DUNE baselines at the level of probability and derive analytical expressions to understand interesting degeneracies and other features. we estimate constraints on the individual LIV parameters at 95% confidence level (C.L.) intervals stemming from the combined analysis of simulated P2O and DUNE datasets, and highlight the improvement over the existing constraints.

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Exploring the effects of LIV on the CP-sensitivities of long-baseline experiments

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The theoretical possibility of a small deviation from the fundamental space-time symmetry is referred to as Lorentz invariance violation (LIV). This violation of the Lorentz invariance symmetry implies that laws of physics can vary under Lorentz transformation. LIV is intrinsic in nature and can exist even in a vacuum. The weakly interacting neutrinos can be a probe for better understanding any possible violation of Lorentz invariance symmetry. We consider these non-standard effects as subdominant terms and use the Standard Model Extension (SME) framework to incorporate LIV as a small perturbation to the standard neutrino Hamiltonian.

We particularly probe the effects of CPT-Violating LIV elements on the neutrino oscillation probabilities for a long-baseline (LBL) experiment. In this work, we first investigate the effects of LIV on the neutrino oscillation probabilities. We then further explore the effects of LIV on the CP-measurement sensitivity for the LBL experiment. We will present our findings on how the possible violation of Lorentz symmetry can compromise the CP-measurement sensitivity in the LBL experiment.

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WIT: from low energy to supernova neutrinos for Super-Kamiokande in the SK-Gd phase.

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The Super-Kamiokande water Cherenkov underground neutrino observatory is located in Japan. Since 2020, it has undergone two loadings with gadolinium sulfate. In the first loading during summer 2020, 13 tons of gadolinium sulfate octahydrate were dissolved, corresponding to a mass concentration of 0.02% gadolinium sulfate. In the second loading, 26 tons were diluted, resulting in a mass concentration of 0.06% gadolinium sulfate. These loadings enabled approximately 50% and 75% of neutron captures on gadolinium after the first and second loadings, respectively, leading to a new phase known as SK-Gd. In this phase, neutron captures predominantly occur on gadolinium, significantly improving the sensitivity to anti-neutrinos.

The Wide-band Intelligent Trigger (WIT) is a computing farm that receives online data from Super-Kamiokande's data acquisition system (DAQ) and triggers on events with a kinetic energy of at least 2.5 MeV. These events are then stored for later analysis. Although WIT was originally designed to improve Solar analyses, the dissolution of gadolinium has opened up new physics opportunities. One of these opportunities is the study of spallation-induced backgrounds, which are relevant for various analyses. Additionally, the online detection of supernovae has become possible, ranging from the detection of pre-core collapse supernova anti-neutrinos from massive and close stars to the detection of galactic core collapse supernovae using only their anti-neutrinos.

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Update on solar oscillations at Super-Kamiokande.

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Super-Kamiokande, a 50 kton water Cherenkov underground neutrino detector, has been instrumental in studying neutrinos across a wide energy range, from a few MeV to hundreds of GeV. Alongside SNO, Super-Kamiokande has played a pivotal role in providing evidence for solar neutrino oscillations. Specifically, the detection of Boron-8 neutrinos highlighted the deficit in the observed neutrino flux compared to the predictions of solar models. Since then, the Super-Kamiokande collaboration has been regularly sharing updates on various signatures and parameters related to solar oscillations. Most notably, the exclusion of other oscillation parameters, particularly the Small Mixing Angle and vacuum oscillations, and the evidence supporting the Large Mixing Angle solution, as well as the day/night flux difference attributed to the earth's matter electro-neutrino regeneration in the Earth. This presentation will provide an overview of the latest advancements in solar oscillations at Super-Kamiokande.

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A ton-scale single phase LAr CEvNS detector

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Coherent elastic neutrino-nucleus scattering (CEvNS) was predicted in 1974 as a consequence of the weak neutral current. 43 years later, the COHERENT collaboration first observed CEvNS using a 14.6-kg CsI detector. After 3 years, CEvNS on argon was measured using COH-Ar-10 (CENNS-10), 24-kg liquid argon detector. There are many physics opportunities related to CEvNS, but COH-Ar-10 has ~30% statistical uncertainty in the measured cross-section according to the published result. In this talk, I will introduce COH-Ar-750 (CENNS-1ton), a ton-scale liquid argon CEvNS precision detector under construction.

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NEOS-II sensitivity for a light sterile neutrino

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NEOS is an experiment to search for a sterile neutrino oscillation from a nuclear reactor core at a short baseline. The detector was deployed at a 24-m distance from a 2.8 gigawatt-thermal-power reactor core in the tendon gallery of the Hanbit-5 reactor. NEOS-II has recorded 388 (112) live-days of reactor-on (-off) data including a full reactor operation cycle and the reactor maintenance periods before and after the operation cycle. The sensitivity of finding the neutrino mass-squared-split and the mixing angle for the active-to-sterile neutrino oscillation has been studied, considering the statistical and systematic uncertainties of NEOS-II.

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Benchmarking neutrino interaction models with NUISANCE

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A precise modelling of neutrino-nucleus interactions is of fundamental importance to allow current and future accelerator-based neutrino oscillation experiments to achieve their ambitious goals. However, as it stands, no neutrino interaction model currently implemented in event generators has been shown to offer a quantitatively satisfactory agreement with many (and in some cases, any) modern cross-section measurements. But exactly how bad is the agreement? Which regions of kinematic phase space look better or worse? Does the situation improve when fitting uncertainties within the models? The answer to all these questions can be provided by NUISANCE.

NUISANCE is a widely used tool to synthesise the predictions from all major event generators and to confront them with state-of-the-art cross section measurements. It has been used extensively by the T2K, MINERvA and MicroBooNE collaborations to compare models to measurements and to determine uncertainty parameterisations for neutrino oscillation analyses. NUISANCE is also used by theory groups to compare microscopic models to event generator predictions. In this talk, we first summarise the status and functionalities of NUISANCE, before discussing a number of recent analyses conducted within it. These include an evaluation of the robustness of the "low-nu"method [arXiv:2203.11821], a benchmarking of the T2K CCQE uncertainty model against cross-section measurements [arXiv:2202.03219] and comparisons of recent CCQE theory calculations (CRPA and RMF) to event generator predictions [arXiv:2207.02086, arXiv:2110.14601].

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Muonium and Muonic Helium Hyperfine Structure Precision Measurements at J-PARC MUSE

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At the J-PARC Muon Science Facility (MUSE), the MuSEUM collaboration is planning new measurements of the ground state hyperfine structure (HFS) of both muonium and muonic helium atom.
Muonium (a bound state of a positive muon and an electron) and muonic helium (a helium atom with one of its electrons replaced by a negative muon) are both hydrogen-like atoms. Their respective ground-state HFS results from the interaction of the electron and the muon magnetic moment, and they are very similar but inverted because of the different signs of their respective muon magnetic moments. High-precision measurements of the muonium ground-state HFS are recognized as the most sensitive tool for testing bound-state quantum electrodynamics (QED) theory to precisely probe the Standard Model [1] and determine fundamental constants of the positive muon magnetic moment and mass. The same technique can also be employed to measure muonic helium HFS and obtain the negative muon magnetic moment and mass. Moreover, muonic helium HFS is also a sensitive tool to test and improve the theory of the three-body atomic system.
The MuSEUM collaboration already performed HFS measurements at zero magnetic field at MUSE D-line of both muonium and muonic helium atom, with results more accurate than previous measurements [2-4]. High-field measurements are now in preparation at the MUSE H-line, using ten times more muon beam intensity than at the D-line, and with decay positrons/electrons being more focused on the detector due to the high magnetic field, we aim at improving the accuracy of previous measurements by ten times for muonium and hundred times or more for muonic helium. Furthermore, a new experimental approach to recover the negative muon polarization lost during the muon cascade process in helium is being investigated by repolarizing muonic helium atoms using a spin-exchange optical pumping (SEOP) technique [5], which would drastically improve the measurement accuracy, and where a direct improvement by a factor of ten may be realized. An overview of the different features of these new HFS measurements and the latest results will be presented.

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The T2K optical transition radiation proton beam monitor: updates and future plans

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For fixed-target experiments, final proton beam monitoring is key to controlling the properties of the particle flux exiting the target. The T2K experiment makes use of an Optical Transition Radiation (OTR) monitor for this purpose. In support of the J-PARC 750kW beam power upgrade, this monitor has undergone a series of changes targeted at increasing its tolerance to the higher beam intensity and repetition rate. The design and performance of these upgrades, including redesigned titanium foils in the beam path and a new DAQ system, will be discussed with reference to data collected during the recent T2K run 12 period. Finally, a new apparatus to investigate the beam-induced background light contribution is described. This intends to make use of an optical fiber and a PMT in order to better understand the time dependence of the beam-induced background light seen in the OTR data.

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Neutrino oscillation sensitivity of the Hyper-Kamiokande experiment

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The next-generation water Cherenkov experiment Hyper-Kamiokande (HK) includes a rich long-baseline neutrino oscillation component. This will make use of a 1.3MW proton beam from J-PARC, coupled with a suite of near detectors, including an upgraded ND280 and a new Intermediate Water Cherenkov Detector (IWCD). The 185 kton fiducial mass Hyper-Kamiokande will be used for the far detector. The high beam power and this large fiducial mass will provide the statistics necessary for precise determination of the atmospheric mass splitting, Delta mˆ2_23, mixing angle theta_23, and the neutrino CP violating phase delta_CP. Such measurements have the potential to become systematically limited over the course of HK's running period. The impact of systematic uncertainties on the oscillation sensitivity will be discussed, along with the potential to minimise this impact with near-detector measurements.

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Reactor Experiment for Neutrinos and Exotics at Hanbit nuclear power plant in Korea

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We report a conceptual design of Reactor Experiment for Neutrinos and Exotics (RENE), 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 RENE 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 poster, we report the concept of the RENE detector and physics cases.

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Proposal for multi-stage cooling of muon beams

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Muons have been widely used as probes in searches for new physics via precision measurements and rare decay searches. Muon sources with a high-intensity proton beam have enabled experiments requiring high statistics. However, techniques for muon cooling with high efficiency are essential for further breakthroughs in searches for physics beyond the Standard Model.
The ultra-slow muon (USM) at J-PARC, the low-energy muon (LEM) at PSI, and the muon ionization cooling experiment (MICE) at RAL are known as muon cooling schemes.
The USM achieves excellent beam quality by laser ionization of muonium, but for high efficiency, it is necessary to improve the spatial overlap between muonium atoms and laser beams. For this purpose, we aim to develop a multi-stage muon cooling technique with LEM as the first stage and USM as the second stage.
In this contribution, we will report on the overview of the project, simulation results, and R&D progress.

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nuSTORM; Neutrinos from Stored Muons

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A rich cross-section and "beyond the Standard Model" (BSM) search programme will be served by the intense ν_e and ν_μ beams that will be provided by the neutrinos from stored muons (nuSTORM) facility. Exceptional precision in cross section measurement and exquisite sensitivity in BSM searches are afforded at nuSTORM by the precise knowledge of the flavour composition and the energy distribution of the neutrino beams. These unique features are complemented by the ability to tune the mean energy of the beams and use this freedom to analyse the data using synthetic beams of limited energy spread.

The precision that nuSTORM will provide is critical to the elucidation of neutrino-nucleus scattering dynamics. Especially appealing are the prospects for new precise direct or indirect measurement of neutrino scattering cross sections on single nucleons. Such measurements will be a priceless input to the development of event generators and provide valuable information about hadron structure in the axial sector. The sensitivity of which nuSTORM is capable will allows exquisitely sensitive searches for short-baseline flavour transitions, covering topics such as light sterile neutrinos, non-standard interactions, and non-unitarity of the neutrino mixing matrix. In synergy with the goals of the neutrino-scattering program, BSM searches will also profit from measurements of exclusive final states. This would allow BSM neutrino interactions to be probed by means of precise measurements of neutrino-electron scattering, as well by searching for exotic final states, such as dileptons or single-photon signatures. We will describe the status of the development of the nuSTORM facility and the simulation of its performance. Illustrative examples of the precision and sensitivity that can be achieved will be presented. The implementation of nuSTORM as part of a Muon Collider "demonstrator facility" will also be discussed.

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A study of time variations of solar neutrino flux using 5,804 live days of Super-Kamiokande data

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We report a study of time variations of solar Neutrino flux using 5,804 live days of Super-Kamiokande data. The data used in this analysis were obtained from 31 May 1996 to 30 May 2018. The measured exact time of high-yield solar neutrino events for 22 calendar years of accumulated data allows for studying solar neutrino modulations with unprecedented precision. The measured time variation of solar neutrino fluxes is consistent with the Kepler constants of eccentricity(1.53+/-0.35%) and perihelion shift (1.5+/-13.5 days) as preliminary results. Periodic modulations of the solar neutrino flux are probed using a 5-day interval data set. Lomb-Scargle periodogram and maximum likelihood methods are applied to search for potential periodic modulations in the solar neutrino fluxes. We found no statistically significant implication of periodicity other than annual modulation in the observed solar neutrino data. We release the 5-day interval Super-Kamiokande solar neutrino data in this report.

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Combine measurement of θ13 using reactor antineutrino events rates with neutron capture on hydrogen and Gadolinium at RENO

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The RENO Collaboration reports a measured value of the smallest neutrino mixing angle (θ_{13}) based on ˜2800 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 $\sin^2 2\theta_{13}$ = 0.082 $\pm$ 0.006(stat) $\pm$ 0.011(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%. We also measured the $\sin^2 2\theta_{13}$ value from the n-H analysis is combined with that from the most recent n-Gd measurement at RENO. A combined result is obtained by a simultaneous fit of the n-H and n-Gd data sets. Correlations between the two analyses are estimated for the uncertainties of detection efficiencies, backgrounds, Δm^2_{ee}, and reactor-related part. The combined result uncertainty is ˜7% lower than the n-Gd rate only result. Furthermore, the ratio of $\sin^2 2\theta_{13}$ between the n-H and n-Gd rate-only analyses is also reported.

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The Camera System for the IceCube Upgrade: Simulation Studies of the Antarctic Ice Properties

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The IceCube Neutrino Observatory, located at the geographic South Pole, has currently the largest volume among neutrino detectors. IceCube detects neutrinos using Cherenkov light emissions from charged particles produced in neutrino interactions. The optical properties of the ice in the detector is one of the major systematic uncertainties for analyses using IceCube data. One of the major goals of IceCube upgrade, where 7 new strings with novel optical modules and calibration devices are

added to the center of the IceCube volume, is to improve the knowledge of these optical properties. A novel camera-based calibration system will be installed into the photodetection modules to be used in the calibration of the IceCube Upgrade detector. The mass production of these camera systems has completed and integration is in process. There is an ongoing effort to simulate images that are expected from the camera system in the Antarctic ice to develop a method to analyze the image data. This simulation study will allow us to estimate the performance of the camera-based calibration process of the IceCube Upgrade such as the measurement of the optical properties of the Antarctic ice, characterisation of the ice in the new drill holes into which the new strings are installed and measuring the relative geometry of deployed modules. We will provide the status of the ongoing simulation studies processed in this presentation.

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Discrimination of Fluor Concentration in Liquid Scintillator Using PMT Waveform and Short-Pass Filter

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Linear alkyl benzene (LAB)-based liquid scintillator (LS) has been widely used as the target for neutrino detectors in recent decades due to its environmentally friendly and economic characteristics. The reconstruction of neutrino events is based on the scintillation light emitted from the LS; thus, understanding the LS response helps to understand the reconstructed neutrino event. It has been reported that the timing, light yield, and wavelength shift of the emitted scintillation light are influenced by the concentration of the fluors dissolved in the LS. However, the timing property and wavelength shift exhibit a non-linear relationship with the fluor concentration, making it difficult to distinguish the fluor concentration. In this study, we employed a convolutional neural network (CNN) to model the non-linear relationship between fluor concentration and LS properties. The network learned the featured characteristics of the scintillation events through observed waveforms and the relative ratio of the light yield below 425 nm to the total light yield (short-passed ratio) detected by a photomultiplier tube (PMT) at the different fluor concentration. The trained CNN was able to discriminate the scintillation events with different PPO concentrations concentration from the observed waveform. When the information from the short-passed ratio was combined with the waveform information, scintillation events were distinguished from samples with different PPO and bis-MSB concentrations. The classified scintillation events for each LS sample exhibited clear characteristics for the different LS concentrations, demonstrating the discrimination power of the trained CNN. This is the first demonstration of LS concentration discrimination using a machine-learning technique.

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High purity and high brightness muon beam for next generation muon-electron conversion experiments

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The search for muon-electron conversion processes that violate the conservation of charged lepton flavors has attracted much attention for its superior sensitivity to the discovery and verification of new physical phenomena beyond the Standard Model. Two experiments, COMET and Mu2e, are currently underway in Japan and the United States to search for muon electron conversion processes

with O(10ˆ-17) single-event experimental sensitivity. The Mu2e-II experiment, which improves the experimental sensitivity by a factor of 10, is also under investigation.
What should be done next as a muon-electron conversion process depends on the results of these experiments. In the case that the muon electron conversion process is not found, further exploratory experiments with increased experimental sensitivity are needed. If the muon-electron conversion process is discovered, the dependence of the decay ratio on the muon stopping target material should be investigated to clarify the physical mechanism causing this process. In either case, the next generation experiments should not only increase the muon beam intensity, but also improve its purity and energy spread.
Therefore, we have proposed the PRISM project, in which phase-space rotation is performed in a muon storage ring. In this talk, I will explain the key points and outline of the PRISM project and discuss the possibility of future muon-electron conversion experiments.

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

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Neutrino oscillation experiments require accurate measurements of the neutrino energy. However, the kinematic detection of final-state neutrons in neutrino interactions is currently absent in these experiments. A revolutionary 3-Diensional projection scintillator tracker (3DST) is capable of detecting both the kinetic energy and direction of neutrons on an event-by-event basis with precision through Time-of-Flight technique. This presentation will demonstrate the constraint of DUNE antineutrino flux uncertainty, illustrating the application of neutron kinematic detection, under the assumption that the 3DST is placed at the DUNE ND SAND.

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Overview of Accelerator Programs in Korea and Their Potential Contributions to Neutrino/Muon Physics

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Korea has several cutting-edge accelerator user facilities that are currently operational or in the commissioning phase. These include the 3rd Generation Synchrotron Light Source (PLS-II) and the X-ray Free Electron Laser (PAL-XFEL) situated in Pohang, the Korea Multi-purpose Accelerator Complex (KOMAC) located in Gyeongju, and the Rare Isotope Accelerator complex for ON-line experiments (RAON) based in Daejeon. Additionally, construction is underway for a new 4th Generation Storage Ring (4GSR) in Cheongju. In this presentation, we will provide an overview of the key specifications and planned upgrades for these accelerators and explore their potential roles in advancing neutrino/muon physics research.

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Recent results on flavour physics

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In this talk, I will present recent results with heavy flavour decays at the LHCb experiment. Future prospects will be highlighted in view of the recent start of Run 3 of the LHC. In particular, I will focus on searches for new physics and tests of lepton flavour universality that are particularly sensitive to the presence of physics beyond the Standard Model.

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The 2x2 Demonstrator: DUNE ND-LAr Prototype

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The Deep Underground Neutrino Experiment (DUNE) is a precision long-baseline neutrino oscillation experiment that will employ LArTPC technology in a near detector placed at Fermilab and a far detector at the Sanford Underground Research Facility, at a baseline of 1300 km. The DUNE Liquid Argon Near Detector (ND-LAr) design takes into account the high neutrino intensity expected from the LBNF beam: several optically separated time projection chambers are instrumented with a pixel-based, true 3D charge readout alongside scintillation light traps to disentangle the O(50) neutrino events expected per 10us beam spill. The 2x2 Demonstrator will test the DUNE ND-LAr design between upstream and downstream repurposed MINERvA tracking planes under the NuMI beam at Fermilab in the few-GeV energy range. It consists of four 0.7m x 0.7m x 1.4m TPC modules filled with 2.6t of LAr, read out by over 300k charge-collecting pixels. Every module has been commissioned and tested with cosmic ray data at the University of Bern. The 2x2 Demonstrator is scheduled to begin data-taking in Fall 2023, collecting the first neutrino beam data with this technology. This talk will provide an overview of the detector design for ND-LAr and the 2x2 demonstrator, as well as the latter's status and expected physics program.

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Reactor Antineutrino Oscillations with JUNO

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The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator detector scheduled to come online in 2024 with a main physics goal of precisely measuring reactor antineutrino oscillations. JUNO is located at a distance of 53 km from eight nuclear reactors in Southern China. The detector will be instrumented by 17,612 20-inch and 25,600 3-inch photomultiplier tubes, resulting in over 75% photocoverage. This design alongside a careful control of systematics is expected to achieve a 3% energy resolution at 1 MeV, allowing a measurement of $sin^2\Theta_{12}$, Δm^2_{21}, and Δm^2_{32} to sub-percent precision. Furthermore, JUNO will be able to determine the neutrino mass ordering to 3σ with ˜6 years of data-taking. This talk will describe JUNO's expected measurements in neutrino oscillations with reactor antineutrinos and report the most recent sensitivities.

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T2K Neutrino Cross Section Measurements

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Precise knowledge of how neutrinos interact with matter is essential for measuring neutrino oscillations in long-baseline experiments. At T2K, the near detector complex measures neutrino interactions to constrain cross-section models for oscillation studies and to characterise the beam flux. The near detector complex provides a platform for performing neutrino-nucleon cross section measurements. The design of the ND280 near detector allows for a variety of cross section measurements on different targets to be performed. The additional WAGASCI near detector at a different off-axis angle features an increased Water/Carbon target ratio. Finally, the on-axis INGRID detector can be combined with ND280 and WAGASCI to measure the cross-section at different neutrino energies and to further constrain the nuclear models for different targets.

Recent cross section measurements from the near detector complex will be presented. The latest measurements of pion production in ND280, including measurements of transverse pion kinematics, and an improved analysis of coherent pion production making use of an anti-neutrino sample for the first time, will be shown. The first measurement of cross section without pions in the final state at the WAGASCI off-axis angle will be presented, as well as the first combined measurement of ND280 and INGRID allowing the first simultaneous measurement of cross-section at different neutrino off-axis angles, energies and different detectors on the same flux.

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Non-standard neutrino interactions mediated by light scalar

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Neutrino oscillation experiments have provided crucial insights into the nature of neutrinos, including the discovery of neutrino oscillations and the observation of CP violation. Non-Standard Neutrino Interactions (NSIs) have emerged as an important topic of study, as they can potentially modify the neutrino oscillation probabilities and affect the measurement of CP violation parameters. In this work, we investigate the impact of light scalar-mediated NSIs on CP violation measurements at the Deep Underground Neutrino Experiment (DUNE). We explore the parameter space probed by DUNE and discuss the constraints imposed by other relevant experiments.

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COMET Phase-Alpha Experiment to Investigate COMET's New Muon Beamline at J-PARC

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The COMET experiment aims to search for the muon-to-electron conversion process with a sensitivity 10,000 times better than the current best result. The muon-to-electron conversion process violates charged lepton flavor conservation, which is strictly forbidden in the Standard Model. Once discovered, the muon-to-electron conversion process will provide definitive evidence of the existence of new physics beyond the SM.

The key to significantly improving sensitivity lies in providing an intense muon beam. By utilizing the 8 GeV proton beam from the J-PARC facility, the COMET experiment will deliver a muon beam with a world-record intensity. To achieve this, the superconducting pion capture system and muon transportation system play crucial roles. In addition to intensity, the transportation system can select beam particles based on their charge and momentum to ensure the quality of the muon beam, which is essential for precise measurements. To investigate the muon beam and its transportation, the COMET collaboration proposed an experiment known as Phase-α to generate muons in the COMET experimental hall using the transportation system and directly measure the beam.

To measure the muon beam, three detectors were developed for the COMET Phase-α experiment. The first is the Muon Beam Monitor, which utilizes scintillating plastic fibers to measure the position and timing of beam particles. The second is the Straw Tube Tracker, which determines the position and direction of beam particles. The third detector is the Range Counter, consisting of plastic scintillators, absorbers, and targets, capable of counting negative muons in different momentum ranges and identifying positive pion decay chains. To further investigate transportation performance, a beam-masking device was placed in front of the transportation system to precisely control the initial phase space distribution of the injected muon beam. In addition to muon beam measurement, titanium dioxide (TiO_2) sensors were installed for primary proton measurement.

In February and March 2023, the COMET experimental hall received the muon beam for the first time. The COMET Phase-α experiment successfully observed muon beams delivered by the transportation system and collected valuable datasets for in-depth analysis. The ongoing data analysis process will be discussed, including detailed insights into the facility, experiment, detectors, and some preliminary results.

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Charged lepton flavor violation for a probe to the neutrino masses and their hierarchy

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The standard model of particle physics is far from accounting for mysteries about our universe, –e.g., what is origin of neutrino masses and their hierarchy?– and it must be extended to a more fundamental description of nature. Such new physics models allow Charged Lepton Flavor Violating (CLFV) reactions which are exactly forbidden in the standard model. Hence search for CLFV is a clue to the new physics, which unveil the flavor structure and the symmetries behind it. In this talk, the connections between models for neutrino masses and CLFV processes are reviewed, and relevant experimental progresses are discussed.

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J-PARC MR Upgrade Commissioning Status and Future Plan

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The main ring synchrotron (MR) of Japan Proton Accelerator Research Complex (J-PARC) provides high power and high intensity beams for the neutrino and hadron experiments. We have been upgrading hardware from the summer of 2021 to shorten the repetition period aiming at 1.3 MW user operation for the neutrino experiments by 2028. The upgrades are progressing smoothly, and 760 kW equivalent beams were successfully accelerated in the fast extraction mode, which significantly exceeded the maximum beam power of 515 kW until JFY2021. In this presentation, we will report present status of the beam tunings and strategies for further beam power upgrade.

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Inclusive Antineutrino Nucleus Scattering Analysis at MINERvA

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The MINERvA experiment at Fermilab uses ≈ 3 GeV(LE) and ≈ 6 GeV(ME) NuMI neutrino and antineutrinos beams interacting on different nuclear targets (He, C, Fe, Pb, Water and CH) located throughout the detector. Reported here is the ME antineutrino measurement of the inclusive double differential charged current cross section as a function of Bjorken x and four momentum transfer squared (Q^2) on several of these targets. By measuring the cross sections on these targets in the same beamline, the cross sections can be compared with reduced flux and detector uncertainties to determine nuclear effects. This measurement will ultimately help future neutrino experiments on heavy nuclear targets by benchmarking models that may be used by those experiments.

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Nuclear Dependence of Antineutrino Deep Inelastic Scattering in two dimensions at MINERvA

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MINERvA (Main Injector Neutrino ExpeRiment to study ν-A interactions) is a dedicated (anti)neutrino-nucleus experiment in the few GeV energy region which has used the high-intensity NuMI beamline facility at the Fermi National Accelerator Laboratory.
The experiment was performed using several nuclear targets, Iron, Carbon, Lead, Water and Hydrocarbon to study the nuclear medium effects in the low ($< E_{\bar{\nu}_\mu} >\sim 3GeV$) and intermediate ($< E_{\bar{\nu}_\mu} >\sim 6GeV$) energy region. The idea is to understand the nuclear medium effects by taking the ratio of cross section like $\frac{\sigma_i}{\sigma_{CH}}$ and $\frac{d\sigma_i}{d\sigma_{CH}}$ where i = C, Fe, Pb, etc. We shall present the current progress on the two dimensional (2D) charge current antineutrino Deep Inelastic Scattering (DIS) analysis using medium energy $\bar{\nu}_\mu$ beam. The event selection is based on a set of different selection cuts and the DIS signal is defined as the events which contribute in the kinematical region defined

by $Q^2 > 1GeV^2$ and W $> 2GeV$. We will discuss the different steps involved in the analysis. This study will give insight to both weak hadron physics and in the understanding of the nuclear medium effects in antineutrino nucleus interaction.

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Implementation of CRPA in GENIE and comparisons of 1p1h models

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Building on Phys. Rev. D 106, 073001 (2022), we present the implementation and validation of the Hartree-Fock continuum random phase approximation (HF-CRPA) model in the GENIE neutrino-nucleus interaction event generator and a comparison of the subsequent predictions to experimental measurements of lepton kinematics from interactions with no mesons in the final state. These predictions are also compared to those of other models available in GENIE. It is shown that, with respect to these models, HF-CRPA predicts a significantly different evolution of the cross section when moving between different interaction targets, when considering incoming anti-neutrinos compared to neutrinos and when changing neutrino energies. These differences are most apparent for interactions with low energy and momentum transfer. It is also clear that the impact of nucleon correlations within the HF-CRPA framework is very different than in GENIE's standard implementation of RPA corrections. Since many neutrino oscillation experiments rely on their input model to extrapolate between targets, flavours, and neutrino energies, the newly implemented HF-CRPA model provides a useful means to verify that such differences between models are appropriately covered in oscillation analysis systematic error budgets.

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Recent results from MINERvA

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MINERvA is an experiment designed to precisely study neutrino-nucleus interactions in the 1-20 GeV energy range using the NuMI high-intensity neutrino beam at the Fermi National Accelerator Laboratory. MINERvA has improved our knowledge of neutrino cross sections at low energy, low Q^2, and the A-dependence in these interactions. These data are interesting in their own right, and have been important in reducing the systematic errors in oscillation experiments. An overview of MINERvA results will be presented.

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Latest results of the DANSS experiment

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The latest results of the DANSS experiment are presented. The plastic scintillator detector is located under 3.1 GW industrial reactor core of Kalinin Nuclear Power Plant, and its main purpose is the search for the short baseline neutrino oscillations. The inverse beta decay reaction is used for the antineutrino detection. The data are collected at three distances −10.9, 11.9 and 12.9 meters from the reactor core center. The total number of the antineutrino events has reached 7M with about 1.5M new events from the lust year. New limits on the sterile neutrino oscillation parameters are presented. The evolution of the antineutrino counting rate and spectrum with the time of the reactor campaign will also be discussed. A model-dependent analysis of the data, including the absolute antineutrino flux, excludes nearly the whole area of the sterile neutrino parameters, preferred by the recent BEST results, and also the best fit point of the Neutrino-4 experiment. The study of the cosmic muon flux variations at the detector depth of 50 m.w.e., caused by the temperature and barometric effects, is also presented.
The status of the coming DANSS modernization will be presented. This upgrade will improve DANSS energy resolution and increase the sensitive volume, which will allow to cover of even larger area of the sterile neutrino parameters. In this case, the sensitivity of the DANSS detector will allow to check the latest BEST and Neutrino-4 experiments in a model-independent way.

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Development of water-based liquid scintillator tracker for a precise measurement of neutrino-water interactions

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T2K experiment is a long-baseline neutrino oscillation experiment in Japan. One of the T2K goals is to obtain evidence of CP-violation in the leptonic sector at 3σ confidence level. To archive this goal, the reduction of systematic errors is needed, and a new plastic scintillator tracker (Super-FGD) will be installed in the near detector in 2023.
However, in the era of Hyper-Kamiokande (HK) experiment, which is the successor of the T2K experiment, measurements of neutrino interactions with Super-FGD may not be sufficient due to the difference of target nuclei. Since T2K and HK use a water Cherenkov detector as a far detector, the measurements of neutrino interaction with a water-targeted near detector are required.
We are developing a Water-based Liquid Scintillator (WbLS) tracker as a candidate for the water-targeted near detector. WbLS is the liquid that dissolves liquid scintillator in water with a surfactant, allowing observation of scintillation light while keeping a high water ratio. In October 2022, we made the first prototype of the WbLS tracker and tested it with a 500 MeV/c positron beam at ELPH, Tohoku University. I will present the status of the development and the result of the beam test.

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Update on the Bodek-Yang model

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This talk will present the status of the Bodek-Yang model.

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Progress in design of a muon source for muon to electron conversion based on an FFA ring - PRISM

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Future muon to electron conversion experiments require an improvement in sensitivity by a factor of 100 and novel accelerator concepts are necessary to achieve this goal.
A Fixed-Field Alternating gradient (FFA) ring has been proposed to create a Phase Rotated Intense Source of Muons (PRISM), which will allow for a significant purification of the muon beam and suppression of a typically large momentum spread by the use of RF phase rotation. This will provide a reduction of the backgrounds and increase the number of stopped muons in the target. The experimental system based on PRISM-like concept is of interest to be used at J-PARC or in proposed Advanced Muon Facility (AMF) at Fermilab. The challenge of PRISM lays in the necessity to efficiently transport the beam with very large emittance and momentum spread and the use of an FFA is essential to meet this requirement.
An example FFA ring design and its subsystems are presented and their
accelerator physics performance is evaluated.

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Simulation and reconstruction of neutrino interactions in the upgraded T2K ND280 detector

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The T2K magnetized near detector (ND280) at J-PARC is undergoing a major upgrade with a new 3D fine-granularity scintillator active targe with 3D imaging capabilities as well as ~3mm spatial resolution and sub-ns time resolution, two novel Time Projection Chambers (TPC), surrounded by a precise scintillator-based Time of Flight detector (ToF) with 200 ps time resolution.
Thanks to such innovative technologies, unprecedented details of neutrino interactions will be provided.
Hence, it becomes crucial to develop an accurate simulation and reconstruction of neutrino interactions to enhance the phase space acceptance and obtain isotropic particle tracking, low proton momentum threshold, neutron detection with measurement of the kinetic energy and an improved TPC tracking resolution thanks to the charge spreading in the novel resistive Micromegas detectors, all with a 2 tonnes neutrino target mass.
These ongoing efforts, that will pave a new way of looking at neutrino interactions, will be reported.

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Status of muon g-2/EDM experiment at J-PARC

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In 2021, the anomalous magnetic moment of the muon, a_μ = (g_μ-2)/2, was measured at the Fermilab National Accelerator Laboratory (FNAL) with a precision of 0.46 ppm. This measurement result is consistent with the previously value measured more than a decade ago at the Brookhaven National Laboratory (BNL), and the deviation from the Standard Model (SM) prediction has been reported with a significance of 4.2 standard deviations. This suggests the potential existence of new physics beyond the SM, but it needs to be verified through measurements employing different methods. The muon g-2/EDM experiment at J-PARC aims to measure a_μ and the electric dipole moment (EDM) using a low-emittance muon beam realized through the acceleration of thermal muons and silicon tracking detectors, employing a different approach from the BNL and FNAL experiments. This presentation provides an update on the current status of each experimental component.

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An Overview of Neutrino-Nucleus Interactions Physics: Status and Path Forward

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Current and future accelerator-based neutrino facilities utilizing intense neutrino beams and advanced neutrino detectors are focused on precisely determining neutrino oscillation properties and signals of weakly interacting Beyond the Standard Model (BSM) physics. These are subtle effects, such as extracting the CP violation phase and disentangling parameter degeneracies between oscillation effects and BSM physics, and require an unprecedented level of precision in measurements. The potential of achieving discovery-level precision and fully exploring the physics capabilities of these experiments relies greatly on the precision with which the fundamental underlying neutrino nucleus interaction processes are known. This talk will focus on neutrinos from tens of MeV to a few GeV energies. At these energies, neutrino interactions are a non-trivial multi-scale, multi-process problem that lies in an uncharted territory that spans from low-energy nuclear physics to perturbative QCD with no known underlying unified physics. In this talk, I will present an overview of the field, discuss these challenges, highlight recent progress, and attempt to outline a path forward.

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Neutrino scattering in the NOvA Near Detector

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NOvA is a long-baseline accelerator-based neutrino experiment based in the USA. NOvA uses an intense neutrino beam produced at Fermilab's accelerator complex to make physics measurements of neutrino oscillations, neutrino cross sections, and much more. For its physics goals, NOvA uses two functionally-identical detectors. The Near Detector (ND) is situated at Fermilab, 1 km from the neutrino target and the Far Detector (FD) is located at Ash River, MN, a distance of 810 km from the neutrino source. The ND receives a high statistics neutrino flux which gives a unique opportunity for high-precision neutrino cross-section measurements and is used as a control for the oscillation analyses.
In this talk/poster, I will give an overview of the NOvA experiment. I will also talk about the current and future status of the NOvA's cross-section physics program.

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Cross-Section Modeling on the NOvA Experiment

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Neutrino interaction cross sections are a significant source of uncertainty for many experiments dependent on the determination of neutrino properties from the inference of neutrino flavor or energy. To mitigate the effect of these large uncertainties on results from NOvA Experiment, a long-baseline experiment currently operating at Fermilab, the collaboration undergoes a critical evaluation of available cross-section models and implements the most appropriate models in simulation. In the process of model evaluation, a tune of GENIE simulation customized to the NOvA experiemnt is produced, along with a robust treatment of the appropriate systematics. This talk will review the relevant details of 3-flavor oscillations analyses on NOvA, the MEC tune that NOvA has developed for these analyses, and the status of model evaluation for future NOvA measurements.

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NOvA Three Flavor Results

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NOvA is a long-baseline neutrino experiment placed in the muon neutrino-dominated NuMI beam based at the Fermi National Accelerator Laboratory, USA. Utilizing two functionally-identical tracking calorimeters placed 809 km apart, NOvA observes the appearance of electron neutrinos and the disappearance of muon neutrinos. By observing these neutrino oscillations along with their antineutrino counterparts, NOvA is probing outstanding questions in neutrino physics including the neutrino mass ordering, leptonic CP violation parameterized by the phase dCP, the larger neutrino mass splitting dmsq32, and the mixing angle th23. This talk will present the most recent 3-flavor neutrino oscillation results from NOvA in both the Frequentist and Bayesian formalisms.

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NA61/SHINE experiment for neutrino physics

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In long-baseline neutrino oscillation experiments, understanding hadron reactions is essential for neutrino generation. Neutrinos are produced by striking a carbon target with proton beam and then decaying the emitted hadrons such as pions and kaons. The hadron interaction is a primary source of the neutrino beam flux prediction uncertainty. Therefore, accurate hadron production and hadron-nucleus interaction measurements are critical. The NA61/SHINE experiment at the Super Proton Synchrotron at CERN is being conducted with that as one of its objectives. In this presentation, the results of the neutrino program so far are reviewed. Next, the recent measurements for T2K and Fermilab long-baseline neutrino experiments are presented. Finally, we discuss the prospects for future hadron production measurements including a low-energy beamline that may extend NA61/SHINE's physics program in the near future. The low-energy hadron production measurements will be beneficial for not only long-baseline neutrino oscillation but also atmospheric neutrino oscillation experiments.

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Welcome

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Introduction

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Keynote 1 Neutrino Experiments

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Keynote 2 Neutrino Theory

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WG1 introduction : Oscillation

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Plenary / 202

WG2 introduction : Scattering

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Plenary / 203

WG3 introduction : Accelerator

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Plenary / 204

WG4 introduction : Muon

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Plenary / 205

WG5 introduction : beyond PMNS

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Plenary / 206

WG6 introduction : Detector

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Plenary / 207

WG7 introduction : IDEEO

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Plenary / 208

LOC: introduction to the lunch place, reception, schedule etc

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Plenary / 209

Oscillation theory and future

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Cross sections for future experiments

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Overview of Reactor neutrinos

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Plenary / **212**

Overview of near detector technologies and status

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Plenary / **213**

Modeling neutrino-nucleus cross section: theory and generators

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Latest results from the KATRIN experiment

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Plenary / **215**

Constraints on new physics in (Nu)SMEFT

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Plenary / **216**

New results on LHC neutrinos from the FASER experiment

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Heavy neutrino search at LHC

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Neutrino experiments in Yemilab, Korea

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0vbb experiments summary

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Plenary / 220

Mapping viable parameter space for leptogenesis

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Overview of cross section experimental results: argon based technologies

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Plenary / 222

Overview of cross section experimental results: non-argon based technologies

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Plenary / 224

Beam power upgrade status and plan at J-PARC

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Proton beam upgrade plan at Fermilab

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Status of beam commissioning at ESS

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New suggestion from China for the new muon beam-ling building plan

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Plenary / **228**

Muon g-2 and other precision measurements

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Muon CLFV and g-2 theories

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Muon CLFV experiments

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Plenary / **231**

Detection of neutrons in accelerator neutrino interactions

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Plenary / **232**

PRISM technique: challenges in infrastructure and analysis

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Activities of Women Committee in Korean Physical Society

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The Women Committee (WCiKPS) in Korean Physical Society has been established in April 2002, just after the 1st IUPAP international conference on Women in Physics held in Paris, in March 2002 aiming for spreading women's science culture to increase employment and promotion of women physicists and to improve research and work environments women friendly. The number of female physicists in KPS was 238 (9.3%) in 2002, and has been increasing steadily, now reaching 922 (15.5%) in 2020.
The WCiKPS has carried out various activities for achieving its goals: the Female Graduate Student Awards for fostering female workforce, Physics Camps for high school girls and Site Visits for college students to guide young students, Special Sessions in KPS meetings, National/International Workshops for WIP to expand basic competencies in science and technology through the exchange of physics information and knowledge on networking, career development, and leadership training of female physicists, and Surveys to improve the status of female physicists and advocating for their rights / Proposing the Government policies for female physicists. These activities are explained in detail in the following sections.

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Public Communication

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Diversity and outreach in research

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Plenary / 237

Status of T2K

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Status of NovA

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Status of MicroBooNE

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Overview of Atmospheric neutrinos

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Overview of CEvNS Experiment

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Plenary / **242**

ESSnuSB+ and summary of the mini workshop (satellite)

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Plenary / **243**

Korea Neutrino Observatory status

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JUNO status

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DUNE status

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Hyper-K status

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Panel Discussion on the prospect of future neutrino program

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Moderator: Alain Blondel
Panel:
Mary Bishai (DUNE Spokesperson)
Masato Shiozawa (Hyper-K Spokesperson)

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LOC: Excursion and Banquet guide

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LOC: Workshop photograph (SNU building-28)

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Summary WG 1: Oscillation

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Summary WG 2: Scattering

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Summary WG 3: Accelerator

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Summary WG 4: Muon

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Summary WG 5: Beyond PMNS

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Summary WG 6: Detector

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Summary WG 7: IDEEO

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Prospect of the Neutrino Physics

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LOC: Poster Award

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LOC: Closing Remark and Announcement of NuFACT24

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LOC: Closing

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Measurement of the Nucleon Axial Form Factor from Antineutrino Proton Elastic Scattering at MINERvA

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The transition axial form factor of the nucleon is a probe of nucleon structure and important for accurate prediction of charged current elastic and quasielastic scattering. Using the hydrogen in its hydrocarbon target, the MINERvA experiment has extracted a sample of antineutrino proton elastic scattering events, and directly extracted the form factor in a technique analogous to that used for the first measurements of the electromagnetic nucleon form factors in the 1950s. The results are compared to other theoretical predictions and derived measurements of the axial form factor.

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Introduction to the ESSnuSB+ mini Workshop

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Introduction to the physics and experimental aspects of the project

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Neutrino-Nucleus cross section modeling at the low energy regime: Theoretical overview

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ESSnuSB+ mini workshop / **265**

The status of the design studies on the special ESSnuSB+ target station

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ESSnuSB+ mini workshop / **266**

The design of the LEnuSTORM racetrack ring

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ESSnuSB+ mini workshop / **267**

Status of LEMNB facility design

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ESSnuSB+ mini workshop / **268**

The design of the new near detector and the physics reach of the project

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parallel (room#303) / **269**

Recent LFV Results From CMS

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Several experimental observations lead to the availability of lepton-flavor violating(LFV) processes, which is also thoroughly examined by the CMS experiment. In this presentation, several recent LFV results from CMS within different sectors are presented.

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no session

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dummy

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no session

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no session

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no session

Public Lecture / 277

(Planetarium): Supernova, Blackhole, and Neutrinos (in Korean, 한국어강연). Only 90 audiences with reservation

Poster / 278

poster introduction

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no session

parallel (room#303) / 280

no session

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no session

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no session

parallel (room#102) / 283

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no session

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no session