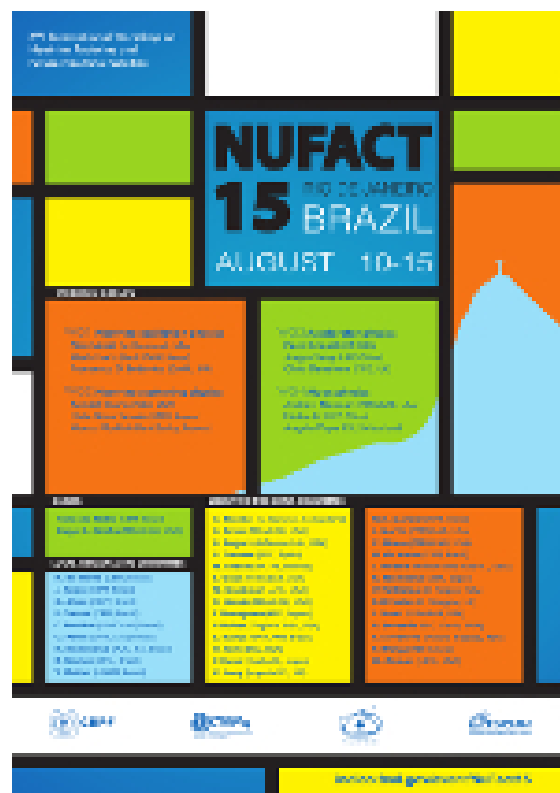


NuFact15 : XVII International Workshop on Neutrino Factories and Future Neutrino Facilities

Monday 10 August 2015 - Saturday 15 August 2015

Centro Brasileiro de Pesquisas Físicas



Book of Abstracts

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A Complete Demonstrator of a Cooled-Muon Higgs Factory

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A novel neutrino beamline for the measurement of the electron neutrino cross section

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Joint WG1-WG2 session / 153

ANNIE

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Atmospheric Neutrino Status and Prospects

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Baksan Experiment on Sterile Transitions

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A neutrino deficit is observed in radio-chemical solar neutrino experiments GALLEX and SAGE in measurements with radioactive sources. This result can be explained by neutrino transitions to a hypothetical sterile state on a short baseline, corresponding to the squared mass difference of the order of 1 eV^2 . A new underground experiment to search for this type of neutrino transition is planned to be carried out at the Baksan Neutrino Observatory on the Gallium-Germanium Neutrino Telescope, which has been used in the solar neutrino experiment SAGE. The idea is to observe the neutrino capture rate at two distances from the source. A Ga target is divided in two concentric zones in a way that the neutrino path lengths in each zone are equal. A statistically significant difference of the neutrino capture rate in these zones, as well as a considerable deficiency of the average rate in both zones in comparison with the expected rate, will indicate to the existence of the neutrino oscillation on a short baseline. The key features of this experiment are the intense compact neutrino source, which provides a high flux of monochromatic neutrinos, low backgrounds (including solar neutrinos), and a well established during decades technique of neutrino detection. The experiment allows to put constraints on squared mass difference and mixing angle corresponding to the oscillations to the hypothetical sterile neutrinos.

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Belle LFV

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WG2: neutrino scattering physics / 268

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Joint WG1-WG2 session / 152

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CCQE-like events in MicroBooNE

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MicroBooNE is a 170 ton liquid argon TPC placed in the Booster Neutrino Beam at Fermilab. The detector is currently being commissioned and first neutrino beam data is expected towards the end of this year. Located in a beam with energies between 0.1 and 3 GeV, MicroBooNE is able to make high statistics measurements of CCQE-like events. Recently, there have been indications experiments of correlated nucleon ejection from both QE-like neutrino scattering on argon, as well as electron

scattering measurements. With bubble chamber-like image quality and calorimetric information, MicroBooNE will be able to make detailed measurements of the hadronic side of the interactions and investigate these nuclear effects. This poster will compare different generator predictions for MicroBooNE and investigate its potential to discriminate between models.

WG1:neutrino oscillation physics / 184

CHIPS

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Plenary session 5 / 250

CLFV and Future Facilities (Experimental Overview)

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WG2: neutrino scattering physics / 171

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WG4: muon physics / 210

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WG2: neutrino scattering physics / 170

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WG2: neutrino scattering physics / 164

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Calibration and energy reconstruction at Daya Bay

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Daya Bay is an international experiment based in China. Its primary goal is the measurement of the neutrino mixing angle θ_{13} with unprecedented precision. In addition, it can address other topics in neutrino physics including sterile-neutrino searches, and high-statistics measurements of reactor anti-neutrinos. In Daya Bay, electron anti-neutrinos from 6 reactor cores are detected via the inverse beta-decay reaction in 4 near and 4 far liquid scintillator detectors with identical performance. A key feature of most of the physics done in Daya Bay is the relative measurements of physical quantities among detectors as a function of energy which is reconstructed based on the amount of detected light in the photo-multiplier tubes. To ensure energy is measured correctly, periodic calibration of the detectors with a number of radioactive sources and natural radioactivity in the liquid scintillator are performed. All aspects of energy calibration in Daya Bay will be briefly presented in this poster.

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Can Neutrinos Decay?

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Before the establishment of the LMA-MSW solution, Neutrino Decay was studied - both by itself and together with standard flavor oscillations - to explain the difference between the expected Solar Neutrino flux from nuclear fusion processes in the Sun and the detected flux on Earth - the so-called Solar Neutrino Problem (SNP).

In this work, we studied Neutrino Decay as a sub-leading effect in the propagation of Solar Neutrinos and, combining the data from Solar Neutrino experiments with the data from Kamland and Daya Bay experiments, we set a new lower bound to the ν_2 neutrino eigenstate lifetime at $\tau_2 / m_2 \geq 7.7 \times 10^{-4} \text{ s} \cdot \text{eV}^{-1}$, at 99% C.L..

Also, we calculate how seasonal variations in the Solar Neutrino data, which can be enhanced through decay, can give additional information about Neutrino's lifetime. Including in our analysis current data for the seasonal variation of Solar Neutrino flux, it results in a slightly lower value at 99% C.L. for $\tau_2 / m_2 \geq 7.2 \times 10^{-4} \text{ s} \cdot \text{eV}^{-1}$ due to the fact that the current eccentricity measurements and errors will favor lower, already excluded, lifetimes, for which the enhancement in the seasonal variation (and hence measured eccentricity) is higher.

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Coherent elastic scattering between neutrinos and nuclei

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In the limit of low momentum transfer for neutrino nuclei elastic scattering is expected to observe a coherent superposition in the cross section for the nucleons that compose the nucleus, increasing the interaction cross section. This effect was already observed for scattering for electrons, but due to experimental difficulties it have never been verified in neutrino scattering. Some groups dedicated to its verification were created. Beside it, the next generations of dark matter detectors probably will be sensitive to this interactions.

A study of the expected signal produced by coherent elastic scattering for neutrinos from different sources (solar, atmosphere, diffuse flux from supernovae, reactors and accelerators) was made. Considering a conservative threshold of 1 keV, as a detectable nuclear recoil, the most promising source to be observed is the 8B neutrinos produced in the Sun, with an expected rate of ~ 100 events/(tonyear). *Another promising source is the reactor, but the use of this source is quite dependent of the possible distance between reactor and detector. For a detector far 1 km from the reactor it is expected ~ 10 events/(tonyear), but if be possible decrease this distance for 100 m the rate would be increased to 1000 events/(ton*year).*

WG1:neutrino oscillation physics / 179

Compact formulas for neutrino oscillation probabilities in matter

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Computation of atmospheric neutrinos production

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Atmospheric neutrinos are produced by the interactions of cosmic rays with Earth's atmosphere which create unstable secondary particles that decay producing neutrinos. Due to have a wide energy spectrum of some hundreds of MeV until order of TeV, these neutrinos are good objects to test new theories and to study neutrino oscillation where there is a change of neutrino flavor state to another. In addition, atmospheric neutrinos constitute both the background and calibration of high energy neutrino telescopes and the search for rare processes, which motivates us to study how is its production and evolution in the atmosphere. In this way, we want to determinate the basic reactions of atmospheric neutrino creation by weak interactions and the processes of absorption and scattering of charged particles, such as pions and muons, produced by the interactions of protons (main constituents of cosmic rays) with the atmosphere. For this, we will proceed to solve cascade equations that relate source and sink terms of the particle flux to obtain its evolution up to the earth

surface, including the dependence of atmospheric density and the different arrival directions for incident protons. We started with analytical calculation to understand the physics of the cascade development and the dependence on the free mean path, the decay length and particle energy loss observing how this parameters are modified for each particle that compose the cascade.

Plenary session 6 / 251

Connections between g-2, EDMs, CLFV and LHC (Theory Overview)

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Constraining Majorana CP Phase in Precision Era of Cosmology and Double Beta Decay Experiment

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We show that precision measurement of sum of neutrino masses by cosmological observation and effective neutrino mass by neutrinoless double beta decay, together with beta decay experiments, have a synergy which allows us to get information on the Majorana phase of neutrinos. In order to quantify this information, we use, in addition to the allowed region plots, the CP exclusion fraction function as a complementary tool. This function shows how much fraction of the CP phase parameter space can be excluded for a given set of assumed inputs parameters. We find that one of the two CP neutrino phases can be constrained by excluding 10-50% of the phase space at 3σ CL for the lowest neutrino mass of 0.1eV. We also consider if the nuclear matrix element can be constrained by consistency of such measurements.

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Constraint on Neutrino Decay with Medium-Baseline Reactor Neutrino Oscillation Experiments

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In this work we use the fact that JUNO has the best opportunity to put the most stringent constraint in ν_3 lifetime over others experiments which utilize artificial neutrinos source. If there is a neutrino decay into invisible states, we find, by studying the χ^2 , that the ν_3 lifetime can be constrained to $\tau_3/m_3 > 7.5 (5.5) \times 10^{(-11)} \text{ s/eV}$ at 95%(99%) C.L. by JUNO by 100kt.years of exposure. We also discuss the effect of ν_3 decay on the determination of neutrino mass ordering as well as the precision of oscillation parameters measured by JUNO.

WG3:accelerator physics / 119

Cooling structure at the MOMENT target

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265

Cosmological bounds of sterile neutrinos in a $SU(3)_C \otimes SU(3)_L \otimes SU(3)_R \otimes U(1)_N$ model as dark matter candidates

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We study sterile neutrinos in an extension of the standard model, based on the gauge group $SU(3)_C \otimes SU(3)_L \otimes SU(3)_R \otimes U(1)_N$, and use this model to illustrate how to apply cosmological limits to thermalized particles that decouple while relativistic. These neutrinos, $N_{\alpha L}$, can be dark matter candidates, with a keV mass range arising rather naturally in this model. We analyse the cosmological limits imposed by N_{eff} and dark matter abundance on these neutrinos. Assuming that these neutrinos have roughly equal masses and are not CDM, we conclude that the N_{eff} experimental value can be satisfied in some cases and the abundance constraint implies that these neutrinos are hot dark matter. With this information, we give upper bounds on the Yukawa coupling between the sterile neutrinos and a scalar field, the possible values of the VEV of this scalar field and lower bounds to the mass of one gauge boson of the model, U_L . Also, these Hot Dark Matter sterile neutrinos should have an impact on the neutrino mass sum measured in cosmology, $\sum m_\nu < 0.23 \text{ eV}$, and we verify that this bound is satisfied in the model.

Plenary session 7 / 135

Current Status of the Fermilab Neutrino Beamlines

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WG1:neutrino oscillation physics / 205

DUNE Physics

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Joint WG1-WG2 session / 151

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joint WG1-WG4 / 193

Daya Bay/JUNO

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WG1:neutrino oscillation physics / 190

Decay at rest experiments

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WG3:accelerator physics / 123

Decay ring design for long baseline NF a la NuMAX

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Decoherence and Relaxation in Long Baseline Neutrino Experiments

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Focusing in the next generation of Long Baseline Neutrino Experiments, we study phenomenologically the neutrino oscillations behavior when decoherence and relaxation effects are taken into account in the propagation. In three neutrino oscillation approach, we can see that one particular oscillation channel may be enhanced due to decoherence and matter effect in the resonant region

decoherence. We can explain this effect even in two neutrino approximation. We also show as it is possible to implement these effects in the analytical solution that use $\Delta m_{12}^2 \ll \Delta m_{31}^2$ approximation. In the behavior study, we use numerical solution to investigate the three possible decoherence effects and two relaxation effects. We discuss the situation where all effects are combined and how these future experiments may limit all these effects.

WG4: muon physics / 211

DeeMee

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WG2: neutrino scattering physics / 172

Deep inelastic scattering at MINERvA

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Development of muon LINAC for the muon g-2/EDM experiment at J-PARC

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The muon anomalous magnetic moment (g-2) and electric dipole moment (EDM) are one of the effective paths to beyond Standard Model of elementary particle physics. The E34 experiment aims to measure g-2 with a precision of 0.1 ppm and search EDM with a sensitivity to 10-21 e*cm with high intensity proton driver at J-PARC and a newly developed novel technique of the ultra-cold muon beam. The ultra-cold muons, which are generated from surface muons by the thermal muonium production and laser ionization, are accelerated to 300 MeV/c by muon linear accelerator. The muon LINAC consists of RFQ and following three types of the RF cavities. The muon acceleration with RF cavity to this energy will be the first case in the world. This poster reports about status of the initial acceleration test with RFQ and the development of the RF cavities.

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Discussion

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Double CHOOZ

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WG4: muon physics / 227

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WG3:accelerator physics / 142

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Experimental status of neutrino scattering

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FORBUSH EVENT DETECTED BY CARPET ON 2012 MARCH

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We present preliminary results of cosmic rays flux behavior during a disturbed geomagnetic period detected by CARPET installed in CASLEO at the Argentinian Andes. CARPET was conceived to study cosmic rays modulation during transients and, sporadic events associated with coronal mass ejections (CME) and solar proton events, as well as long duration phenomena associated with 11-year solar cycle. CARPET data was corrected by pressure and temperature effects, which influence in the cosmic rays counts. We chose a period, 2012 March 6 - 12, with 2 geomagnetic storms associated with a CME/X1 flare on March 5. CARPET detected a gradual decrease on the muons count rate, namely a Forbush decrease. Comparison was made with neutron monitor data, Dst and kp indexes for this period. Forbush decrease event detected by CARPET exhibits a good time correlation with neutron monitor and geomagnetic indexes.

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Fermilab SBN Program(includes MicroBooNE)

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Fermilab proton driver

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WG3:accelerator physics / 130

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Closing / 311

Final remarks

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Future Accelerator-based Neutrino Physics in America and Europe

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Plenary session 9 / 240

Future Accelerator-based Neutrino Physics in Asia

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Plenary session 5 / 243

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Plenary session 3 / 234

Global Neutrino Oscillation Fits

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WG1:neutrino oscillation physics / 206

HK Physics

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263

HTS Pion Capture Solenoid for Next Generation Muon Beam Line

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High intensity muon beam is required for the muon electron transition experiment due to its low branching ratio. Thus, the pion capture superconducting solenoid has to be operated under the high radiation environment. Currently, LTS coil has small temperature margin and limit of magnetic field, whereas HTS coil has not only the large temperature margin but also good radiation resistance. We finished the conceptual design for compact pion capture solenoid with HTS.

WG1:neutrino oscillation physics / 201

Heavy Neutrinos

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WG3:accelerator physics / 127

High-intensity and high-brightness muon beams

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WG3:accelerator physics / 129

Hybrid cooling channel

WG1:neutrino oscillation physics / 183

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WG1:neutrino oscillation physics / 181

IceCube/PINGU

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Impact of systematic uncertainties on DUNE

joint WG1-WG2-WG3 session / 155

Impact of systematic uncertainties on Hyper-K

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Joint session WG1+WG2

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Joint session WG1+WG2+WG3

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J-PARC high intensity neutrino beam

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WG3:accelerator physics / 126

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WG4: muon physics / 219

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WG4: muon physics / 220

LHC LFV CMS

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WG3:accelerator physics / 146

Latest results on in-beam W powder target at CERN

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WG4: muon physics / 207

MEG

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WG4: muon physics / 208

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WG3:accelerator physics / 113

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WG3:accelerator physics / 112

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WG3:accelerator physics / 114

MICE cooling demonstration preparation

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WG3:accelerator physics / 143

MICE trackers and magnets

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WG1:neutrino oscillation physics / 185

MINOS/MINOS+

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WG3:accelerator physics / 117

MOMENT as multiple neutrino sources

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MOMENT synergies with other projects

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WG3:accelerator physics / 115

MTA status and progress

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WG1:neutrino oscillation physics / 202

Mass model summary

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MeV gauge boson and secret interaction of sterile neutrinos

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Recent results from the neutrino experiments show evidence for light sterile neutrinos which do not have any SM interactions. These light sterile states are disfavored by cosmology due to the constraints from onthe Big Bang nucleosynthesis and the Large Scale Structure Formation. This tension could be solved if the sterile neutrino states could have interaction with a light gauge boson X with mass M_X (the secret interaction model) with a field strength at least 100-1000 times beggar than the Fermi constant. We show in this paper that such large interaction strength is disfavored from MINOS experiment and we can constrain the mass of the light gauge boson. A tiny region was found compatible with anomalous g-2 results, constrains from cosmology and MINOS data with $M_X \sim 10-100$ MeV and $g_x \sim 10^{-3} - 10^{-4}$.

Summary:

We work the implications of secret interactions of sterile neutrinos with light gauge boson in neutrino phenomenology and we have found a curious common region for constrains from cosmology, MINOS data and g-2 anomalous results.

joint WG3-WG4 / 138

Mu2e

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WG4: muon physics / 310

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WG4: muon physics / 212

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WG4: muon physics / 217

Mulan

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WG3:accelerator physics / 125

Muon acceleration for NF/MC

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joint WG3-WG4 / 141

Muon beam line for COMET

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joint WG1-WG4 / 197

NA61 (focused on pion yields)

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WG2: neutrino scattering physics / 267

NEUT model improvements, external data fit comparisons

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WG2: neutrino scattering physics / 161

NOvA ND

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Neutrino Nucleon Cross Sections at High Energies

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We present a new calculation of the neutrino nucleon cross sections for charged and neutral currents using recent PDF fits that incorporate LHC data. We have performed a simple LO calculation as well as full NLO calculation, and further include corrections important at O(1GeV) energies such as lepton mass suppression for ν_τ and target mass corrections (TMC).

WG2: neutrino scattering physics / 166

Neutrino-induced meson productions in resonance region

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Neutrinoless Double Beta Decay Results and Prospects

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WG3:accelerator physics / 124

Neutrinos from pion beam line

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Neutrinos generating events for intranuclear cascade in CRISP code

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Some years ago, the CRISP (Collaboration Rio-Ilhéus-São Paulo) code was developed to describe spallation and fission reactions [1] using the Monte Carlo method approach. In order to improve the physics and the capacity of prediction of the code, the neutrino channel is being implemented. This improvement could be applied in several experiments where the neutrino-nucleon/nucleus cross section is used to measure neutrino oscillations [2]. A study of the neutrino-nucleon interaction was made and critically analyzed taking into account the advantages and shortcomings of CRISP when the neutrino event generator is implemented. It is known that the neutrino-nucleus interaction is fundamental for event detection in neutrino oscillation experiments. The treatment of the interaction in the nuclear medium is more complicated due to the processes involve effects of nuclear structure and interactions between the various nucleons. The effect of the nuclear medium and the interactions of the final state will be included to make more accuracy comparisons with the different experiments fluctuations. An accurate event generation program leads to the elimination of “false events”. The primary amplitudes of neutrino-nucleon interaction developed by C. Barbero and A. Mariano [3] will be used. This formalism is essentially different from other ones in the way to treat the resonances and their interference with the non-resonant background. A comparison will be performed with others formalisms employed in neutrino generator events, such as in NUANCE [4] or GENIE [5] codes.

WG1:neutrino oscillation physics / 204

Non-Standard Interactions: Current status and future prospects

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WG2: neutrino scattering physics / 275

NuSTEC Update

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WG3:accelerator physics / 122

NuSTORM overview

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WG1:neutrino oscillation physics / 186

OPERA

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WG4: muon physics / 215

PIBETA/PEN

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joint WG3-WG4 / 137

PRISM

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Parameter Limits for Neutrino Oscillation with Decoherence in KamLAND

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In the framework of quantum open systems we analyze data from KamLAND by using a model which considers neutrino oscillation in a three-family approximation with the inclusion of the decoherence effect. Using a χ^2 test we find new limits for the decoherence parameter which we call γ , considering the most recent data by KamLAND.

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Phenomenology of single spin asymmetries in inclusive reactions involving photons and leptons

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A phenomenological model which has had some success in explaining polarization phenomena and left-right asymmetry in inclusive proton-proton scattering is considered for reactions involving photons. In particular, the reactions (a) $\gamma + p \rightarrow H + X$; (b) $\gamma + p(\uparrow) \rightarrow \pi^\pm + X$ and (c) $p(\uparrow) + p \rightarrow \gamma + X$ are considered

where γ = resolved photon and hyperon $H = \Lambda, \Sigma, \Xi$ etc. Predictions for hyperon polarization in (a) and the asymmetry in (b) and (c) provide further tests of this particular model. Feasibility of observing (b) at the accelerators the effect of the polarization of the sea in the proton in $p(\uparrow) + p \rightarrow \pi^\pm + X$ is briefly discussed.

We also see the possibility of these effects in leptons (including neutrinos)

Round table / 295

Physics potential of non-conventional neutrino beams: Neutrino Factory +

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WG2: neutrino scattering physics / 160

Pion and kaon production at MINERvA

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Plenary session 5 / 249

Precision Muon Physics and EDMs (Experimental Overview)

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Probing Neutrino-Scalar Couplings

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Motivated by discovery of scalar particles at the LHC, we revisit the bounds from Yukawa couplings of scalar particles with neutrinos. Using data from meson decays and including for the first time the spectrum from meson decays we manage to put the following constraints for massless scalars: $|g_e|^2 < 1.9 \times 10^{-6}$, $|g_\mu|^2 < 7.4 \times 10^{-8}$ and $|g_\tau|^2 < 2.1 \times 10^{-2}$ at 90% C.L. and we get bounds on massive light scalars.

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Progress on Cherenkov Reconstruction for MICE

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Two beamline Cherenkov detectors (Ckov-a,-b) support particle ID in the MICE beam line. Electrons and high-momentum muons and pions can be identified with good efficiency. We report on the Ckov-a,-b performance in detecting pions and muons with Step I data.

joint WG1-WG2-WG3 session / 133

Prospects for precision of neutrino cross-section measurements over the next 10 years

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joint WG1-WG2-WG3 session / 134

Prospects for reducing beam flux uncertainties with hadron production experiments over the next 10 years

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WG3:accelerator physics / 120

Protons after bombarding the target at MOMENT

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WG2: neutrino scattering physics / 165

QRPA-based calculations for neutrino scattering and electroweak excitations of nuclei

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WG2: neutrino scattering physics / 159

Quasi-elastic measurements at MINERvA

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WG1:neutrino oscillation physics / 192

RENO/RENO-50

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Plenary session 7 / 239

Reactor Neutrino Oscillation Results and Prospects - Daya Bay/JUNO

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Plenary session 2 / 308

Recent developments in neutrino-nucleus scattering theory

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WG2: neutrino scattering physics / 162

Relativistic description of meson-exchange currents and Super-Scaling predictions in charged-current neutrino reactions

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Plenary session 4 / 235

Results and Prospects from NOvA

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Results and Prospects from T2K

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Revisiting T2KK and T2KO physics potential and ν_{μ} - anti- ν_{μ} beam ratio

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In this presentation, we revisit the sensitivity studies of a Tokai-to-Kamioka-and-Korea (T2KK) and Tokai-to-Kamioka-and-Oki (T2KO) proposals where a 100 kton detector is placed in Korea ($L = 1000$ km) and Oki island ($L = 653$ km) in Japan, respectively, in addition to the Super-Kamiokande (SK) for determination of the neutrino mass hierarchy and leptonic CP phase (δ_{CP}).

We systematically study the ν_{μ} and anti- ν_{μ} focusing beam ratio with dedicated estimation of backgrounds for the ν_e appearance and ν_{μ} disappearance signals, especially improving treatment of the neutral current (NC) π^0 backgrounds.

Using a $\nu_{\mu} : \text{anti-}\nu_{\mu}$ beam ratio between $3 : 2$ and $2.5 : 2.5$, the mass hierarchy determination with $\Delta\chi^2 = 10-30$ by the T2KK and $3-20$ by the T2KO experiment are expected for 5×10^{21} POT when $\sin^2(\theta_{23}) = 0.5$.

The CP phase is measured with the uncertainty of $20 \text{ deg.} - 50 \text{ deg.}$ by the T2KK and T2KO using the $\nu_{\mu} : \text{anti-}\nu_{\mu}$ focusing beam ratio between $3.5 : 1.5$ and $1.5 : 3.5$.

These findings indicate that the T2KK and T2KO experiments can improve their sensitivity to both the mass hierarchy determination and leptonic CP phase measurement simultaneously, using ν_{μ} and anti- ν_{μ} focusing beams with $3 : 2 - 2.5 : 2.5$ beam ratio.

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Round table: Developing an International Strategy toward a Neutrino Factory

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WG1:neutrino oscillation physics / 188

SBL Reactor Experiments

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SPC meeting / 315

SPC/WG meeting

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Searching for QCD effects in the neutrino absorption by the Earth's interior at ultra high neutrino energies

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We investigate how the uncertainties in neutrino-nucleon charged-current cross-section due the different QCD dynamic models would modify the neutrino absorption while they travel across the Earth. We compare the predictions from FJKPPP model, based in linear QCD evolution equation for the parton densities with BBMT model, which impose a Froissart unitarity of CC neutrino-nucleon cross-section at such UHE. We find that while the absorption function integrated with respect the angular direction is not sensitive to such effects, the probability of neutrino absorption by the Earth, for different neutrino incident directions, should be sensitive to the QCD dynamics at few percent at IceCube energies and reaches a factor greater than two at UHE limit.

WG1:neutrino oscillation physics / 189

Source Experiments

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WG3:accelerator physics / 121

Studies on charge selection at MOMENT

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WG3:accelerator physics / 118

Studies on pion/muon capture at MOMENT

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Study of the impact of using directionality to investigate geophysical models via the $\bar{\nu}_e + e^-$ elastic scattering interaction

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The ν_e from radioactive decays (238U, 232Th, 40K) inside the Earth, called geoneutrinos provide the best way to investigate the composition of the Earth. First experimental results and evidence of these neutrinos were observed by KamLAND and Borexino utilising the inverse beta decay process. Using this process the directionality of the neutrino can not be measured making the measurements sensitive only to the bulk composition. In our study utilising the Likelihood ratio test, we investigate $\bar{\nu} + e$ elastic scattering as a technique to measure the neutrino directionality and the geochemical

structure of the Earth. Such a measurement could take place at the proposed ANDES laboratory to be completed in 2022 in Chile.

WG1:neutrino oscillation physics / 180

Super-K

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WG2: neutrino scattering physics / 158

T2K CC0pi results

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WG2: neutrino scattering physics / 266

T2K CC1pi+CC coherent results (on and off axis)

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Joint WG1-WG2 session / 178

T2K Near Detector Experience

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Joint WG1-WG2 session / 150

T2K and HK future near detectors

WG3:accelerator physics / 147

Targets for high-intensity muon sources

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Plenary session 8 / 110

The ANDES project

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The Angra neutrino project

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WG2: neutrino scattering physics / 173

The BONuS Experiment: Recent Results and Future Plans

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The Multiple Muon Charge Ratio in the MINOS Far Detector

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Atmospheric muons are produced when primary cosmic ray nuclei interact near the top of the atmosphere to produce hadronic showers which contain pions and kaons. These secondary mesons can either interact in further collisions in the atmosphere or decay to produce atmospheric muons. Since the majority of primary cosmic rays are protons, there is an excess of positively charged mesons in the showers, and consequently, the atmospheric muon charge ratio $R_\mu = N_{\mu^+} / N_{\mu^-}$, defined as the number of positive over negative muons, is larger than unity. It is expected that heavier elements become a more important component of cosmic ray primaries as the energy increases. This increasingly heavy composition would decrease the ratio of primary protons to neutrons, which in turn, would decrease the muon charge ratio. With careful measurements of the muon charge ratio in the cosmic rays, models of the interactions of cosmic rays in the atmosphere can be improved.

The MINOS Far Detector is a magnetized planar steel-scintillator detector situated underground at depth of 2070 mwe. A small fraction of the cosmic ray muons observed in the MINOS FD contain multiple muons. Using the complete MINOS atmospheric data set we will present the first measurement of the multiple muon events charge ratio $R_\mu = N_{\mu^+} / N_{\mu^-}$. Systematic uncertainties on the charge ratio were minimized by utilizing data collected with both forward and reversed magnetic field running.

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The Neutrinos Angra experiment

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The *Neutrinos Angra* experiment aims to measure the antineutrino flux from the reactor cores of the Angra dos Reis nuclear power plant. The main objective is to determine the reactor power and the nuclear fuel composition from the detected antineutrinos. Since this method could find application as a tool for nuclear safeguards and non-proliferation, the detector is designed to be safe, compact and cost-effective, according to recommendations of the IAEA.

Neutrinos Angra employs a water Cherenkov detector. Its central component is the 1 m³ Target volume for the detection of antineutrinos via the inverse beta decay. This volume is doped with Gadolinium to observe the resulting neutron and thus create a characteristic coincidence signal. In addition the Target is surrounded by three veto volumes to reject cosmic muon events and other backgrounds. This is all the more important since the detector was planned as an above-ground experiment and will have no overburden. Currently the detector is set up and taking data at the CBPF in Rio de Janeiro, where it is placed for extensive testing. The acquired data has already been used to validate and characterize the PMTs and readout electronics as well as to assess the Target volume. It also allows a study of the cosmic muon flux and the rate of further background, which helps to improve the Monte Carlo simulations of the experiment. After the tests are concluded the detector will be shipped to Angra later this year.

Summary:

The *Neutrinos Angra* experiment aims to measure the antineutrino flux from the reactor cores of the Angra dos Reis nuclear power plant. The main objective is to determine the reactor power and the nuclear fuel composition from the detected antineutrinos. Since this method could find application as a tool for nuclear safeguards and non-proliferation, the detector is designed to be safe, compact and cost-effective, according to recommendations of the IAEA.

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The impact of sterile neutrinos on CP measurements at long baselines

WG2: neutrino scattering physics / 163

The relativistic Green's function Model and the Optical Potential

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WG1:neutrino oscillation physics / 194

Theia Experiment

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Theoretical Status of Neutrino Physics

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WG1:neutrino oscillation physics / 200

WG1 Summary Preparation

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WG1 summary

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WG1: plans and questions

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WG2: neutrino scattering physics / 276

WG2 Summary Preparation

Plenary session 9 / 289

WG2 summary

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Plenary session 1 / 285

WG2:plans and questions

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WG3:accelerator physics / 149

WG3 Summary Preparation

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WG3 summary

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WG3:plans and questions

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WG4: muon physics / 300

WG4 Summary Preparation

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WG4 summary

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Opening / 309

Welcome

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Closing / 316

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WG4: muon physics / 216

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WG4: muon physics / 229

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WG4: muon physics / 301

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joint session WG1+WG2+WG3

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joint session:WG1+WG4

WG4: muon physics / 218

mucap

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