International Workshop on Neutrino Factories, Super Beams and Beta Beams

Monday, 19 August 2013 - Saturday, 24 August 2013

IHEP

Book of Abstracts

Contents

1

Measurement of muonium hyperfine splitting at J-PARC

Author: Kazuo Tanaka[1]

[1] *University of Tokyo*

Corresponding Author: tanaka@kaduo.jp

We are planning a measurement of the ground state hyperfine structure of muonium at J-PARC/MLF. Muonium is a hydrogen-like bound state of leptons, and its HFS is a good probe for testing QED theory. The muon mass mm and magnetic moment mm which are fundamental constants of muon have been so far determined by the muonium HFS experiment at LAMPF. The high intensity beam soon to be available at J-PARC allows one order of magnitude more accurate determination of those constants, which also plays an important role in the new measurement of anomalous magnet moment.

WG1 / **2**

Confidence in the Neutrino Mass Hierarchy

Author: Jarah Evslin[1]

[1] *Institute of High Energy Physics, Chinese Academy of Sciences*

Corresponding Author: jarah@ihep.ac.cn

Analyses of neutrino mass hierarchy determinations at future experiments determine an expected Delta Chiˆ2. As the hierarchy is a discrete choice, and not a continuous degree of freedom, this Delta Chiˆ2 does not obey Wilks' theorem. As a consequence it does not follow a chiˆ2 distribution and its square root is not the number s of sigmas of confidence that can be expected. I will present a simple formula for s as a function of the expected value of Delta chiˆ2.

Summary:

I will review Wilks' theorem, which is used to relate Delta Chiˆ2 to the confidence in a null hypothesis. I will then explain why Wilks' theorem does not apply to the neutrino mass hierarchy. I will show that Delta chiˆ2 obeys a Gaussian distribution even considering the effects of nuisance parameters. I will then use this distribution to answer 3 questions: (1) What is the probability that a fit of the data to the true hierarchy yields a lower chiˆ2 than a fit to the false hierarchy? (2) With what confidence does the median experiment determine the hierarchy? (3) What is the probability of determining the hierarchy with s sigmas of confidence?

WG2 / **3**

Hadron production measurement from NA61/SHINE

Author: Alexander Korzenev[1]

[1] *University of Geneva*

Corresponding Author: alexander.korzenev@cern.ch

New results from the NA61/SHINE experiment on the determination of charged hadron yields in proton-carbon interactions are presented. They aim to improve predictions of the neutrino flux in the T2K experiment. Analysis is based on the main dataset collected by NA61/SHINE in the year 2009.
The data were recorded using a secondary-proton beam of 31 GeV/c momentum from CERN SPS which impinges on a graphite target. To determine the inclusive production cross-section for charged pions, kaons and protons the thin (0.04 λI) target was exploited. Results of this measurement are used in the T2K beam simulation program to reweight hadron yields in the interaction vertex. At the same time, NA61/SHINE results obtained with the T2K replica target (1.9 λI) allow to constrain hadron yields at the surface of the target. It would correspond to the constraint up to 90% of the neutrino flux, thus reducing significantly a model dependence of the neutrino beam prediction. All measured spectra are compared to predictions of hadron production models.
In addition a status of the analysis of data collected by NA61/SHINE for the NuMI target (Fermilab) is reviewed. These data will be used further in neutrino beam calculations for the MINERvA, MINOS(+) and LBNE experiments.

4

The MEG experiment: recent result and upgrade

Author: Galli Luca[1]

[1] *Paul Scherrer Institut and INFN Pisa*

Corresponding Author: luca.galli@psi.ch

The MEG experiment at PSI is searching for the lepton-flavour violating decay mu-> e gamma with unprecedented sensitivity. MEG set the most stingent experimental bound to date, based on the analysis of 2009, 2010 and 2011 data, to be <5.7 x 10**-13.**
After a successful run in 2012 and a final run in 2013 also a MEG Upgrade is envisaged, with a new positron spectrometer and an improved gamma ray detector. This upgrade plan has just been approved by the founding agencies and the host laboratory, and it is planned to take place before 2015, with subsequent three years of data taking towards a final sensitivity of ˜6 x 10-14.

5

Mu to e gamma search using converted photon

Author: Chih-hsiang Cheng[1]

[1] *California Institute of Technology*

Corresponding Author: chcheng@hep.caltech.edu

Current search for charged lepton flavor violating decay mu -> e gamma is limited by the accidental background. Future facility such as Project X at Fermilab could provide a much more intensive beam but one needs a more sensitive detector as well. One of the limiting factors in current detectors is the photon energy resolution of the calorimeter. We present a study of a conceptual design of a new detector, using a fast simulation software, that detects converted e+e- pairs from signal photons, taking advantage of a much better energy resolution of a charged particle tracking device.

6

Studies Progress of the High Intensity H2+ Cyclotrons for DAEδALUS and IsoDAR Projects

Author: Jianjun Yang[1]

[1] *CIAE*

Corresponding Author: yangjianjun2000@tsinghua.org.cn

The DAEδALUS (Decay-At-rest Experiment for CP studies At the Laboratory for Underground Science) project has been proposed to measure the value of the CP violating phase through the oscillation of muon antineutrinos to electron antineutrinos. In this project, high intensity H2+ cyclotron chains are proposed to efficiently provide proton beams with a kinetic energy of 800MeV and an average power in the MW range. The 60MeV/amu high intensity injector cyclotron of DAEδALUS can also be used as the driver of a pure electron antineutrino source for the IsoDAR (Isotropic Decay At Rest) project. Here we will describe the recent studies progress of the injector cyclotron and the main ring cyclotron development. We also report the results of experimental tests on the ion source, injection line and the central region that are under way. These tests aim to answer some critical questions concerning high intensity H2+ beam generating, separating and cooling.

7

Results from Step I of MICE and the Physics Plan for Step IV

Author: Vittorio Palladino[1]

[1] *Univ & INFN Napoli, Italy*

Corresponding Author: vittorio.palladino@na.infn.it

The Muon Ionisation Cooling Experiment (MICE) will demonstrate ionisation cooling, an essential technology for a
Neutrino Factory and/or Muon Collider, by measuring a 10% reduction in emittance of a muon beam. A realistic
demonstration requires beams closely resembling those expected at the front-end of a Neutrino Factory, i.e. with large
transverse emittance and momentum spreads. The MICE muon beam line at ISIS, RAL, was built to provide beams of
different momenta and emittance so that the performance of the cooling channel can be fully explored.
During the initial stage of MICE, a novel technique based on time-of-flight counters was used to establish that the beam
emittances are in the range 0.7–2.8 mm-rad, with central momenta from 170–280 MeV/c, and momentum spreads of about
20 MeV/c. These beams will be increased by means of scattering from high-Z material in the next stage of MICE and
measured using magnetic spectrometers. Finally, low-Z absorbers such as liquid hydrogen and LiH will be used to reduce
the emittance of the beam. The physics program of this step of MICE will be discussed, including all stages necessary for a
first demonstration of ionisation cooling.

8

Progress towards completion of the MICE demonstration of ionisation cooling of muons

Author: Vittorio Palladino[1]

[1] *Univ & INFN Napoli, Italy*

Corresponding Author: vittorio.palladino@na.infn.it

The Muon Ionisation Cooling Experiment (MICE) based at the Rutherford Appleton Laboratory aims to demonstrate 10%
ionisation cooling of a beam of muons by its interaction with low Z absorber materials followed by restoration of
longitudinal momentum in RF linacs.
Extensions to the apparatus required to achieve STEP IV, including the first absorber cell, of either liquid hydrogen or
lithium hydride, sandwiched between two particle tracking spectrometers shall be described. Two very large
superconducting spectrometer solenoids (the first of which has just completed acceptance trials) and one focus coil
solenoid (currently under test), manufactured in the US and UK respectively, will provide a magnetic field of ˜ 4T in the
volume of the two trackers and the absorber cell. The development, testing and integration of these challenging
components will be reported.
Progress towards STEPs V & VI including the 8 RF cavities to provide the required 8MV/m gradient in a strong magnetic
field will be presented, including the RF drive system to deliver 2MW, 1ms pulses of 201MHz frequency at a PRF of 1Hz,
the distribution network to deliver 1MW to each cavity with correct RF phasing, diagnostics to determine the gradient and
transit phase of the muons and the development of the very large diameter magnets required for the linacs.

9

The MUSE Experiment: A Study of the "Proton Radius Puzzle" with simultaneous mu-p and e-p Elastic Scattering

Author: William Briscoe[1]

[1] *The George Washington University*

Corresponding Author: briscoe@gwu.edu

The controversy over the significant difference between the determination of proton radius using high-precision muonic hydrogen techniques and from electronic scattering and atomic measurements is called the "Proton Radius Puzzle" (PRP). The resolution of the puzzle remains unclear and appears to require new experimental results. The MUSE Collaboration will perform an experiment at the Paul Scherrer Institut (PSI) to make simultaneous measurements of muon-proton and electron-proton elastic scattering in an attempt to resolve the PRP.

Summary:

The Proton Radius Puzzle stems from a radius determined from atomic muonic hydrogen of 0.84184±0.00067 fm,[1] and later updated to 0.84087±0.00039 fm.[2] The CODATA 2006 value, base mainly on atomic hydrogen measurements is 0.8768±0.0069 fm[3]. This has been confirmed by new electon scattering experiments[4,5] and re-analysis of existing data[6-8].The current CODATA value is 0.8775 ± 0.0051 fm.[9]

1. R. Pohl et al., Nature 466, 213–216 (2010).
2. A. Antognini et al. Science 339, 417–420 (2013).
3. P. J. Mohr, B. N. Taylor, and D. B. Newell, Rev.Mod.Phys. 80, 633–730 (2008), 0801.0028.
4. J. Bernauer, et al., Phys.Rev.Lett. 105, 242001 (2010), 1007.5076.

5. X. Zhan, et al., Phys.Lett. B705, 59–64 (2011), 1102.0318.
6. I. Sick, Few Body Syst. 50, 367–369 (2011).
7. I. Sick, Prog.Part.Nucl.Phys. 67, 473–478 (2012).
8. R. J. Hill, and G. Paz, Phys.Rev. D82, 113005 (2010), 1008.4619.
9. P. J. Mohr, B. N. Taylor, and D. B. Newell (2012), 1203.5425.

WG2 / 10

Probing Neutrino-Nucleus Interactions: New Results from ArgoNeuT

Author: Tingjun Yang[1]

[1] *Fermilab*

Corresponding Author: tjyang@fnal.gov

The liquid argon TPC (LArTPC) is a novel technique that provides excellent energy and spacial resolution and is an optimal tool to study neutrino-nucleus interactions. ArgoNeuT was the first LArTPC placed in a low energy neutrino beam. During the 5 months of running, ArgoNeuT accumulated several thousand neutrino and antineutrino interactions in the liquid argon. In this talk, I will discuss the latest results from ArgoNeuT, including inclusive CC cross sections and studies of final-state interactions and short-range correlations.

12

The Mu2e Experiment

Author: Zhengyun You[1]

[1] *University of California Irvine*

The Mu2e collaboration will search for coherent, neutrino-less conversion of muons into electrons in the field of a nucleus with sensitivity of one detected event for a branching fraction of ˜2x10ˆ-17; this would improve on the existing upper limit by a factor of ˜10ˆ4. Such a lepton flavor-violating reaction probes new physics at a scale inaccessible to direct searches at either currently operating or planned high-energy colliders. The experiment both complements and extends the current studies at MEG and at the LHC. I will present the physics motivation for Mu2e and describe the design of the muon source and the experiment itself. I will also discuss the sources of background to the conversion signal and the expected performance of the experiment.

13

Limits on the Dipole Moments of the \nu_\tau and energy scale f induced in a simplest little Higgs model

Author: Maria de los Angeles Hernandez-Ruiz[1]

Co-author: Alejandro Gutierrez-Rodriguez [1]

[1] *Universidad Autonoma de Zacatecas*

Corresponding Author: mahernan@uaz.edu.mx

Using as an input the data obtained by the L3 Collaboration for the reaction eˆ+eˆ- –> \nu\bar\nu\gamma, we obtained limits on the electromagnetic dipole moments of the tau-neutrino in the context of a Simplest Little Higgs Model (SLHM). Our bounds on the electromagnetic moments are consistent with the bounds obtained by the L3 Collaboration for the reaction eˆ+eˆ- –> \nu\bar\nu\gamma. In addition, we obtained a limit on the characteristic energy scale of the model: f ≥ 5.5 TeV, which is competitive with those reported in the literature. Our work complements other studies on the electromagnetic dipole moments of the tau-neutrino and on the characteristic energy scale of the model f.

14

Emissivity of Neutrinos in Supernova via the Process $e^+e^- \to \nu\bar{\nu}$ in a 331 Model

Author: Alejandro Gutierrez-Rodriguez[1]

Co-author: Maria de los Angeles Hernandez-Ruiz [1]

[1] *Universidad Autonoma de Zacatecas*

Corresponding Author: alexgu@fisica.uaz.edu.mx

We calculate the emissivity due to neutrino-pair production via the process $e^+e^- \to \bar{\nu un}$ in the context of a 331 model in a way that can be used in supernova calculations. We also present some simple estimates which show that such process can act as an efficient energy-loss mechanism in the shocked supernova core. We find that the emissivity is almost independent on the mixing angle phi of the model in the allowed range for this parameter.

15

EM vs Weak Structure Functions in DIS processes

Author: huma haider[1]

Co-authors: I. Ruiz Simo [2]; Mohammad Sajjad Athar [3]

[1] *aligarh muslim university*

[2] *Departamento de F\'\i sica Te\'orica and IFIC, Centro Mixto Universidad de Valencia-CSIC*

[3] *Aligarh Muslim University*

Corresponding Author: huma.haider8@gmail.com

We shall present the results for nuclear correction factor for the electromagnetic and weak structure functions. The calculations have been performed in several nuclei like
^9Be, ^{12}C, ^{40}Ca, ^{56}Fe, and ^{208}Pb. These calculations are performed in a microscopic nuclear model using relativistic nuclear spectral functions which incorporate Fermi motion,
nuclear binding, and nucleon correlations. The pion and rho meson cloud contributions are calculated from a microscopic model of meson self-energies. The target mass correction has been made using prescription of Schienbein et al.~\cite{tmc} and shadowing effect has been taken into
account using Glauber-Gribov multiple scattering model following the prescription of Kulagin and Petti~\cite{kulagin2006}.
We have obtained the ratios of the structure function in nuclei with the deuteron structure function and compared the results~\cite{sajjadnpa} with the available JLab data
with special attention to the slope of the x distributions. Using the same prescription we have obtained the results in weak structure functions~\cite{prc87,prc85,prc84}
and compared the results with the available data on the weak structure functions and differential

scattering cross sections.
In this conference we shall explicitly present the results of the medium effects on $F_1^{\nu N}(x,Q^2)$, $F_1^{\bar{\nu} N}(x,Q^2)$, $F_2^{\nu N}(x,Q^2)$, $F_2^{\bar{\nu} N}(x,Q^2)$,
$xF_3^{\nu N}(x,Q^2)$, $xF_3^{\bar{\nu} N}(x,Q^2)$, the study of which may be quite useful as the future large samples and better beam-related systematics
will allow neutrino experiments to independently isolate all the structure functions.

Summary:

For the next generation long baseline experiments which are aimed to precisely determine the parameters of the PMNS mixing matrix such as θ_{13} and the CP violating phase δ it has been realized that for these experiments a good knowledge of the anti(neutrino) DIS cross sections is very important. As these experiments are going to use nuclear targets, therefore a better understanding of medium effects in the DIS processes is required. The present understanding of nuclear correction is based mainly on charged current lepton nucleus DIS data, which may not be necessarily correct while applying it to anti(neutrino)-A DIS data.
In this work we have performed a model dependent analysis of nuclear corrections in the weak structure functions and observed that nuclear correction in F_3^A is different from F_2^A. We shall present the results for nuclear correction factor in the structure function F_i^A(i=1,2,3) and compare the results with the free nucleon structure function as well as with the available data on $\bar{\nu}(\nu)$-A scattering.

16

Hadron Energy Resolution and Three Flavor Neutrino Physics Analysis at INO-ICAL Detector

Author: Daljeet Kaur[1]

[1] *University Of Delhi*

Corresponding Author: daljeet.kaur97@gmail.com

The proposed detector for India-based Neutrino Observatory (INO) is a magnetized Iron Calorimeter (ICAL) consisting of Resistive Plate Chambers (RPC) as the active detector. The main purpose of ICAL detector is to study the neutrino physics. Determination of neutrino mass and mixing parameters is one of the important open challenge in
today ' s physics. The ICAL detector is designed to to perform these measurements. The detector will have a modular structure of total size 48m x 16m x 14.5m and consists of stack of 151 horizontal layers of 5.6 cm thick iron slab interleaved within 4 cm gap for the active detector element. The RPC ' s of dimension 2m x 2m will be used as an activedetector. The readout of the RPC ' s is through the external orthogonal copper pick up strips. This type of detector has good time resolution (1ns) and spatial resolution.
When cosmic rays interact with atmosphere it produces pions which then further decays into muons and corresponding neutrinos. These atmospheric neutrinos act as a source for the ICAL detector. Atmospheric neutrinos interaction with detector produces associated
leptons and hadronic shower. In order to get back the neutrino parameters we need to reconstruct the muons and hadrons with reasonable precision. Simulation studies has been carried out for finding the hadron energy resolution for INO-ICAL detector with the help of GEANT4 based simulation. Analysis has been done for Monte Carlo and NUANCE (neutrino generator) generated events at various direction and energy. Hadrons produces shower hits inside the active detector. The energy of hadrons can be reconstructed by taking these hits into account. Hit distribution for each energy and angle bin has been obtained and fitted with different distribution function and
it was observed that the hadron energy is proportional to the number of hits in an event.
Resolution of the detector based on this proportionality behavior has been obtained and different fitting function has been applied to calibrate the resolution as a function of energy.
Further, using the INO-ICAL detector resolutions, we have also performed two and three flavor neutrino oscillations studies for the precision measurement of neutrino oscillation parameters. From our analysis we have obtained the sensitivity of the ICAL detector for
the oscillation parameters. In the talk, we will present the results for the hadron energy resolution and the latest status on the oscillation parameter studies for the INO-ICAL detector.

17

Simulation Studies for Reconstructed Muon Energy and Direction Resolutions in the ICAL Detector

Authors: Animesh Chatterjee[1]; Kanishka Rawat[1]; Meghna K K[1]; Tarak Thakore[1]

[1] *RESEARCH SCHOLAR*

Corresponding Author: meghna_k_k@yahoo.co.in

The main goals of the proposed magnetized Iron Calorimeter (ICAL) detector at the India-based Neutrino Observatory(INO) are to make precision measurements of the atmospheric neutrino oscillation parameters and to determine neutrino mass hierarchy. Neutrinos interact with the the detector material via the charged current or the neutral current processes and produce leptons and hadrons. The ICAL detector is optimized primarily to measure the muon momentum and direction with good resolutions and efficiency. The charge,momentum and the direction of the muons can be determined by measuring its curvature as it passes through the magnetized volume of the detector. Here we present the simulation results for the muon energy resolution(σ_E), direction resolution($\sigma_{cos\ \theta}$), reconstruction efficiency(ϵ_R) and the charge identification efficiency(ϵ_C) for the current ICAL configuration with a magnetic field of about 1.5 T in the central region.

We have used a GEANT4 based simulation code developed by the INO collaboration for the detailed simulation of ICAL geometry and propagation of particles. This gives us the hit positions in the active detector as a particle propagates through the detector. A Kalman filter based algorithm is used to reconstruct the muon energy and the direction at the vertex. We propagate an ensemble of muons with fixed energy(E) and zenith angle(cos θ) through the detector in order to determine the resolutions and efficiencies. We have obtained the resolutions and efficiencies in the energy range 0.5-25 GeV and in the cos θ range [-1,1].

18

Conceptual Design of the CN2PY secondary beam line

Author: Philippe Velten[1]

[1] *CERN EN-STI*

Corresponding Author: philippe.velten@cern.ch

A design study for a long baseline neutrino oscillation experiment (LBNO) with a new conventional neutrino beam line facility (CN2PY) at CERN was initiated in September 2011, in the framework of the LAGUNA/LBNO EU/FP7 design study. The new beam and associated infrastructure will service a next generation deep-underground neutrino observatory located at the Pyhäsalmi (Finland) mine at a distance of 2300 km.
The present paper will review the main elements of the secondary beam line conceptual design, currently conducted at CERN with the FLUKA Monte Carlo simulation package. The simulation studies are employed at each stage of the secondary beam line design, from the early optimization of the focusing elements to compute the neutrino beam flux at the LAGUNA far detector, to the complete description of the facility for engineering driven studies and radio protection related issues. The baseline primary beam configuration foresees a first stage driven by an upgraded SPS running at 400 GeV/c - 750 kW beam power and a second stage driven by a new HP-PS machine, capable of delivering 50 GeV/c at 2 MW of beam power.
The challenges that this MW-class facility will have to face to provide a neutrino beam spectrum matching the experimental requirements for neutrino flavour oscillations and CP-violation will be explained. And finally, an outlook to the layout of the whole installation including the perspectives and design parameters for the high-power PS (HP-PS) machine will be discussed.

WG1 / 19

The Laguna-LBNO neutrino oscillation project: status and plan

Author: Alain Blondel[1]

[1] *DPNC UNiversity og Geneva*

Corresponding Author: alain.blondel@cern.ch

The LAGUNA-LBNO European design study aims at defining a deep underground neutrino observatory for the study of neutrino oscillations at long baselines, the investigation of the Grand Unification of elementary forces and for the detection of known and unknown astrophysical sources of neutrinos. For the neutrino oscillation studies, the project is specifically considering long baseline neutrino beams from CERN towards two possible far sites, Fréjus (130 km) and Pyhäsalmi (2300 km) with three detector technologies, Water Cherenkov, Liquid Scintillator and Liquid Argon.
The design study work findings and physics case led the consortium to select as a first priority option a very long baseline of 2300 km with a muti-GeV neutrino beam produced at CERN towards the Pyhäsalmi underground site and a large Liquid Argon TPC with double phase readout and a mass of 20 kton as a first phase. This LBNO setup allows for effectively measuring the oscillation patterns as a function of the energy over the first and the second maxima, assessing the neutrino oscillation phenomenology with an optimal sensitivity to the mass hierarchy determination and a competitive CP search reach.
A unique possibility of having a second neutrino beam from Protvino accelerator complex to Pyhäsalmi (1160 km) is also considered. The physics reach and performances of the neutrino detectors with the various neutrino beam options will be reviewed together with the LAGUNA-LBNO perspectives and status.

WG1 / 20

Studying Low Energy Neutrinos at the South Pole with the PINGU Detector

Author: Kenneth Clark[1]

[1] *University of Toronto*

Corresponding Author: kjc20@psu.edu

IceCube and its low energy extension DeepCore have been deployed at the South Pole and taking data since early 2011. DeepCore provides a neutrino energy threshold of about 10 GeV, which allows IceCube to access a rich variety of physics including indirectly searching for WIMP dark matter and studying atmospheric neutrinos. Currently under consideration is a new in-fill array named PINGU, which will continue to lower the threshold for neutrino detection. This new lower threshold opens up opportunities to explore a great deal of new physics, including the determination of the neutrino mass hierarchy. This talk will discuss the PINGU detector and the new physics it makes available with a focus on the hierarchy measurement.

WG2 / 21

Measurement of Neutrino-Induced Coherent Rho in High Resolution Neutrino Detectors

Author: Xinchun Tian[1]

[1] *U. of South Carolina*

Corresponding Author: tianxc@fnal.gov

Status and preliminary result of the Coherent-Rho production in NOMAD is presented. Prospect of future measurements and its implication is briefly described.

22

A 325 MHz Front End System for a Muon Accelerator

Author: David Neuffer[1]

[1] *Fermilab*

Corresponding Author: neuffer@fnal.gov

In previous versions, the muon front end was matched to 201.25 MHz, the baseline Fermilab Linac acceleration frequency. In this note we rematch the front end to 325 MHz, a baseline acceleration frequency for Project X. The rematch requires shorter, higher-gradient rf cavities, but results in a more compact and possibly more affordable system. We demonstrate that a 325 MHz system is possible with similar acceptance to that of the previous 201.25 MHz system. Matching into a neutrino factory or Muon Collider complete cooling channel is discussed.

23

A Staged Approach for Muon-based Facilities

Author: David Neuffer[1]

Co-authors: Jean-Pierre Delahaye [2]; Mark Palmer [1]

[1] *Fermilab*

[2] *SLAC*

Corresponding Author: neuffer@fnal.gov

We present a staged approach for muon based facilities for intensity and energy frontier science, building upon existing and proposed facilities at Fermilab. Each stage would provide both a project exploring new physics as well as provide an R&D platform to develop technology needed for following stages. The program could begin with nuSTORM, which would provide precision neutrino measurements while developing the technology of using and cooling muons. This could be followed by low-luminosity and higher-intensity stages of a neutrino factory that would use the enhanced intensity of stages of Project X and the LBNE detector facility for detailed exploration of neutrino properties, while establishing the technology of using intense bunched muon beams. This could be followed by muon colliders, starting at 125 GeV with measurements of the Higgs resonance at sub-MeV levels and continuing to multi-TeV Colliders for the exploration of physics beyond the standard model at the energy frontier.

24

Low Energy Muon Beams from the AP0 Target

Author: milorad popovic[1]

[1] *Fermilab*

Corresponding Author: popovic@fnal.gov

This note describes the possibility of extracting low energy pions/muons from the AP0 target without (or with very limited) degradation of the pion flux used by the Muon g-2 Experiment. The extracted beam will produce muons with momentum up to ~ 300 MeV/c. This beam can be used for muon cooling experiments and/or material science experiments.

WG2 / 25

Quasi-Elastic Neutrino and Anti-Neutrino Scattering in MINERvA

Author: Chris Marshall[1]

[1] *Univ. Rochester*

Corresponding Author: marshall@pas.rochester.edu

Quasi-elastic neutrino scattering is a valuable tool for determining the neutrino beam energy in oscillation experiments and provides a means of studying multi-nucleon final states. Disagreements exist between measurements for neutrino energies below 1 GeV on scintillator and those at higher energies. MINERvA (Main INjector Experiment for v-A) is a neutrino scattering experiment in the NuMI high intensity neutrino beam at Fermilab. MINERvA provides a bridge between the two regimes. We will present our first results for charged current quasi-elastic scattering for both neutrino and anti-neutrinos on scintillator.

WG2 / 26

Neutrino induced pion production in MINERvA

Author: Aaron Higuera[1]

[1] *Guanajuato University*

MINERvA is a few-GeV neutrino-nucleus scattering experiment located in the high intensity NuMI beam line at Fermilab. The goal of MINERvA is to make precise measurements of low energy neutrino interactions, both in support of neutrino oscillation experiments and as a pure weak probe of the nuclear medium. Employing a fine-grained, high resolution detector composed of plastic scintillator as well as carbon, iron and lead targets, MINERvA is well-suited to study inclusive and exclusive pion production channels. This presentation will focus on pion production from plastic scintillator.

WG2 / 27

Charged-current inclusive scattering in MINERvA

Author: Alessandro Bravar[1]

[1] *Univ. Geneva*

MINERvA is a few GeV neutrino-nucleus scattering experiment located in the high intensity NuMI beam line at Fermilab. MINERvA aims to make precision measurements of low energy neutrino interactions, both in support of neutrino oscillation experiments and as a pure weak probe of the nuclear medium. The experiment employs a fine-grained, high resolution detector. The active region is composed of plastic scintillator with additional targets of helium, carbon, iron, lead and water placed upstream of the active region. We present preliminary results for inclusive charged current cross sections on iron, lead and plastic targets.

28

Upgrade of the T2K magnetic horns for a high power beam beyond 1MW

Author: Tetsuro Sekiguchi[1]

[1] *KEK*

Corresponding Author: tetsuro.sekiguchi@kek.jp

T2K (Tokai to Kamioka) magnetic horn system in the J-PARC neutrino facility is designed for a 30GeV 750kW proton beam. The design current for the horns is 320kA (peak) with a half-sine wave (2-3msec). The horns are contained inside a large helium vessel and are operated in a helium atmosphere in order to reduce tritium and NOx productions.
The current horns have been used from 2009 and have been operated more than ten million pulses. The current achieved beam power is 230kW for T2K (the number of protons accelerated in a spill is 1.2x10^14). Major problems for 750kW beam are a hydrogen production and an insufficient stripline cooling, which limit the acceptable beam power to 400kW. We have been modifying the horns to solve the problems. The upgraded horns will be installed in this summer and summer in 2014. We describe the problems and the modifications in the upgraded horns.
We also describe the further upgrades for the beam power beyond 750kW in the near future.

29

The need for an early anti-neutrino run of NOνA

Author: Ushak Rahaman[1]

Co-authors: Suprabh Prakash [1]; Uma Sankar Sankhagiri [1]

[1] *IIT Bombay*

The moderately large value of θ_{13}, measured recently
by reactor experiments, is very welcome
news for upcoming accelerator experiments. In particular,
the NOνA experiment, with 3 years of ν run followed
by an equal $\bar{\nu}$ run, will be able to
determine the mass hierarchy if one of the following
two favorable combinations is true:
normal hierarchy with $-180° \leq$
$dcp \leq 0$ or
inverted hierarchy with $0 \leq$
$dcp \leq 180°$.
In this work, we study the hierarchy reach of the
first 3 years of NOνA data.
Since $\sin^2 2\theta_{23}$ is measured to be non-maximal,
θ_{23} can be either in the lower or higher octant.
The true octant of θ_{23} has a deep impact on the
hierarchy reach of early NOνA data.

With the present
uncertainty of 10% in $\sin^2 2\theta_{13}$,
equal 1.5 year ν and $\bar{\nu}$ runs have better
hierarchy determination capability compared to a
pure 3 year ν run. Daya Bay expects to reduce
the uncertainty in $\sin^2 2\theta_{13}$ to 5%. Such a
reduction improves the hierarchy reach of a 3 year
ν run for two of the four octant-hierarchy combinations,
but still fails to give any sensitivity for the other two.
However, equal 1.5 year ν and $\bar{\nu}$ runs have reasonable
hierarchy sensitivity for all four combinations.

WG2 / 30

Photon emission in (anti)neutrino neutron current interactions with nucleons and nuclei

Author: En Wang[1]

Co-authors: Juan Nieves [2]; Luis Alvarez Ruso [1]

[1] *IFIC, University of Valencia, Spain*

[2] *IFIC, Spain*

Corresponding Author: wangen@ific.uv.es

We report on the study of photon emission induced by E_nu ~ 1 GeV (anti)neutrino neutral current interactions with nucleons and nuclei. This process is an important background for nu_e appearance oscillation experiments. At the relevant energies, the reaction is dominated by the excitation of the Δ(1232) resonance, but there are also non-resonant contribution, that, close to threshold, are fully determined by the effective chiral Lagrangian of strong interactions. In addition, we also consider the heavier resonances contributions in high energy region. With our model, we predict the events number of photon emission of the NC interactions in the MiniBooNE experiments and T2K experiment.

31

Hadron energy resolution as a function of plate thickness and theta resolution of hadrons at the Iron Calorimeter Detector in India based Neutrino Observatory

Authors: Anushree Ghosh[1]; Daljeet Kaur[2]; LAKSHMI S MOHAN[3]; Moon Moon Devi[4]

[1] *Harishchandra Research Institute, Allahabad 211 002, India*

[2] *Department of Physics & Astrophysics, University of Delhi, Delhi 110 007, India*

[3] *INSTITUTE OF MATHEMATICAL SCIENCES , CHENNAI , INDIA*

[4] *Tata Institute of Fundamental Research, Mumbai 400005, India*

Corresponding Author: slakshmi@imsc.res.in

The study of atmospheric neutrinos is the primary goal of the proposed India based Neutrino Oservatory (INO), which will make use of a magnetized Iron CALorimeter (ICAL) for this purpose. ICAL is very sensitive to muons which leave clean tracks in the detector which can be studied to calculate the properties of the incident neutrinos which interacted with the iron target to created these muon tracks. These neutrinos not only produce muons, but hadrons also and determining the energy and

direction of hadrons produced in these neutrino interactions are very crucial in determining the energy and direction of the parent neutrino.
The thickness of the iron plate is a crucial factor in determining the hadron energy response in ICAL. The present study takes into account various plate thicknesses and studies the variation in hadron energy resolution as a function of plate thickness. Hadron energy response is found to be almost independent of the thickness in the energy range of interest for hadrons from atmospheric neutrinos, due to the presence of a constant residual resolution.

For the study of theta resolution of hadrons, we use three different methods called the centroid method, orientation matrix method and raw hit method. For 2 GeV pions the direction resolution using orientation matrix method is in the range $7^\circ - 12^\circ$, while for 5 GeV pions it is in the range $5^\circ - 8^\circ$ for different angular bins.
The resolution for the hadron shower produced in atmospheric neutrino events is worse by up to a factor of 2 (depending on incident direction) because there can be more than one hadron in each event.

Summary:

The energy resolution of hadrons as a funtion of iron plate thickness is studied for the proposed Iron CALorimeter (ICAL) detector to be situated at the India-based Neutrino Observatory (INO). Methods to reconstruct the hadron direction from the information obtained only as shower hits are also studied and various methods are compared.

32

The NuSTORM Facility-Muon Storage Ring and Injection

Author: David Neuffer[1]

Co-authors: Alan Bross [1]; Ao Liu [1]

[1] *Fermilab*

Corresponding Author: neuffer@fnal.gov

We present the design of a muon storage ring for a Neutrino source from a STORage ring for Muons (NuSTORM). In this facility a high-intensity proton beam produces ˜5 GeV pions that decay into muons that are captured in a ˜3.8 GeV/c racetrack storage ring. Muon decays in the long straight sections provide neutrino beams of precisely known flux and flavor that can be used for precision measurements. Design and simulation of the storage with calculations of injection and storage efficiency are presented.

WG2 / 33

Neutrino Scattering Measurements in the NOvA Experiment

Author: Jonathan Paley[1]

[1] *Argonne National Laboratory*

Corresponding Author: jpaley@anl.gov

The NuMI Off-Axis ν_e Appearance (\nova) experiment is a long-baseline neutrino oscillation experiment optimized for the measurement of $\nu_\mu \to \nu_e$ appearance. A prototype 220 ton liquid-scintillator tracking calorimeter near detector, built and operated on the surface, was exposed to the NuMI beam at Fermi National Laboratory. This detector was placed at a far off-axis angle of 106 mrad, where neutrinos above 1.5 GeV are predominantly born from kaons produced in the neutrino target. A 300

ton underground near detector, which will provide an opportunity for precise measurements of neutrino scattering off carbon nuclei, is currently under construction at Fermilab at a 14 mrad off-axis from the NuMI beam. This talk will provide an overview of the detectors and neutrino scattering analyses performed and expected in the future.

WG1 / **34**

Status of the NOvA Experiment

Author: Jonathan Paley[1]

[1] *Argonne National Laboratory*

Corresponding Author: jpaley@anl.gov

The NuMI Off-Axis ν_e Appearance (\nova) experiment, currently under construction, is a long-baseline neutrino oscillation experiment optimized for the measurement of $\nu_\mu \to \nu_e$ appearance. The experiment consists of two nearly identical fully-active liquid-scintillator tracking calorimeter detectors separated by 810 km and exposed to an upgraded 700 kW NuMI beam from Fermi National Laboratory. Goals of the experiment include measurements of θ_{13}, resolution of the neutrino mass hierarchy, measurement of the CP-violating angle δ_{CP}, and the octant of the θ_{23} mixing angle. This talk will provide an overview of the detectors, physics goals and sensitivities of the experiment, and a first look at commissioning data from the far detector.

WG2 / **35**

Measurement of Hadron Production Off the NuMI Target in the MIPP Experiment

Author: Jonathan Paley[1]

[1] *Argonne National Laboratory*

Corresponding Author: jpaley@anl.gov

The fixed-target Main Injector Particle Production (MIPP) Experiment was designed to produce large sets of hadron production data on variety of nuclear targets using a range of beam particles and momenta. The spectrometer has excellent momentum resolution, and particle identification is determined for particles ranging between 0.3 - 80 GeV/c using dE/dx, time-of-flight and Cherenkov radiation measurements. MIPP collected $\sim 1.6x10^6$ events of 120 GeV Main Injector protons striking a spare NuMI target. This talk will review the experimental setup, performance of the detectors, and preliminary results of the measurement of pion and Kaon yields from the NuMI target data.

WG1 / **36**

MIND: A Detector for Probing CP Violation at a Neutrino Factory.

Author: Ryan Bayes[1]

[1] *University of Glasgow*

Corresponding Author: ryan.bayes@glasgow.ac.uk

A neutrino factory provides a well defined neutrino beam with a wide range of oscillation channels for the direct detection of CP violation in the neutrino sector. To make use of this beam, a detector must have excellent charge discrimination capabilities because the un-oscillated background has the same flavour, but with the opposite charge to the signal. A magnetic field is required to achieve the required charge discrimination. The most reliable method for the generation of a magnetic field over a volume required for a neutrino factory experiment is using a Magnetized Iron Neutrino Detector (MIND). A detailed simulation of a MIND has been developed for the neutrino factory with advanced reconstruction and analysis software for the identification of muons resulting from the appearance of muon neutrinos from electron neutrino oscillations. The sensitivity of MIND at a neutrino factory to CP violating effects in this appearance oscillation is discussed, with consideration of systematic uncertainties. The combination of this detector concept at a neutrino factory provides the best sensitivity to CP violation of all possible future experiments and the best accuracy in the measurement of the CP violating phase delta.

WG1 / 37

Challenges in resolving neutrino mass hierarchy in medium-baseline reactor experiments

Author: Wei Wang[1]

[1] *William and Mary*

The value of the last mixing angle theta13 has been measured the Daya Bay Reactor Neutrino Experiment, followed by consistent results from RENO and Double Chooz. Its large value, compared with most speculated values before its discovery, creates a unique opportunity in resolving neutrino mass hierarchy (MH) using medium-baseline reactor antineutrino experiments employing massive liquid scintillator (LS) detectors like JUNO and RENO-50. Such medium-baseline reactor experiments have both the solar and the atmospheric oscillation signals presented in their data. Due to the nature of the MH signal in such experiments and the small ratio between the solar and the atmospheric mass-squared differences, we find the energy scale uncertainty places a challenge besides the well-known factors like energy resolution. Under a certain class of energy non-linearity biases allowed by its uncertainty, normal hierarchy (NH) and inverted hierarchy (IH) can exhibit similar oscillation patterns in a LS detector. To make such experiments successful in resolving neutrino MH with high confidences, energy scale uncertainty needs to be constrained well. In addition to the energy scale challenge, we also find that the MH determination confidence level and the so-called delta-chi-square obtained in model comparison follow a different relation from the conventional squared-root one. To reach the same confidence levels, compared with physics quantities whose measurements can be approximated by normal distributions, larger chi-square differences are needed.

38

Measurement of muon neutrino disappearance with NOvA

Author: Louise Suter[1]

[1] *Argonne National Lab*

Corresponding Author: lsuter@fnal.gov

The NOvA long-baseline neutrino experiment consists of two totally active, segmented, liquid scintillator detectors located 14 mrad off Fermilab's NuMI beam axis, with a Near Detector located at Fermilab, and a Far Detector 810 km away. The NOvA experiment will measure theta(23) and delta m^2_(32) through the observation of muon neutrino and muon antineutrino disappearance. The analysis techniques that have been developed to perform this measurement will be discussed, specifically the prediction of the Far Detector rates as determined from the observed Near Detector data. The expected sensitivity that can be achieved with these methods will also be presented.

39

Development of Six-Dimensional Helical Muon Beam Ionization Cooling Channel for Muon Colliders

Author: Katsuya Yonehara[1]

[1] *Fermilab*

Corresponding Author: yonehara@fnal.gov

Muon collider is a considerable candidate of the next-generation high-energy lepton collider machine. Six-dimensional (6D) muon beam ionization cooling channel is one of the most essential parts of the muon accelerator complex because the achievable luminosity is determined by its performance. Novel cooling concept was proposed to overcome several intrinsic issues of muon cooling. It consists of a helical dipole and solenoid magnetic components at the beam path to generate a continuous dispersion in a homogeneous ionization material. A helical quadrupole magnetic component is superimposed to stabilize a beam phase space. RF cavities are followed with a helical beam path to recover lost beam energy due to ionization process. The helical beam elements have been developed and verified experimentally for last decade. Recent research and development of the 6D helical cooling channel will be reviewed in this presentation.

40

PRISM system - status and challenges

Author: Jaroslaw Pasternak[1]

[1] *Imperial College London/RAL-STFC*

Corresponding Author: j.pasternak@imperial.ac.uk

The PRISM system was proposed to provide high intensity and high quality muon beams for next generation lepton flavour violation experiments. In PRISM such beams can be produced by sending a short proton pulse to a pion production target, capturing pions and performing RF phase rotation on the resulting muon beam in an FFAG ring. This paper presents the current status of the PRISM design obtained by the PRISM Task Force. The baseline design is reviewed and necessary modifications dictated by the injection/extraction are discussed. Several alternative designs for the PRISM FFAG ring are also presented and their performance compared to the baseline one. The status of the design of injection/extraction systems and matching to the solenoid channels upstream and downstream of the FFAG ring are presented. The feasibility of the construction of the PRISM system and its challenges are discussed.

41

The High-Power Target System for a Neutrino Factory/Muon Collider

Author: Kirk T McDonald[1]

[1] *Princeton University*

Corresponding Author: kirkmcd@princeton.edu

A Neutrino Factory based on muon beams and a Muon Collider both require an intense source of muons with similar parameters: collection of pions/muon of low energy and both signs from a multimegawatt proton beam with pulses at 10-100 Hz and only 2 ns duration. A Target System based on capture in a solenoid field (rather than a toroidal field) has been studied. An initial strong magnetic field followed by a lower field in the pion decay/muon bunching channel permits initial transverse cooling via longitudinal-transverse emittance exchange. Operation with a several megawatt proton beam favors use of a free-liquid-metal-jet target. Shielding of the superconducting solenoid coils from radiation damage leads to large coil dimensions, large stored energy, and substantial mass in the Target System. The present status of conceptual design of this challenging system will be presented.

42

Muon Analysis in the Peripheral Region of INO-ICAL

Author: Kanishka Rawat[1]

Co-authors: D Indumathi [2]; Vipin BHATNAGAR [1]

[1] *Panjab University, Chandigarh*

[2] *The Institute of Mathematical Sciences, Chennai-600113, India*

Corresponding Author: kanishka.rawat.phy@gmail.com

The proposed magnetised Iron Calorimeter (ICAL) detector at the India-based Neutrino Observatory aims in determining the neutrino oscillation parameters precisely with atmospheric muon neutrinos, matter effect in neutrino oscillations and to determine the sign of $\Delta m^2 32$ using the
matter effect. ICAL is mostly sensitive to atmospheric muon neutrinos, which are detected through their interaction with iron layers via charged-current (CC) and neutral-current (NC) interactions producing muons and hadrons. The most crucial part to determine the neutrino
oscillation paramaters is to determine the energy and direction of muons and hadrons. Muon momentum can be reconstructed through the curvature of their track whereas hadrons can be reconstructed through the shower produced by them. Here we present the preliminary results on muon momentum and angular resolution and momentum reconstruction and charge identification efficiencies in the peripheral region. The INO-ICAL detector simulation has been implemented in GEANT-4 framework. The softwares used for this purpose are: Geant4.9.4p02, inoical0_20112011
(with inhomogeneous magnetic field) (officially released version). Muons with fixed energy and direction are generated in the peripheral part of the detector where the magnetic field is rapidly changing in both magnitude and direction. The muons are reconstructed according to INOICAL code through a Kalman filter algorithm that returns both the magnitude and direction of the muon momentum. Selection criteria is applied to select muons whose track is closest to the vertex.
The results are analysed to obtain the resolution in both magnitude and direction (cosθ) of muons as a function of their energies. As anticipated, vertically passing muons are reconstructed better than those at larger angles because they traverse more layers. We find the quality of reconstruction worse than, but still comparable to the reconstruction of tracks produced in the central region of the ICAL detector where there is an almost constant and large magnetic field
of roughly 1.4T. This has implications for the fiducial volume of the detector as well as accuracy of reconstruction. The resolutions functions obtained in this manner have then been made available for analysis of physics processes with ICAL, for studying neutrino
oscillation phenomena.

43

The ESS neutrino super beam optimization design studies

Author: Nikolaos Vassilopoulos[1]

Co-authors: Eric Baussan [2]; Marcos Dracos [1]

[1] *IPHC, CNRS*

[2] *University of Strasbourg, IPHC*

Corresponding Author: nikolaos.vassilopoulos@iphc.cnrs.fr

The European Spallation Source (ESS) neutrino super beam has the prospective to become the world's most intense neutrino beam facility and has possibly the best physics potential for the discovery of leptonic CP-violation and neutrino mass hierarchy. The adaptation of the secondary-beam elements of CERN's SPL (Superconductive Proton Linac) neutrino super beam to ESS requirements is discussed in this presentation. Due to the higher power and lower energy of ESS linac compared to CERN's SPL, studies are performed to optimize the design of the target station including the target in order to achieve maximal pion yield, horn's inner conductor shape to best focus charged pions within the useful momentum range and shielding to reduce the amount of irradiation as well as the decay tunnel geometry. These studies are performed in order to examine the technical feasibility and assure the maximal physics potential for the ESS neutrino super beam.

44

Last results on tau CLFV and perspectives

Author: Chengping Shen[1]

[1] *Beihang University*

Corresponding Author: shencp@ihep.ac.cn

Searches for Charged Lepton Flavor Violation (CLFV) processes are powerful probes of physics beyond the Standard Model. In this report, we will review the latest lepton-flavor and lepton-number-violating τ decays at Belle, together with the comparison to other experiments' results. At the same time, we will investigate the physics accessible on CLFV in the coming Belle II experiment. We will learn what searches for CLFV have already told us, and examine the prospects for experiments and new facilities planned for the coming Belle II.

45

A new DC muon beam line at MuSIC

Author: Akira Sato[1]

[1] *Osaka University*

Corresponding Author: sato@phys.sci.osaka-u.ac.jp

The first muon source with a pion capture system was build at RCNP, Osaka University in 2009. We successfully demonstrated its beam performance to provide a high intense DC muon beam. In 2013, construction of a new beam line for the MuSIC muon beam will be started. The beam line is dedicated for muon science with a low intensity muon beam, such as muSR measurements and experiments with muonic X-rays. Design and status of the beam line will be described in this presentation.

46

muon g-2/EDM at J-PARC

Author: Tsutomu Mibe[1]

[1] *KEK*

Corresponding Author: mibe@post.kek.jp

A new measurement of the anomalous magnetic moment (g-2) and electric dipole moment (EDM) of the positive muon is proposed with a novel technique utilizing an ultra-cold muons accelerated to 300 MeV/c and a 66 cm-diameter compact muon storage ring without focusing-electric field. This measurement will be complementary to the previous BNL experiment and proposed continuation at FNAL with the muon beam at the magic momentum 3.1 GeV/c in a 14 m-diameter storage ring.

In this talk, I present overview of the experiment, and status including recent development on muon source as well as high rate silicon tracking detector.

48

Mu->3e at PSI

Author: Alessandro Bravar[1]

[1] *Universitè Geneve*

Submitted by WG4 conveners

49

Present status of J-PARC MUSE

Author: Koichiro Shimomura[1]

[1] *KEK*

Submitted by WG4 conveners

50

AlCap

Author: Yoshi Kuno[1]

[1] *Osaka U*

Submitted by WG4 conveners

51

Mu2E Extinction Systems

Author: peter kasper[1]

[1] *fermilab*

Corresponding Author: kasper@fnal.gov

The Mu2E experiment uses a bunched beam to eliminate prompt backgrounds. For this to work, the fraction of the beam arriving between bunches, the so-called extinction, must be less than 1.0E-10. In this talk we will describe our plans for achieving and monitoring extinction at this level of precision.

52

Acceleration Complex for NF-IDS

Author: Alex Bogacz[1]

[1] *Jefferson Lab*

Corresponding Author: bogacz@jlab.org

The new baseline to accelerate muons to 10 GeV is presented. It involves a single pass linac to 0.8 GeV, followed by 4.5-pass RLA to 2.8 GeV and finally another 4.5-pass RLA to 10 GeV. All linacs are based on 201 MHz SRF with different styles of cryo-modules. The accelerator complex assumes a horizontal in-plane layout of all tree components, with compact transfer lines (a double-arc chicane) in between. Linear lattices for all beam-lines are described.

53

Racetrack FFAG muon decay ring for NuStorm Project

Author: Jean-Baptiste lagrange[1]

Co-authors: Akira Sato [2]; Jaroslaw Pasternak [3]; Yoshiharu Mori [1]

[1] *Kyoto University Research Reactor Institute*

[2] *Osaka University*

[3] *Imperial College*

Corresponding Author: lagrange@rri.kyoto-u.ac.jp

The interest for NuStorm Project is growing recently for neutrino physics experiments as an early stage of Neutrino Factories. The facility requires a racetrack muon decay ring with both large transverse acceptance and large momentum acceptance. On the one hand, FODO lattices can achieve very large transverse acceptance, but natural chromaticity strongly limits the momentum acceptance, even for a few turns. On the other hand, zero-chromatic Fixed Field Alternating Gradient (FFAG) accelerators can achieve huge 6D acceptance, and recent developments made possible to design zero-chromatic racetrack FFAG lattices. Details of such an FFAG lattice for NuStorm are presented here.

54

CW muon beam acceleration with FFAG

Author: Yoshiharu Mori[1]

[1] *Kyoto University*

Corresponding Author: mori@rri.kyoto-u.ac.jp

Possibility of cw beam acceleration with scaling FFAGs is presented.

WG1 / 55

The neutrino mass hierarchy in KM3NeT - ORCA, a feasibility study.

Author: Thomas Eberl[1]

[1] *Erlangen Centre for Astroparticle Physics*

Corresponding Author: thomas.eberl@physik.uni-erlangen.de

The talk will present the current status of a dedicated feasibility study "Oscillation Research with Cosmics in the Abyss" (ORCA) to evaluate the potential of a neutrino mass hierarchy measurement with "phase 1" of KM3NeT, the future multi-km3 water Cherenkov neutrino telescope in the Mediterranean.

Summary:

After the successful measurement of the mixing angle θ13, the determination of the neutrino mass hierarchy (MH) has become a priority for future neutrino experiments. It has been proposed to perform such a measurement with atmospheric neutrinos and a megaton-scale water or ice Cherenkov detector. The highest sensitivity to the MH is obtained for neutrinos of 5-10 GeV which traverse the Earth at zenith angles of 30-60 degrees. ANTARES, a neutrino telescope in the Mediterranean Sea, designed to search for high-energetic astronomical neutrino signals, has recently demonstrated its ability to reliably measure neutrinos with energies as low as 20 GeV, a range where neutrino oscillations start to play a dominant role. KM3NeT will be the next generation neutrino telescope in the Mediterranean Sea with an effective volume of several cubic kilometers. Funds for "phase 1" of the project, corresponding to about 20% of the total envisaged budget, are meanwhile available. A dedicated feasibility study "Oscillation Research with Cosmics in the Abyss" (ORCA), to evaluate the potential of a mass hierarchy measurement with "phase 1" of KM3NeT is currently underway.
The talk will discuss the status and results of the current study into detector optimization and the feasibility of using KM3NeT technology to this end.

WG4 / 57

The MEG experiment status and upgrade

Corresponding Author: luca.galli@psi.ch

WG4 / 58

Muegamma search with converted photon

Corresponding Author: chcheng@hep.caltech.edu

WG4 / 59

The mu3e experiment

Corresponding Author: alessandro.bravar@unige.ch

WG4 / 60

g-2 at FNAL

WG4 / 61

Muon g-2/EDM at JPARC

Corresponding Author: mibe@post.kek.jp

WG4 / 62

Present status of J-PARC MUSE

Corresponding Author: ksimomu@post.kek.jp

WG4 / 63

Measurement of muonium HFS

Corresponding Author: tanaka@kaduo.jp

WG4 / 64

The MUSE experiment: simultaneous mu-p and e-p elastic scattering

Corresponding Author: briscoe@gwu.edu

WG4 / 65

The Mu2e experiment

Corresponding Author: zyou@uci.edu

WG4 / 66

The Mu2e extinction system

Corresponding Author: kasper@fnal.gov

WG4 / 67

COMET

Corresponding Author: yuany@ihep.ac.cn

WG4 / 68

Experimental Search for μ-e Conversion in Nuclear Field at J-PARC MLF H-Line

Corresponding Author: nakatsu@post.kek.jp

WG4 / 69

AlCap

Corresponding Author: kuno@phys.sci.osaka-u.ac.jp

WG4 / 70

Preparation for summary

WG1 / 71

Determination of the neutrino mass ordering by combining PINGU and Daya Bay II

Author: Mattias Blennow[1]

[1] *KTH Royal Institute of Technology*

Corresponding Author: emb@kth.se

To be supplied

WG1 / 72

Gain fractions of future neutrino oscillation facilities over T2K and NOvA

Author: Mattias Blennow[1]

[1] *KTH Royal Institute of Techology*

Corresponding Author: emb@kth.se

WG1 / 73

MINOS and MINOS+

Author: Joao Coelho[1]

[1] *Tufts University*

Corresponding Author: joao.coelho@tufts.edu

WG1 / 75

Resolving the octant of theta23 with T2K and NOvA

Author: Sanjib Kumar Agarwalla[1]

[1] *Institute of Physics, Bhubaneswar*

WG1 / 76

Status of the T2K Experiment

Author: Megan Friend[1]

[1] *KEK*

Corresponding Author: mfriend@post.kek.jp

WG1 / 77

ENuMI

Author: Karol Lang[1]

[1] *University of Texas at Austin*

Corresponding Author: lang@physics.utexas.edu

WG1 / 78

LBNE

Author: James Strait[1]

[1] *Fermilab*

Corresponding Author: strait@fnal.gov

WG1 / 79

ESS

Author: Marcos Dracos[1]

[1] *IPHC-IN2P3/CNRS*

Corresponding Author: marcos.dracos@in2p3.fr

82

Oscillation parameter predictions from symmetries

84

Q&A

Author: Paul Soler[1]

[1] *University of Glasgow*

Corresponding Author: paul.soler@glasgow.ac.uk

WG1 / 85

Determining the mass hierarchy from Supernovae

Author: Sovan Chakraborty[1]

[1] *Max-Planck Institute for Physics*

Corresponding Author: sovan@mpp.mpg.de

WG1 / 86

INO physics potential

Author: Sandhya Choubey[1]

[1] *Harish-Chandra Research Institute*

Corresponding Author: sandhya@hri.res.in

WG1 / 87

Determining neutrino masses from Cosmology

Author: Yvonne Wong[1]

[1] *UNSW*

Corresponding Author: yvonne.y.wong@unsw.edu.au

WG1 / 88

Status of neutrinoless double beta decay searches

Author: Liang Yang[1]

[1] *University of Illinois at Urbana-Champaign*

Corresponding Author: liangyg@illinois.edu

WG1 / 89

Sterile neutrino contribution to neutrinoless double beta decay

Author: Lopez Pavon Jacobo[1]

[1] *SISSA*

Corresponding Author: jlpavon@sissa.it

WG1 / 90

Systematic decomposition of the neutrinoless double beta decay operator

Author: Toshihiko Ota[1]

[1] *Saitama University*

Corresponding Author: toshi@mail.saitama-u.ac.jp

If the standard model is an effective model of a fundamental theory realized at high energy scales, the full Lagrangian that describes physics at the electroweak scale should contain the series of higher-dimensional operators whose mass dimensions are higher than four. Such effective interactions suppressed by the inverse power of new physics scale Λ_{NP} are typical low-energy remnant of new physics at high energy scales

In this talk, we focus on dim=9 operators which contribute to the neutrinoless double beta decay (0n2b) process. An interesting observation is that the next generation 0n2b experiments, which are aimed at discovering the effective neutrino mass of O(0.1) eV, are also sensitive to the dim=9 operators with $Lambda_{NP}$=O(1) TeV. With a list of the possible high-energy — TeV scale — completions of the effective dim=9 operators, we discuss the complementarity between the 0n2b signal and the LHC observables, and seek the relation between the dim=9 operators and the existent models, such as radiative neutrino mass models.

WG1 / 91

Sterile neutrino searches in the US

Author: Pavlovic Zarko[1]

[1] *LANL*

Corresponding Author: zarko@fnal.gov

WG1 / 92

Cosmological bounds on sterile neutrinos

Author: Maria Archidiacono[1]

[1] *Aarhus University*

Corresponding Author: archi@phys.au.dk

WG1 / 93

Sterile neutrino searches at J-PARC

Author: Takasumi Maruyama[1]

[1] *KEK*

Corresponding Author: takasumi.maruyama@kek.jp

WG1 / 94

Physics Performance of a Low-Luminosity Low Energy Neutrino Factory

Author: Pilar Coloma[1]

[1] *Center for Neutrino Physics at Virginia Tech*

Corresponding Author: pcoloma@vt.edu

J14 / 95

Neutrino and Muon physics connections

Corresponding Author: filipe.joaquim@ist.utl.pt

96

Neutrinos and cLFV

Corresponding Author: petcov@sissa.it

J14 / 97

Last results on tau cLFV and perspectives

Corresponding Author: shencp@ihep.ac.cn

J14 / 98

Muon Analysis in the peripheral region of INO-Cal

99

Post-Acceleration Study for Neutrino Super-beam at CSNS

Author: Wu Yang[1]

Co-author: Jingyu Tang [2]

[1] *McMaster University*

[2] *Institute of High Energy Physics*

A post-acceleration system based on the accelerators at CSNS (China Spallation Neutron Source) is proposed to build a super-beam facility for neutrino physics. Two post-acceleration schemes, one using superconducting dipole magnets in the main ring and the other using room-temperature magnets have been studied, both to achieve the final proton energy of 128 GeV and the beam power of 4 MW by taking 10% of the CSNS beam from the neutron source. The main design features and the comparison for the two schemes are presented. The CSNS super-beam facility will be very competitive in long-baseline neutrino physics studies, compared with other super-beam facilities proposed in the world.

100

Studies on new, high-performance, 6-Dimensional ionization cooling lattices for Muon Accelerators

Author: Diktys Stratakis[1]

Co-authors: J. Scott Berg [1]; Richard Fernow [1]; Robert Palmer [1]

[1] *Brookhaven National Laboratory*

An ionization cooling channel is a tightly spaced lattice containing absorbers for reducing the momentum of the muon beam, rf cavities for restoring the longitudinal momentum and solenoids for focusing the beam. Such a lattice is an essential step for a Muon Collider. Here, we explore two different schemes for designing ionization cooling channels for muon related applications. The first is an upward helical lattice commonly known as the Guggenheim channel. The second is a novel linear channel with either wedge or block absorbers for cooling and tilted solenoids for emittance exchange. The latter scheme addresses several of the engineering challenges of a conventional Guggenheim channel. We incorporate both schemes into a new lattice design for a muon collider, and examine their performance numerically. We optimize the designs and compare the conductor current densities requirements for all of the simulated scenarios.

WG1 / 101

T2HK

Author: Taku Ishida[1]

[1] *J-PARC Center/KEK*

Corresponding Author: taku.ishida@kek.jp

WG1-WG2 Joint Session / 102

NOvA

Corresponding Author: jpaley@anl.gov

WG1-WG2 Joint Session / 103

T2K

Corresponding Author: a.kaboth@imperial.ac.uk

WG1-WG2 Joint Session / 104

MINERvA

Corresponding Author: steven.manly@rochester.edu

WG1-WG2 Joint Session / 105

Discussion

Corresponding Author: pahuber@vt.edu

WG1 / 106

Double Chooz recent results

Author: Ralitsa Sharankova[1]

[1] *Tokyo Institute of Technology*

Corresponding Author: sharankova@hep.phys.titech.ac.jp

WG3 / 107

Neutrinos from ESS: Source, Linac upgrade and Accumulator

Corresponding Author: marcos.dracos@in2p3.fr

WG3 / 108

The ESS neutrino super beam optimization design studies

Corresponding Author: nikolaos.vassilopoulos@iphc.cnrs.fr

WG3 / 109

Conceptual Design of the CN2PY secondary beam line

Corresponding Author: philippe.velten@cern.ch

WG3 / 110

Discussion

WG3 / 111

Upgrade of the T2K magnetic horns for a high power beam beyond 1MW

Corresponding Author: tetsuro.sekiguchi@kek.jp

WG3 / 112

Studies Progress of the High Intensity H2+ Cyclotrons for DAEδALUS and IsoDAR Projects

Corresponding Author: yangjianjun2000@tsinghua.org.cn

WG3 / 113

The High-Power Target System for a Neutrino Factory/Muon Collider

Corresponding Author: kirkmcd@princeton.edu

WG3 / 114

Optimized capture section for staged Neutrino Factory target designs

Corresponding Author: hsayed@bnl.gov

The Neutrino Factory 4MW target system is optimized to increase the captured muon count that fits within the acceptance of the subsequent acceleration section. A proposed staged Neutrino Factory, producing lower muon intensities of 10ˆ20 muons per year assumes a 1 MW target station. The proton driver of the scaled down target station has a lower intensity and lower energy (3 GeV) which could be upgraded to the full power of 4 MW. In this work we present an optimized capture mechanism for both the baseline 8 GeV proton beam target and the 3GeV proton beam target. The capture section and the following bunching channel design are optimized to adapt for both cases.

WG3 / 115

Report on Accelerator Studies of IDS-NF

Corresponding Author: bogacz@jlab.org

WG3 / 116

A 325 MHz Front End System for a Muon Accelerator

Corresponding Author: neuffer@fnal.gov

J34 / 117

Results from Step I of MICE and the Physics Plan for Step IV

Corresponding Author: adey@fnal.gov

J34 / 118

Progress towards completion of the MICE demonstration of ionisation cooling of muons

Corresponding Author: kaplan@iit.edu

J34 / 119

A Staged Approach for Muon-based Facilities

Corresponding Author: neuffer@fnal.gov

WG3 / 120

The NuSTORM Facility-Muon Storage Ring and Injection

Corresponding Author: neuffer@fnal.gov

WG3 / 121

Racetrack FFAG decay ring for the nuSTORM

Corresponding Author: lagrange@rri.kyoto-u.ac.jp

WG3 / 122

nuSTORM siting at Fermilab

Corresponding Authors: bross@fnal.gov, adey@fnal.gov

WG3 / 123

Discussion

WG3 / 124

Post-Acceleration Study for Neutrino Super-beam at CNSN

Corresponding Author: wuy755@gmail.com

WG3 / 125

CW Superconducting Linac as the Proton Driver for a Medium Baseline Superbeam

Corresponding Author: lizhihui@ihep.ac.cn

WG3 / 126

Discussion

J34 / 127

Vacuum rf 6D cooling lattices

Corresponding Author: palmer@bnl.gov

J34 / 128

Studies of New, High Performance, 6D Ionization Cooling Lattices for the Muon Accelerators

Corresponding Author: diktys@bnl.gov

J34 / 129

Development of Six-Dimensional Helical Muon Beam Ionization Cooling Channel for Muon Colliders

Corresponding Authors: yonehara@fnal.gov, popovic@fnal.gov

J34 / 130

A New DC Muon Beam Line at MuSIC

Corresponding Author: sato@phys.sci.osaka-u.ac.jp

J34 / 131

PRISM system - status and challenges

Corresponding Author: j.pasternak@imperial.ac.uk

132

CW muon beam acceleration with FFAG

Corresponding Author: mori@rri.kyoto-u.ac.jp

J34 / 133

Low Energy Muon Beams from the AP0 Target

Corresponding Author: popovic@fnal.gov

WG3 / 134

WG3 final discussion and summary preparation

WG3 / 135

WG3 final discussion and summary preparation II

136

nuSTORM siting at Fermilab

Author: Alan Bross[1]

[1] *Fermi National Accelerator Laboratory*

The Fermilab Engineering Services Section (FESS) has produced a Project Definition Report that details how nuSTORM could
be constructed at Fermilab. This talk will describe the conclusions of the report and will cover the proton beam line, target station,
pion transport line, decay ring, near detector hall and far detector hall.

137

Vacuum rf 6D cooling lattices

Author: Robert Palmer[1]

[1] *Brookhaven National Laboratory*

Vacuum rf 6D cooling lattices will be reviewed, including FOFO, RFOFOs (Ring, Guggenheim and Balbekov), Helical Snake, and Planar Snake. Advantages and disadvantages of each will be discussed.

WG2 / 138

CC cross section measurements at T2K

Corresponding Author: d.r.hadley@warwick.ac.uk

WG2 / 139

CCQE measurement from MINOS

Corresponding Author: ngraf@iit.edu

WG2 / 140

MiniBooNE cross section results

Corresponding Author: zarko@fnal.gov

WG2 / 141

QE scattering, 2p2h and nu energy reconstruction

Corresponding Author: jmnieves@ific.uv.es

WG2 / 142

Radiative corrections in CCQE neutrino-nucelon interactions

Corresponding Author: krzysztof.graczyk@ift.uni.wroc.pl

WG2 / 143

NC measurements at T2K

Corresponding Author: daniel.ruterbories@colostate.edu

WG2 / 144

The nuSTORM Neutrino Scattering Program

Corresponding Author: morfin@fnal.gov

WG2 / 145

Weak pion production

Corresponding Author: gajatee@usal.es

WG2 / 146

Pion and photon emission in effective filed theory for nuclei

Corresponding Author: zhangx4@ohio.edu

WG2 / 147

Neutrino induced meson production in the forward limit

Corresponding Author: sxnakamura@gmail.com

WG2 / 148

Weak strangeness and eta production

Corresponding Author: rafi.alam.amu@gmail.com

149

SciBooNE coherent pion production

Corresponding Author: masashi@phys.s.u-tokyo.ac.jp

WG2 / 150

Coherent Rho0 Measurement in Neutral Current Interaction

Corresponding Author: duyang@physics.sc.edu

This talk will be devoted to the precision measurements of Coherent-Rho0 production in neutrino neutral current scattering. The new results from the NOMAD data will be presented, which shows the first observation of Coherent-Rho0. Future prospects of such measurements in the proposed high-resolution LBNE-ND will be outlined.

WG2 / 151

MicroBooNE: prospects for making the first neutrino interaction measurements on argon at low energy

Corresponding Author: stjohn@fnal.gov

WG2 / 152

CAPTAIN: Cryogenic Apparatus for Precision Tests of Argo Interactions with Neutrinos

Corresponding Author: cetaylor@lanl.gov

WG2 / 153

CLAS 1pi analysis

Corresponding Author: steven.manly@rochester.edu

WG2 / 154

DUET: pi+ carbon absorption+charge exchange cross section

Corresponding Author: elder@yorku.ca

WG2 / 155

Nuclear dependence in weak structure functions and the determination of the weak angle

Corresponding Author: sajathar@gmail.com

WG2 / 156

Update on the CTEQ nPDF Analysis

Corresponding Author: morfin@fnal.gov

WG1 / 157

Summary preparation

Plenary session #1, Chair: David Wark / 158

Welcome - IHEP

Plenary session #1, Chair: David Wark / 159

Neutrinos and Flavor Puzzle

Plenary session #1, Chair: David Wark / 160

Impacts of precision measurement of neutrino mixing parameters

Corresponding Author: pahuber@vt.edu

Plenary session #1, Chair: David Wark / 161

Cosmological measurements of neutrino properties

Plenary session #2, Chair:James Strait / 162

Summary of US Snowmass 2013 meeting

Corresponding Author: degouvea@northwestern.edu

Plenary session #2, Chair:James Strait / 163

European neutrino physics plan

Corresponding Author: mezzetto@pd.infn.it

Plenary session #2, Chair:James Strait / 164

Performance on CPV and MH of near future accelerator projects.

Corresponding Author: nakadair@neutrino.kek.jp

Plenary session #2, Chair:James Strait / 165

Performance on CPV and MH of long term accelerator projects

Corresponding Author: k.long@imperial.ac.uk

Plenary session #3, Chair:Vittorio Palladino / 166

Overview of high-power proton drivers

Corresponding Author: j.pasternak@imperial.ac.uk

Plenary session #3, Chair:Vittorio Palladino / 167

Technological Challenges for Future Superbeams

Corresponding Author: marco.zito@cea.fr

Plenary session #3, Chair:Vittorio Palladino / 168

Multiple-Megawatt targets for neutrino beams

Corresponding Author: chris.densham@stfc.ac.uk

Plenary session #4, Chair:Alex Bogacz / 169

R&D efforts for Neutrino Factory

Corresponding Authors: kaplan@iit.edu, mszisman@lbl.gov

Plenary session #3, Chair:Vittorio Palladino / 170

A medium-baseline neutrino facility

Corresponding Author: tangjy@ihep.ac.cn

Plenary session #5, Chair: Akira Sato / 171

Future Muon Accelerators

Corresponding Author: mapalmer@fnal.gov

Plenary session #5, Chair: Akira Sato / 172

MASS: Muon Accelerator Staging Scenario

Corresponding Author: jean-pierre.delahaye@cern.ch

Plenary session #5, Chair: Akira Sato / 173

Theory overview on muon physics

Corresponding Author: lcalibbi@ulb.ac.be

Plenary session #5, Chair: Akira Sato / 174

Lepton flavor physics with muon beam

Corresponding Author: satoshi.mihara@kek.jp

Plenary session #6, Chair: Alexandre Sousa / 175

Future Atmospheric Neutrino Experiments

Corresponding Author: nkm@tifr.res.in

Plenary session #6, Chair: Alexandre Sousa / 176

Recent reactor experimental results

Corresponding Author: kettell@bnl.gov

Plenary session #6, Chair: Alexandre Sousa / 177

Future reactor experiments

Corresponding Author: hem@ihep.ac.cn

Plenary session #6, Chair: Alexandre Sousa / 178

Sterile neutrino status

Corresponding Author: giunti.carlo@gmail.com

Plenary session #7, Chair: Juan Nieves / 179

Experimental overview on neutrino-nucleon scattering

Corresponding Author: dwschmitz@uchicago.edu

Plenary session #7, Chair: Juan Nieves / 180

Theory overview on neutrino-nucleon scattering

Corresponding Author: jsobczyk@ift.uni.wroc.pl

Plenary session #7, Chair: Juan Nieves / 181

Effects of cross sections and nuclear effects on oscillation analyses

Corresponding Author: pcoloma@vt.edu

Plenary session #8, Chair: Yoshitaka Kuno / 182

nuSTORM

Corresponding Author: bross@fnal.gov

Plenary session #8, Chair: Yoshitaka Kuno / 183

A final report of IDS-NF

Corresponding Author: paul.soler@glasgow.ac.uk

Plenary session #8, Chair: Yoshitaka Kuno / 184

WG1 - Summary Report

Plenary session #9, Chair: TBA / 185

WG2 - Summary Report

Plenary session #9, Chair: TBA / 186

WG3 - Summary Report

Plenary session #9, Chair: TBA / 187

WG4 - Summary Report

Plenary session #9, Chair: TBA / 188

Workshop Summary Talk

Corresponding Author: lang@physics.utexas.edu

WG1 / 190

Anarchy, neutrinoless double beta decay and leptogenesis

Author: Xiaochuan Lu[1]

[1] *UC Berkeley*

Corresponding Author: luxiaochuan123456@gmail.com

WG1 / 191

Daya Bay recent results

Author: Soeren Jetter[1]

[1] *IHEP*

Corresponding Author: jetter@ihep.ac.cn

WG1 / 192

ICARUS status and results

Author: paola sala[1]

[1] *INFN Milano*

Corresponding Author: paola.sala@cern.ch

J34 / 193

Discussion

Plenary session #4, Chair:Alex Bogacz / 194

Introduction of WG1: Neutrino oscillation

Author: Alexandre Sousa[1]

[1] *University of Cincinnati*

Corresponding Author: alex.sousa@uc.edu

Plenary session #4, Chair:Alex Bogacz / 195

Introduction of WG2: Neutrino scattering physics

Plenary session #4, Chair:Alex Bogacz / 196

Introduction of WG3: Accelerator physics

Plenary session #4, Chair:Alex Bogacz / 197

Introduction of WG4: Muon physics

Corresponding Author: giovanni.signorelli@pi.infn.it

WG1 / 198

Oscillations and decoherence

Corresponding Author: kirkmcd@princeton.edu