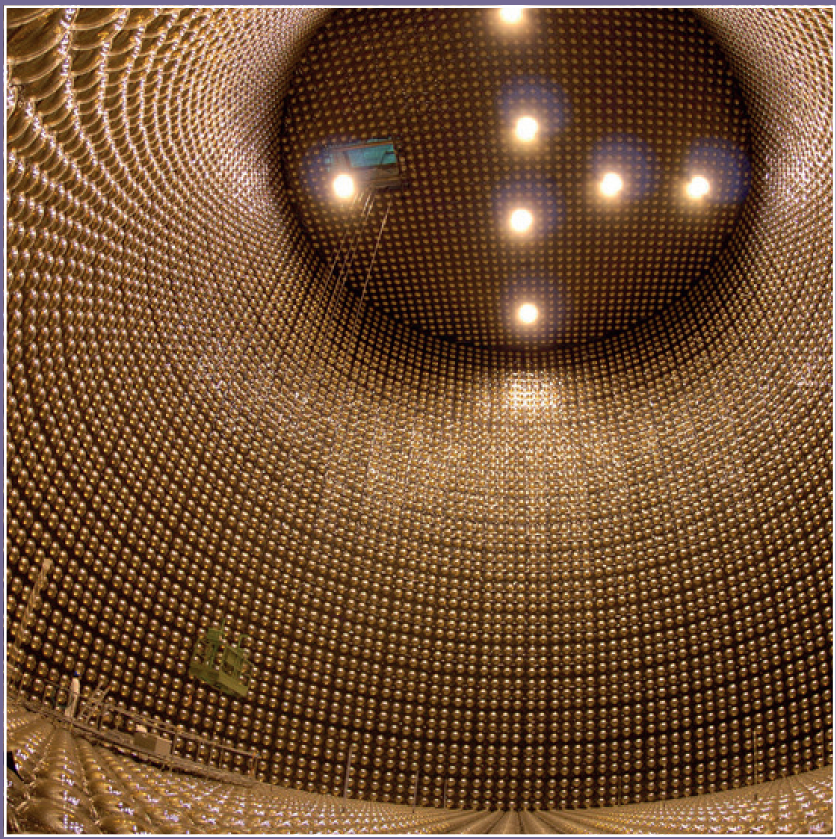
Programme and Abstract Book



International Workshop on Next Generation Nucleon Decay and Neutrino Detectors (NNN17)

26–28 October 2017
University of Warwick, UK

http://nnn2017.iopconfs.org

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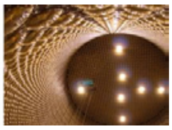
IOP Institute of Physics



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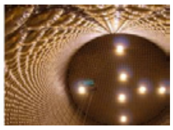


Programme

Thursday 26th October

09:00 **Conference opening**
Gary Barker, University of Warwick, UK

09:05 **Welcome**
Pam Thomas, Warwick Pro-Vice Chancellor for Research, UK

Session 1 - Nucleon decay and neutrino theoretical reviews
Chair: Paul Harrison, University of Warwick, UK

09:20 **Baryon-number violating nucleon decay**
Junji Hisano, Nagoya University, Japan

09:50 **Theoretical overview of neutrino oscillations in the standard 3 neutrino framework**
Jacobo Lopez-Pavon, Conseil Européen pour la Recherche Nucléaire (CERN), Switzerland

10:20 **Overview of neutrino-nucleus interaction physics**
Callum Wilkinson, Albert Einstein Center for Fundamental Physics (AEC), University of Bern (BERN), Switzerland

10:50 **Coffee break**

11:20 **Review of eV-Scale sterile neutrino physics**
Thomas Schwetz, Karlsruhe Institute of Technology, Germany

11:50 **Supernova neutrino production**
Evan O'Connor, Stockholm University, Sweden

12:20 **Neutrinoless double beta decay: motivations, expectations, uncertainties**
Francesco Vissani, National Institute for Nuclear Physics (INFN), Gran Sasso Laboratory, Italy

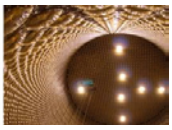
13:00 **Lunch**

Session 2 - Detectors
Chair: Yury Kudenko, Institute for Nuclear Research, (INR), Russia

14:00 **JUNO: Recent progress in detector R&D**
Zhonghua Qin, Institute of High Energy Physics (IHEP), China

14:21 **R&D for the short baseline near detector (SBND) at FNAL**
Joleen Pater, The University of Manchester, UK

14:42 **The DUNE near detector**
Jonathan Asaadi, University of Texas Arlington, United States



15:03 **Status of single phase and dual phase DUNE protodectors at CERN**
Laura Molina Bueno, ETH Zurich, Switzerland

15:24 **R&D towards a High Pressure Gas TPC**
Morgan Wascko, Imperial College, UK

15:45 **Coffee break**

16:15 **Upgrade of the T2K near detector for T2K-II and hyper-kamiokande**
Benjamin Quilain, Laboratoire Leprince-Ringuet (LLR), France

16:36 **Gd loaded SuperK: status and plan**
Yasuhiro Nakajima, ICRR, the University of Tokyo, Japan

16:57 **In search of sterile neutrinos: status of the SoLid experiment**
Simon Vercaemer, Vrije Universiteit Brussel, Belgium

17:18 **The PTOLEMY experiment: towards cosmic neutrino background detection**
Alfredo Cocco, National Institute for Nuclear Physics (INFN), Gran Sasso Laboratory, Italy

17:39 **Status of CONNIE coherent neutrino detection experiment**
Ben Kilminster, University of Zurich, Switzerland

18:00 **Reception and Poster Session**

Session 2 - Sensors/electronics/DAQ/software
Chair: Yasuhiro Nishimura, The Institute for Cosmic Ray Research (ICCR), Japan

14:00 **Event reconstruction techniques for liquid Argon neutrino detectors**
Andy Blake, Lancaster University, UK

14:25 **Electronics and DAQ for liquid argon detectors**
Jose Ignacio Crespo-Anadón, Columbia University Nevis Laboratories, United States

14:50 **Hyper-K electronics/DAQ/sim/recon**
Helen O'Keeffe Lancaster University, UK

15:25 **IceCube and KM3NeT DOM electronics**
Carlos Mollo, National Institute for Nuclear Physics (INFN), Gran Sasso Laboratory, Italy

15:50 **Coffee break**

16:20 **Development of large area picosecond photo-detectors (LAPPDs) and first use in particle physics experiments**
Matthew Malek, University of Sheffield, UK

16:45 **Deep convolutional neural network applications in the NOvA Experiment**
Ryan Murphy, Indiana University Bloomington, United States

17:10 **Superconducting tunnel junction detectors**
Yuji Takeuchi, University of Tsukuba, Japan

17:35 **GPU in modern detectors**
Federico Nova, Rutherford Appleton Laboratory (RAL), UK

18:00 **Reception and Poster Session**

Friday 27th October

Session 3 - Running neutrino oscillation projects
Chair: Laura Kormos, Lancaster University, UK

08:30 **NOvA: latest results and future plans**
Evan Niner, Fermilab (FNAL), United States

08:55 **T2K: latest results and future Plans**
Helen O'Keeffe Lancaster University, UK

09:20 **Overview of reactor neutrinos**
Miao He, Institute of High Energy Physics, China

09:45 **Latest results from double chooz**
Jaime Dawson, Laboratoire Astro Particule et Cosmologie, France

10:05 **Global analysis of neutrino mixing parameters: recent results and prospects**
Francesco Capozzi, The Ohio State University, United States

10:30 **Coffee break**

Session 4 - Results from other running experiments
Chair: Yorck Ramachers, University of Warwick, UK

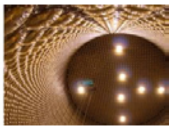
10:45 **Recent results from NA62 on heavy neutrino searches from k-decays**
Viacheslav Duk, University of Birmingham, UK

11:10 **MicroBooNE first results and the prospect of the SBN program**
Joseph Zennamo, University of Chicago, United States

11:35 **Status of the neutrinoless double beta decay programme**
Stefano Dell'Oro, Virginia Tech, United States

12:00 **Neutrino physics with dark matter detectors**
Marco Selvi, University of Bologna, Italy

12:30 **Lunch**



Session 5 - Future neutrino experiments
Chair: Chang-Kee Jung, Stony Brook University, United States

14:00 **Status of the Hyper-K experiment**
Itaru Shimizu, Tohoku University, Japan

14:25 **Status of DUNE experiment**
Dorota Stefan, Conseil Européen pour la Recherche Nucléaire (CERN), Switzerland

14:50 **Status/potential of Jinping**
Qian Liu, University of Chinese Academy of Sciences (UCAS), Chin

15:15 **Indirect neutrino mass determination using cosmological surveys**
Marilena Loverde, State University of New York Stony Brook, United States

15:45 **Coffee break**

16:15 **Solar+SN neutrinos: detection methods and prospects**
Shirley Li, The Ohio State University (OSU), United States

16:40 **Status of KM3Net/ORCA**
Paschal Coyle, Centre de physique des particules de Marseille (CPPM), France

17:05 **Neutrino oscillation physics with IceCube (now) and PINGU (next generation)**
Jason Koskinen, Neils Bohr International Academy, University of Copenhagen, Denmark

17:30 **SHiP (Search for Hidden Particles at CERN): status and physics prospects**
Anne-Marie Magnan, Imperial College London, UK

Saturday 27th October

Session 6 - Neutrino facilities
Chair: Alfons Weber, STFC-RAL, UK

08.30 **MW neutrino targets for LBNF/JPARC**
Chris Densham, Rutherford Appleton Laboratory (RAL), UK

08.55 **To a megawatt and beyond: accelerators for high power neutrino beams**
Phil Adamson, Fermilab (FNAL), United States

09.20 **Engineering challenges for underground projects**
Shoei Nakayama, Institute for Cosmic Ray Research (ICRR), University of Tokyo, Japan

09.45 **The ESSnuSB project and neutrino CP violation**
Marcos Dracos, University of Strasbourg, France

10.15 **Coffee break**

Closing session
Chair: Gary Barker, University of Warwick, UK

10.45 **Poster winner talks**

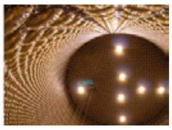
11.00 **Summary of parallel session 1**
Zhimin Wang, Institute of High Energy Physics (IHEP), China

11.35 **Summary of parallel session 2**
Matt Wetstein, Iowa State University, United States

12.10 **Advertisement for NNN'18**
Akira Konaka, TRIUMF via video link

12.20 **Closing remarks and close of the workshop**
Stefan Soldner-Rembold, University of Manchester, UK

12.45 **Lunch**



Poster Programme

P1. Pre-supernova neutrino signal - 10 years of progress in modelling
Andrzej Odrzywolek, Jagiellonian University, Poland

P2. Solar neutrino measurements at Super-Kamiokande
Yasuhiro Nakajima, The University of Tokyo, Japan

P3. The large enriched germanium experiment for neutrinoless double beta decay (LEGEND)
Yoann Kermaidic, Max Planck Institute fur Kernphysik, Germany

P4. Detector design considerations for the WATCHMAN detector
Tom Marshall, AWE PLC for the WATCHMAN collaboration, UK

P5. ARIADNE: a photographic 1-ton two-phase liquid argon detector
Jared Vann, University of Liverpool, UK

P6. Low energy event reconstruction for the E61 detector
Mahdi Taani, University of Edinburgh, UK

P7. A study of charged kaon-nucleon total interaction cross section in liquid argon
Elena Gramellini, Yale University, USA

P8. The CERN neutrino platform
Nektarios Benekos, CERN, Switzerland

P9. Dynamics of the positive ions in large scale liquid argon detectors and electron signal quenching
Roberto Santorelli, CIEMAT, Spain

P10. The upgrade project of the T2K near detector
Marco Zito, CEA-Saclay, France

P11. A “nu” look at gravitational waves: The black hole birth rate from neutrinos combined with LIGO
Jonathan Davis, Kings College London, UK

Session 1 - Nucleon Decay and Neutrino Theoretical reviews

Baryon-number violating nucleon decay

J Hisano

Nagoya University, Japan

Baryon-number violating nucleon decay is sensitive to new physics at high energy scale, which we cannot reach to by accelerator physics, such as GUTs. In this talk baryon-number violating nucleon decay is reviewed from theoretical points of view.

Theoretical review of neutrino oscillations (in standard 3-flavour framework)

J Lopez-Pavon

Conseil Européen pour la Recherche Nucléaire (CERN), Switzerland

In the last decade, the observation of neutrinos produced in nuclear plants, particle accelerators, inside the Sun and in the atmosphere allowed us to measure most of the light neutrino mixing parameters. Near future measurements will give us extremely valuable information about the remaining unknowns of the light neutrino sector as fundamental as the existence of leptonic CP violation. I will review why these measurements are physically very relevant and the main strategies to follow in order to pursue this goal. In particular, the measurement 5 years ago of a "large" theta13 has important implications for the future searches of the neutrino mass hierarchy and CP-violation, which I will discuss. Neutrino oscillation experiments might also be an interesting tool to search for deviations from the standard 3-neutrino mixing scenario. At the end of the talk, I will also briefly discuss the potential of future facilities to look for well-motivated new physics signals.

Overview of neutrino-nucleus interaction physics

C Wilkinson

University of Bern, Switzerland

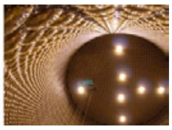
Current and planned neutrino oscillation experiments operate in the 0.1-10 GeV energy regime and use a variety of nuclear targets. At these energies, the neutrino cross section is not well understood: a variety of interaction processes are possible and nuclear effects play a significant role. This talk will review the status of neutrino-nucleus interactions, with a particular focus on the issues which are most relevant for current and future neutrino oscillation experiments, and will discuss prospects for the future.

Review of eV-Scale sterile neutrino physics

T Schwetz

Karlsruhe Institute of Technology, Germany

I review the status of a possible explanation of various neutrino anomalies in terms of sterile neutrino oscillations at the eV scale. Emphasis is given on recent developments regarding reactor neutrinos as well as other recent constraints on mixing with eV-scale neutrino mass states. We argue that a sterile neutrino explanation of the reactor anti-neutrino and Gallium anomalies is viable, but it gets exceedingly difficult to explain the LSND anomaly in this framework.



Supernova neutrino production

E O'Connor

Stockholm University, Sweden

Core-collapse supernovae are extreme astrophysical events. They mark the end point of a massive star's life. The energy for driving these explosions is sourced from the gravitational binding energy released when the iron core collapse to a neutron star. This process ultimately releases a few times 10^{53} ergs of energy. A small fraction of this goes into powering the explosion (where neutrinos also play an important role), unbinding all of the matter outside of the newly formed neutron star, and producing photons that give the bright optical display. However, the majority of the binding energy released is radiated in neutrinos. Neutrinos are by far the dominant process by which the protoneutron star cools in the first 10s of seconds. In this talk I will describe the neutrino production processes and expected neutrino signals at various stages of a core-collapse supernovae, including the pre-collapse, collapse, bounce, accretion, and cooling phases. I will also highlight the important role we believe neutrinos play in powering the explosion. I will also briefly mention the neutrino signal expected from other types of supernovae, for which next generation neutrino detectors may be sensitive to for a galactic event.

Neutrinoless double beta decay: motivations, expectations, uncertainties

F Vissani

National Institute for Nuclear Physics (INFN), Italy

The reasons of the interest toward the "neutrinoless double beta decay" and the key importance of this transition in the search for physics beyond the standard model are discussed. Expectations for the transition rate are examined, in the assumption that ordinary neutrinos have Majorana masses. The great relevance of cosmological measurements is demonstrated and the uncertainties attributable to nuclear physics are examined. [Talk based on the review article, Adv.High Energy Phys. 2016 (2016) 2162659]

Session 2 – Parallel Session: Detectors

JUNO: Recent progress in detector R&D

Z Qin

Institute of High Energy Physics (IHEP), China

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment. The primary goal is to determine the neutrino mass hierarchy and precisely measure the oscillation parameters by reactor anti-neutrinos. To meet the physics goal, JUNO detector requires an energy resolution of 3% @ 1MeV. The detector is currently under R&D stage, which includes the central detector, the PMT system, the liquid scintillator (LS), the calibration system and the VETO detector. The central detector will build a large acrylic sphere of 35.4m in diameter to contain the 20kt LS, and the acrylic sphere is supported by a stainless-steel truss. The PMT system consists of 20000 20-inch PMTs and 25000 3-inch PMTs. Mass production of 20-inch PMTs has started with first 4300 PMTs have been delivered. PMT testing and instrumentation is ongoing. Bidding 3-inch PMTs is finished and instrumentation of the PMTs is also under preparation. The pilot plant of the LS has been finished. Calibration system with four complementary methods is considered. The veto detector includes the top tracker and the water Cherenkov detector. In this talk, the recent progress of the JUNO detector in terms of energy resolution will be addressed.

R&D for the short baseline near detector (SBND) at FNAL

J Pater

The University of Manchester, UK

SBND is part of Fermilab's short-baseline neutrino (SBN) physics programme and is expected to start taking data in 2019. SBND will contribute to neutrino-oscillation studies by measuring the un-oscillated flavour fluxes produced by the Booster Neutrino Beam (BNB) and will also provide the largest dataset for studying neutrino-nucleus interactions in argon, as its core is a 112-tonne liquid Argon TPC. In addition to these immediate physics goals, SBND is an essential part of the continuing R&D programme expected to culminate in huge next-generation neutrino detectors such as DUNE. This talk will present an overview of the design of SBND and report on the current status of its development and production.

The DUNE near detector

J Asaadi

University of Texas at Arlington, USA

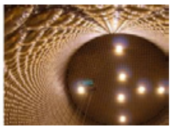
The primary role of the DUNE near detector system is to characterize the energy spectrum and the composition of the neutrino beam at the source, in terms of both ν_μ /$\bar{\nu}_\mu$ and ν_e / $\bar{\nu}_e$, and to provide measurements of neutrino interaction cross sections. The goal of the ND is to constrain the systematic errors below the corresponding statistical error in the far detector, for all oscillation studies; and to conduct a wide range of precision measurements and searches in neutrino physics. The current reference design for the DUNE near detector is a high-resolution Fine-Grained Tracker (FGT) capable of precisely measuring all species of neutrinos. Recent developments within the DUNE collaboration have pointed to the necessity of including a liquid argon component to the near detector as well as exploring a high pressure argon gas TPC design as a "hybrid" approach in order to minimize systematics associated theoretical differences in neutrino cross-section associated with different nuclei, nuclear modelling and neutrino interaction final state effects, and differences in detector response. In this talk, an overview of the current design and progress on the various aspects of the DUNE near detector.

Status of single phase and dual phase DUNE protodectors at CERN

L Bueno

ETH Zurich, Switzerland

Liquid Argon Time Projection Chamber (LAr TPC) is currently the most attractive technology for neutrino oscillations studies. Not only LAr TPCs are cost-effective and scalable to multi-ton scales, but they are also excellent calorimeters and are able to 3D reconstruct the tracks of ionising particles arising from neutrinos decay products. Future giant liquid Argon TPCs, at the ten-kiloton level, are now at the design and prototyping stage in the context of the Deep Underground Neutrino Experiment (DUNE). DUNE will comprise four 10 kton LAr TPC modules placed at the Sanford Underground Research Facility (SURF) in South Dakota (USA). To gain experience in building and operating such large scale LAr detectors, two prototypes are currently under construction in the extension of CERN north experimental hall area (EHN1) which eventually will be exposed to the SPS beam. The prototypes consist of a single-phase LAr TPC, called ProtoDUNE Single-Phase (SP), and a dual-phase LAr TPC, called ProtoDUNE Dual-Phase (DP). The cryostats hosting the detectors have been already completed, and construction of the TPCs is already ongoing. The detectors will be assembled by 2018. An overview of the status and progress of both detectors and how they fit in the general context of DUNE will be addressed in this talk.



R&D towards a High Pressure Gas TPC

M Wascko

Imperial College London, UK

High pressure gas time projection chambers (HPTPCs) are one of the most promising novel neutrino detection technologies for improving neutrino-nucleus systematic uncertainties to the level required for the neutrino oscillation physics goals of the next generation of long baseline accelerator neutrino experiments. I will survey ongoing HPTPC R&D efforts in Europe and the USA. I will focus on work to build a cubic meter HPTPC prototype, utilising high-resolution readout technology, in the UK. This prototype will be used to measure proton-argon and pion-argon interaction cross sections in the range of energies that will be emitted by neutrino-nucleus interactions. The results will be used to tune neutrino generator Monte Carlo simulations (such as NEUT and GENIE) with new p-Ar data and perform neutrino oscillation studies assessing the feasibility of achieving 2% interaction systematics.

Upgrade of the T2K near detector for T2K-II and Hyper-Kamiokande

B Quilain

Laboratoire Leprince-Ringuet (LLR), France

In the search for CP violation at the T2K and future Hyper-Kamiokande experiments, it is crucial to reduce the present systematic uncertainties. The current T2K near detector, ND280, reduces the uncertainties in the electron neutrino appearance channel from 11.9% to 5.4%. Of the remaining uncertainties, 3.5% comes from the Super-Kamiokande detector. The other residual uncertainties come from intrinsic limitations of ND280, that might be due to its difference in target material and angular acceptance with the far detector.

We will report on an upgrade of the ND280 detector that can improve the evidence (subsequently observation) of CP violation in the T2K phase-II (Hyper-Kamiokande) experiment. It considers a fully active target surrounded by Time Projecting Chambers, ensuring particle reconstruction with full coverage of the lepton scattering angle. It will also be shown that this coverage can be employed to constrain the neutrino-multi-nucleon interactions that remain poorly understood.

Gd loaded SuperK: status and plan

Y Nakajima

The Institute for Cosmic Ray Research (ICRR), the University of Tokyo, Japan

Super-Kamiokande, a 50-kton water Cherenkov detector, has been observing solar neutrinos through their electron recoils for more than 20 years. Its unprecedented statics allow us to precisely measure the solar neutrino oscillation parameters, to test the matter effect through the sun and the earth, and to search for possible periodicity of the solar neutrino flux. Currently, one of the largest source of the systematic uncertainties for the solar neutrino measurements is the energy scale uncertainty for electron recoils. In order to further reduce the uncertainty, we are improving the energy calibration method by precisely taking account for time variations of the detector responses. In this poster, I will present the latest results of solar neutrino measurements, as well as the status of improving the energy calibration at Super-Kamiokande.

In search of sterile neutrinos: status of the SoLid experiment

S Vercaemer

Vrije Universiteit Brussel, Belgium

SoLid is a short-baseline reactor neutrino oscillation experiment, probing the disappearance of anti-neutrinos using a novel detector design. Installed at a very short distance from the BR2 research reactor at SCK•CEN in Mol (Belgium), it will be able to search for active-to-sterile neutrino oscillations, exploring most of the allowed oscillation parameter space.

The SoLid detector is a highly segmented detector, built from 5 x 5 x 5 cm^3 PVT cubes, interleaved with ^{6}LiF:ZnS(Ag) screens; light from the cubes and screens is extracted via optical fibers and read out by Silicon Photomultipliers. The detector granularity allows for precise localization of the positron and neutron signals from $\bar{\nu}_e$ inverse beta decay interactions; robust neutron identification capabilities, offered by the ^{6}LiF:ZnS(Ag) inorganic scintillator, provide background suppression to an unparalleled level.

This talk reviews the experimental layout and current status of SoLid. A large scale prototype has operated under realistic circumstances, results from this prototype will be presented. Part of the full scale detector will start taking data during the fall of 2017, a first look at commissioning and calibration data will be given.

The PTOLEMY experiment: towards cosmic neutrino background detection

A Cocco

National Institute for Nuclear Physics (INFN), Italy

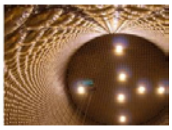
The PTOLEMY project aim at the direct detection of the Cosmic Neutrino Background (CvB) by the use of a Tritium target. Neutrino produced in the early stage of the Big Bang are predicted to have thermally decoupled from other forms of matter at approximately 1 second after the Big Bang; they represent the oldest detectable Big Bang relics and as such they carry an invaluable content of information about the genesis and evolution of our Universe. Despite their very small energy they present a sizable interaction cross section on nuclei that decay through beta decay, as it was pointed out by recent studies. In particular Tritium is among the nuclei having the most favorable detection conditions. We will report about the project, the technological key aspects being addressed and about the status of the PTolemy prototype, which is ready to be moved to the Laboratori Nazionali del GranSasso (Italy) underground site.

Status of CONNIE coherent neutrino detection experiment

B Kilminster

University of Zurich, Switzerland

CONNIE (Coherent Neutrino-Nucleus Interaction Experiment) is an operational experiment designed to detect the signal from reactor neutrinos scattering elastically and coherently from silicon nuclei in CCD detectors. I will present first results from 2015, indicating the sensitivity of the experiment, and the upgrade in 2016, which corresponds to an increase in signal neutrino rate of a factor of 30, and the potential for evidence of coherent neutrino scattering after collection of 1-2 years of data. Newest results will be shown.



Session 2 – Parallel Session: Sensors/Electronics/DAQ/Software

Event reconstruction techniques for liquid argon neutrino detectors

A Blake

Lancaster University, UK

One of the key detector technologies in the current and future neutrino programmes is the Liquid Argon Time Projection Chamber (LAr-TPC). The use of large-scale LAr-TPC detectors for neutrino physics was pioneered by the ICARUS experiment, and now forms the basis of the Fermilab short-baseline neutrino programme and the DUNE long-baseline neutrino experiment. LAr-TPC detectors offer superb imaging capabilities, enabling complex neutrino event topologies to be resolved with exquisite spatial and calorimetric precision. In order to fully exploit the detailed information available in each image and to handle the corresponding large volumes of data, the LAr-TPC community is developing advanced and automated techniques of neutrino event reconstruction. The goal of reconstruction is to identify the final-state particles produced by each neutrino interaction, classify the neutrino flavour and type of interaction, and measure the neutrino energy. LAr-TPC neutrino detectors typically measure sets of projected 2D images which must be merged into 3D events. Each 2D image is pre-processed to filter out noise and correct for the detector response. The 3D neutrino events are then reconstructed using pattern recognition, particle identification and energy estimation algorithms. Over the past couple of years, the development of automated reconstruction algorithms for LAr-TPC detectors has advanced considerably. In this presentation, I will review a variety of innovative and sophisticated approaches that are being developed to support the short-baseline and long-baseline neutrino programmes.

Electronics and DAQ for liquid argon detectors

J Crespo-Anadón

Columbia University Nevis Laboratories, United States

The liquid argon time projection chamber technology has been chosen for the detectors of the Short-Baseline Neutrino (SBN) program at Fermilab and the future Deep Underground Neutrino Experiment (DUNE), which will address many of the open questions in neutrino oscillation physics. These experiments record neutrino interactions from accelerator-produced beams arriving at predictable times, but also aim at recording rare events such as supernova neutrinos or potential nucleon decays, requiring trigger schemes which can deal with both, and maximum uptime. For each event, with energies ranging from a few MeV to several GeV, the detectors collect both the scintillation light and the ionization electrons produced by the interactions of charged particles in the liquid argon. The scintillation light is collected using photomultipliers, while the signal from the drifted ionization electrons is captured using induction or collection wire planes. The large scale of these experiments requires to read out of the order of ten thousand or more channels at rates of a few MHz. In order to cope with the huge data volume, segmented readouts and compression algorithms are used to reduce the data rate to manageable levels.

In this talk I will review the technology solutions, from front-end electronics to DAQ systems, that the SBN experiments –MicroBooNE (taking neutrino data since October 2015), and the upcoming ICARUS and SBND– have adopted. In addition, I will discuss the challenges faced by the future DUNE Far Detector, and the designs used in the DUNE prototypes, currently under construction at CERN.

Hyper-K electronics/DAQ/sim/recon

H O'Keeffe

Lancaster University, UK

The Hyper-Kamiokande (Hyper-K) experiment is a planned large-scale, multi-purpose experiment. It will have unprecedented sensitivity to low energy physics, particularly proton decay and solar, atmospheric and supernova neutrinos. In addition, it will utilise a beam of muon neutrinos produced by the upgraded J-PARC facility in Tokai to search for neutrino-sector CP violation via electron neutrino appearance and muon neutrino disappearance. It is anticipated that the experiment will begin operation in 2026.

Key to the success of the experiment will be electronics and data acquisition systems that are durable and stable for the length of the experiment. In addition, high-speed event reconstruction software/firmware will be crucial for lowering the energy threshold and maximising sensitivity to low energy physics in addition to reducing data throughput and noise. This talk will present on-going work into the development of electronics, DAQ, triggering, reconstruction methods and simulation software.

IceCube/Km3NeT DOM/electronics

C Mollo

National Institute for Nuclear Physics (INFN), Italy

The KM3NeT collaboration is currently building a neutrino telescope in the Mediterranean Sea. Once completed it will have over 300 detection units and more than 5000 digital optical modules (DOMs) in a volume of several cubic kilometres. Along with Ice Cube Telescope they will cover the entire celestial sky in search of astrophysical neutrino sources. The two experiments will be complementary and, despite the operating principle, they differ greatly with regard to the structure of the detection units, the geometry of the optical modules, the number of photomultipliers and data acquisition electronics.

This contribution focuses on the main components of the read-out electronics in the digital optical module of Ice Cube and KM3NeT. It will compare the main features of both modules and point out the differences due to the diverse design specifications. It will also show how the signals from the photomultipliers of both experiments are acquired, stored and transmitted.

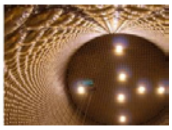
Development of large area picosecond photo-detectors (LAPPDs) and first use in particle physics experiments

M Malek

University of Sheffield, UK

The physics reach of the next generation of neutrino detectors and nucleon decay experiments can be greatly enhanced through the use of advanced photodetectors. To this end, Large Area Picosecond Photo-Detector (LAPPD) Collaboration was formed in 2009 to develop imaging sensors with timing resolution of the order of tens of picoseconds, accompanied by sub-centimeter spatial resolution. The collaboration succeeded in these goals, producing 20 cm x 20 cm modules with gains greater than 1e7 and transit time spreads less than 50 picoseconds for individual photons. In parallel, bespoke electronics such as the PSEC4 chip, have been designed to optimise the potential of the LAPPD. Commercialisation of these modules has been passed on the US-based Incom company, with the first production quality modules produced earlier this year.

This presentation will cover the design and capabilities of LAPPDs, as well as their first deployments in particle physics experiments. The initial use will be in the Accelerator Neutrino-Nucleus Interaction Experiment (ANNIE) at



Fermilab; other potential applications include the E61 near detector for the J-PARC long-baseline neutrino programme, and possible use in Hyper-Kamiokande.

Deep convolutional neural network applications in the NOvA Experiment

R Murphy

Indiana University Bloomington, United States

Convolutional Neural Networks (CNNs) have been successful in many complex computer vision problems in image identification and analysis due to recent advents in efficient GPU training. Due to these successes, effort was put forth to bring this technology to applications in HEP where the data could be pictorialized. NOvA is a long baseline neutrino oscillation experiment designed to visually identify and reconstruct neutrino interactions in our detectors. Using a CNN, we deployed a Convolutional Visual Network (CVN) for the identification of neutrino interaction types and neutrino flavors using the Caffe framework. In 2016 NOvA released observation results in the ν_μ to $\bar{\nu}_e$ oscillation channel, the first HEP result that employed CNNs. In this talk I will describe the concepts behind CNNs, our implementation of CNN in the Caffe framework, and its application to NOvA events. I will also discuss recent developments in our application of CNNs.

Superconducting tunnel junction detectors

Y Takeuchi

University of Tsukuba, Japan

Because of smaller gap energies of the superconductor materials than of the ordinal semi-conductor materials by three or more orders of magnitude, detectors based on the superconductor materials provide an epoch-making high sensitivity and have been practically used for several experiments. The Superconducting Tunnel Junction (STJ) detector can measure energy deposited on the superconductor as tunneling current of quasiparticles which are created with breaking of Cooper pairs. In this talk, we present an introduction to STJ detectors and application to experiments on the elementary particle physics, mainly on COBAND experiment as an example, where STJ in combination with silicon-on-insulator (SOI) cryogenic amplifier is being developed for 25meV photon detection to search for the neutrino decay in the cosmic neutrino background.

GPU in modern detectors

F Nova

Rutherford Appleton Laboratory (RAL), UK

We review advantages offered by Graphic Processing Units (GPU) in the detection of rare events. We show that GPUs allow intelligent data acquisition systems to perform real-time triggering of large data volumes under constraints on data rate and bandwidth. Through parallelization, complex algorithms can be executed at high speed, improving the experimental sensitivity and matching the challenge posed by modern detectors which steadily push the data rate to higher levels.

Session 3 - Running neutrino oscillation projects

NOvA: Latest results and future plans

E Niner

Fermilab (FNAL), United States

The NOvA experiment is a long-baseline neutrino oscillation experiment that uses two detectors separated by 809 kilometers to measure muon neutrino disappearance and electron neutrino appearance in the beam produced at Fermilab. These oscillation channels are sensitive to unknown parameters in neutrino oscillations including the mass hierarchy, θ_{23}, and CP violation. Ir
improvements from electron neutrino appearance and muon neutrino disappearance from the experiment based on 6.05x1020 protons on target collected over two years. I will also show new 2017 results for neutral current disappearance with 8.85x1020 POT and projections for future NOvA running.

T2K: Latest results and future plans

H O'Keeffe

Lancaster University, UK

The Tokai to Kamioka (T2K) experiment utilises a beam of muon neutrinos produced by the J-PARC facility in Tokai. The neutrino beam is sent 295 km across Japan to the Super-Kamiokande detector in order to study neutrino oscillations via electron neutrino appearance and muon neutrino disappearance. Since 2014, T2K has also run with an antineutrino beam, thus allowing both neutrino and antineutrino oscillations to be studied in combination, to produce the most precise measurements of the neutrino mixing parameters to date and also to provide sensitivity to neutrino-sector CP violation from T2K data alone.

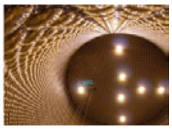
This talk will present recent results from T2K oscillation analyses including constraints on the CP-violating phase delta, and future prospects for the experiment.

Overview of reactor neutrinos

M He

Institute of High Energy Physics, China

Reactor neutrinos played an important role in the history, leading to the first discovery of the neutrino, and the first confirmation of solar neutrino oscillation. The current generation reactor experiments, Double Chooz, Daya Bay and RENO observed the neutrino oscillation driven by the least mixing angle theta13, and provided the most precision measurement of theta13 to date. On the other hand, they have published the measured absolute reactor neutrino flux and spectrum, which have discrepancies compared with the reactor model prediction. Daya Bay also observed the nuclear fuel evolution and found U235 seems the main contributor to the Reactor Antineutrino Flux Anomaly. Sterile neutrino as the sole cause is disfavored by 2.8σ. These anomalies suggest an underestimation of the reactor prediction uncertainty. Light sterile neutrino searches were played in Daya Bay and RENO. Combined with the accelerator result from MINOS, part of the sterile neutrino parameter space allowed by LSND and MiniBooNE were rejected. Tens of short baseline reactor projects are about to start and further explore the sterile neutrinos at eV scale.



Latest results from double chooz

J Dawson

Laboratoire Astro Particule et Cosmologie, France

Double Chooz is a reactor neutrino experiment based at the Chooz nuclear powerplant in France. The experiment began data taking in 2010, running only with its far detector at ~1 km from the reactor cores, announcing in 2011 an indication of a non-zero value of the mixing angle $theta_{13}$. Robust observations of $theta_{13}$ followed shortly after in 2012 by Daya Bay and RENO, already running with near and far detectors.

Without a near detector to constrain the flux and spectrum of the neutrinos emitted from the two reactor cores, the precision obtained by Double Chooz on $theta_{13}$ was totally dominated by the reactor flux uncertainty. Now, Double Chooz has been running since 2015 in its final two-detector configuration, with a near detector at 400m from the reactor cores which greatly reduces the systematics. A novel neutrino selection has been adopted, which includes both neutrino events from the Gadolinium-loaded target volume and larger surrounding volume (gamma-catcher), significantly boosting the statistical power of the experiment. In order to mitigate the background which would otherwise dominate this selection, an Artifical Neural Network is implemented. The latest results from the experiment, using this strategy and first shown in September 2016, gives a value of sin^2 $2theta_{13}$ of 0.119 +/- 0.016.

I will describe the analysis strategy adopted, focusing on the methods which are unique to Double Chooz, and describe the ongoing work related to the characterisation of the Reactor spectrum.

Global analysis of neutrino mixing parameters: recent results and prospects

F Capozzi

The Ohio State University, USA

Within the three-neutrino framework an up-to-date global analysis of neutrino mass-mixing parameters is presented, using the latest data from oscillation experiments, neutrinoless double beta decay searches, and cosmological surveys. We discuss the improvements on the five known oscillation parameters and the current status of the three unknowns: the mass ordering, the CP violating phase and the octant of $\theta 23$. In particular, we find a hint for CP violation in the lepton sector and a preference for normal ordering at the $\sim 2\sigma$ level. No significant information is currently available on the octant. Prospects and challenges of global neutrino data analyses are also discussed.

Session 4 - Results from Other Running Experiments

Recent results from NA62 on heavy neutrino searches from k-decays

V Duk

University of Birmingham, UK

In this talk heavy neutrino (V_h) production searches in charged kaon decays at the NA62 experiment are presented. New limits are set on the branching ratio (BR) of two-body decays $K+ \rightarrow \mu + V_h$ and $K+ \rightarrow e + V_h$. The upper limit for the BR($K+ \rightarrow \mu + V_h$) was measured using 2007 data at the level of 10^{-5} for $m(V_h)$ = 300-375 MeV/c2. The results are published. The upper limit for the BR($K+ \rightarrow e + V_h$) was set from the 2015 data in the V_h mass range 170-448 MeV/c^2 and varies between 10^{-6} and 10^{-7}. The paper is in preparation.

MicroBooNE first results and the prospect of the SBN program

J Zennamo

University of Chicago, United States

Since the discovery of neutrino flavor oscillations the study of this new phenomena has become a very active area of research. At long-baselines we can accurately parameterize the observed results in the context of oscillations between three neutrino flavors. This three-neutrino paradigm has been questioned due to a number of anomalous results from experiments using different neutrino sources studying oscillations at short-baselines. Liquid argon time-projection chambers offer us a scaleable detector technology that can make precision measurements of neutrino interactions to investigate these anomalies. MicroBooNE is the largest surface liquid argon time-projection chamber to operate in a neutrino beam. Over the past year the collaboration has worked to model and calibrate our detector, and build the tools necessary to perform precision analyses of neutrino interactions. This talk will cover the measurements performed by the MicroBooNE collaboration to understand the detector and a first look at neutrino interactions.

Status of the neutrinoless double beta decay programme

S Dell'Oro

Virginia Tech, USA

The discovery of the neutrino masses revealed by flavor oscillation experiments has brought renewed impetus to the search for neutrinoless double beta decay ($0\nu\beta\beta$). The experimental effort, which began more than 50 years ago, has seen rapid progress in recent years.

Today, sensitivities on the decay half-lives of the order of (10^{25} – 10^{26}) yr have been reached. In this talk, we review the challenges of $0\nu\beta\beta$ decay experiments and give an overview of the most effective experimental techniques. Finally, the strategies for the future hunt for $0\nu\beta\beta$ are discussed, focusing in particular on the background abatement and the most promising forthcoming experiments.

Neutrino physics with dark matter detectors

M Selvi

University of Bologna, Italy

The current and future generation of experiments dedicated to directly detect the tiny interactions of Dark Matter particles will start to be sensitive also to neutrino interaction through their scattering both on electrons and nuclei.

In the talk we will review the current status and future plans of such detectors, in particular those using the double-phase LXe and LAr time projection chamber technique.

We will then focus mainly on their sensitivity to solar and SN neutrinos as well as on other neutrino sources (51Cr neutrino, spallation, beta beams, ...).

Session 5 - Future Neutrino Experiments

Status of the Hyper-K experiment

I Shimizu

Tohoku University, Japan

Hyper-Kamiokande (Hyper-K) is a next generation large water Cherenkov detector. We will probe the GUT theory and history of the universe through the proton decay and CP violation searches, and neutrino astrophysics. The detector design was optimized considering physics sensitivities, cost, construction period, and maintenance. The fiducial mass of Hyper-K is almost an order of magnitude larger than Super-K, so the physics sensitivities in Hyper-K will be significantly enhanced. In addition, the improvement of the photo-sensor allows the efficient background rejection using the neutron tagging.

In this talk, the various physics sensitivities and the time-line of the Hyper-K project will be shown. For the beam neutrinos, the statistics will be further enhanced by an upgrade of the proton drivers in the J-PARC accelerator facility. The CP-violation sensitivity will reach to 8-sigma in 10 year operation for the case of the maximum CP-asymmetry. In Super-K, the sensitivities on nucleon decay searches are not limited by the background, so Hyper-K can extend the sensitivities by almost an order of magnitude in the proton lifetime. The lifetime less than 10^{35} years for the proton decay into a positron and a neutral pion will be investigated. In neutrino astrophysics, we will observe the matter oscillation with solar neutrinos, and investigate the star formation history with the supernova neutrinos.

Status of DUNE experiment

D Stefan

Conseil Européen pour la Recherche Nucléaire (CERN), Switzerland

The Deep Underground Neutrino Experiment (DUNE) provides a rich science program with the focus on the neutrino oscillation physics and proton decay studies. The high-intensity wide-band neutrino beam will be produced at Fermilab and will be directed to the 40 kt Liquid Argon far detector at the Sanford Underground Research Facility (SURF), 1300 km from Fermilab. One of the most important goals of the experiment is to determine the neutrino mass ordering and the measurement of the CP violating phase. The underground location of the large DUNE far detector and its excellent energy and spatial resolution will allow also conducting non accelerator physics programs predicted by GUT models, such as nucleon decay or n-nbar oscillations. Moreover, it will be sensitive to measure of the electron neutrino flux from a core-collapse supernova providing valuable information on the mechanism of a supernova. This ambitious project involves worldwide contribution and extensive prototyping and testing program to guarantee that all parts of the technology are fully understood and well tested. Two such prototypes, in both single phase (ProtoDUNE-SP) and dual phase (ProtoDUNE-DP) technologies, are under construction and will be operated at the CERN Neutrino Platform (NP) starting in 2018.

Status/potential of Jinping

Q Liu

University of Chinese Academy of Sciences (UCAS), China

Jinping Neutrino Experiment (Jinping) is a unique neutrino observatory with overburdens of about 2.4 km of rock located in China JinPing underground Laboratory (CJPL). For solar neutrinos, Jinping has the capability to measure the oscillation transition phase from vacuum to matter, to discover the CNO cycle neutrino, and to address the solar metallicity problem. For geo-neutrinos, Jinping is capable of measuring the flux with signal-to-background ratio of

8.2:1.0 in the energy range of 1.8 MeV to 3.3 MeV, and the ratio of U/Th can be determined to 10%. Currently the 1-ton prototype with liquid scintillator is in operation. The achieved results, status as well as the R&D, and the efforts towards a kton-scale prototype are reported.

Indirect neutrino mass determination using cosmological surveys

M Loverde

State University of New York Stony Brook, USA

Cosmic background neutrinos are nearly as abundant as cosmic microwave background photons, but their mass, which determines the strength of their gravitational clustering, is unknown. Even if the neutrino masses are the minimum required by oscillation data, their gravitational effects on cosmological structure will nevertheless be detectable in — and in fact required to explain — data within the next decade. I will discuss the physical effects of the cosmic neutrino background on structure formation and the prospects for detecting the neutrino mass with future galaxy surveys and cosmic microwave background experiments.

Solar+SN neutrinos: detection methods and prospects

S Li

The Ohio State University (OSU), United States

There is a wealth of untapped potential in solar and supernova neutrino experiments. First, I will give an overview of existing detection methods. Then I will show exciting new progress in the field, ranging from new background rejection techniques to new experiments.

Status of KM3Net/ORCA

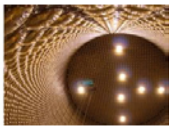
P Coyle

Centre de physique des particules de Marseille (CPPM), France

KM3NeT, located in the abysses of the Mediterranean Sea, is a distributed research infrastructure hosting a km3-scale neutrino telescope (ARCA), offshore from Capo Passero in Italy, for high-energy neutrino astronomy, and a megaton scale detector (ORCA), offshore from Toulon in France, for the study of fundamental neutrino properties with atmospheric neutrinos.

For both cases, the detector arrays comprise a three dimensional grid of photomultipliers tubes designed to detect the Cherenkov light induced by charged leptons from neutrino interactions in and around the instrumented volume. KM3NeT has developed a cost effective Optical Module based on many small 3" photomultiplier tubes. Depending on the target neutrino energy, the Optical Modules are densely (ORCA) or sparsely (ARCA) packed. Recently, the first KM3NeT/ORCA detection string is operational and providing high quality data.

The ORCA array, 115 strings with an instrumented volume of about 8 Mton, targets atmospheric neutrinos in the energy range 3-100 GeV. Physics studies indicate that the neutrino mass ordering can be determined with a significance of 3-7 sigma (depending on the true value of the hierarchy and the value of mixing angle sin θ23) after three years of operation. ORCA will also provide competitive measurements of the mass difference squared (ΔM232) and θ23 in the atmospheric sector, tau appearance, sterile neutrinos, etc.



Neutrino oscillation physics with IceCube (now) and PINGU (next generation)

J Koskinen

Niels Bohr Institute - University of Copenhagen, Denmark

The DeepCore low energy extension of IceCube collects tens of thousands of atmospheric neutrinos each year that are used to probe a wide array of neutrino oscillation physics (neutrino mass ordering, numu disappearance, nutau appearance, sterile neutrino searches, and other exotic phenomena). I will discuss recent results from an atmospheric measurement of θ_{23} and Δm^2_{32} and first tau neutrino appearance results. I will conclude by covering the potential for neutrino oscillations and atmospheric neutrino physics with the Phase1 deployment of PINGU, the next generation low energy infill of IceCube-Gen2.

SHiP (Search for Hidden Particles at CERN): status and physics prospects

A Magnan

Imperial College London, UK

SHIP is a new general purpose fixed target facility, whose Technical Proposal has been recently reviewed by the CERN SPS Committee and by the CERN Research Board. The two boards recommended that the experiment proceeds further to a Comprehensive Design phase in the context of the new CERN Working group “Physics Beyond Colliders”, aiming at presenting a CERN strategy for the European Strategy meeting of 2019. In its initial phase, the 400GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating 2×10^{20} protons on target events in 5 years. A dedicated detector, based on a long vacuum tank followed by a spectrometer and particle identification detectors, will allow probing a variety of models with light long-lived exotic particles and masses below O(10) GeV /c2. The main focus will be the physics of the so-called Hidden Portals, i.e. search for Dark Photons, Light scalars and pseudo-scalars, and Heavy Neutrinos. Another dedicated detector will allow the study of neutrino cross-sections and angular distributions. This talk will review the current status of the experiment and highlights the expected performances in terms of physics reach.

Session 6 - Neutrino Facilities

MW Neutrino targets for LBNF/JPARC

C Densham

Rutherford Appleton Laboratory (RAL), UK

Future Long Baseline Neutrino Facilities require a copious and reliable source of neutrinos. In both the T2HK and LBNF experiments, a neutrino production target is required to convert intense pulses of protons into pions. The charged pions are captured and focused by a magnetic horn system so that as they decay they generate a beam of neutrinos in the direction of the far detector. Optimisation of the design of the target and horn focusing system of the future wide-band, on-axis Long Baseline Neutrino Facility at Fermilab has converged on a design that is similar in outline to the existing narrow-band, off-axis T2K system in Japan. Since both systems will also be operated at similar beam powers of over 1 MW, there are many potential benefits from exploiting synergies for the two facilities.

Both T2K and the existing NuMI/NOvA experiment at Fermilab use graphite as a target material due to its favourable thermal and mechanical properties. Higher Z materials have been considered, the objective being to increase the pion yield, reduce wrong-sign backgrounds and to make a more point-like source that fits better within the depth of field of the focusing system. However, any potential gains need to be weighed against any reduction in reliability due to e.g. increases in complexity resulting from the higher deposited heat density and radiation damage.

To a megawatt and beyond: accelerators for high power neutrino beams

P Adamson

Fermilab (FNAL), USA

Future neutrino experiments require large increases in neutrino flux in order to reach their optimum sensitivities. This talk covers the present and future landscape of proton beams for neutrino production.

Engineering challenges for underground projects

S Nakayama

Institute for Cosmic Ray Research (ICRR), University of Tokyo, Japan

Construction of next-generation nucleon decay and neutrino detectors in deep underground faces various engineering challenges. The main challenge is excavation of huge caverns. For example, the cavern for the Hyper-Kamiokande detector will have the world largest span (76 meters in diameter and 78 meters in height). To excavate such a huge cavern successfully, the geological survey for the site selection is very important. Only the standard boring survey sometimes can not get enough geological information over the entire candidate area for the cavern position. As an alternative survey, a wide-area 3D seismic prospecting was carried out using existing mine tunnels at the Hyper-K candidate site. Some details of the survey and results will be presented. Other challenges associated with large cavern excavations, such as groundwater treatment, waster rock transportation, and containment liner design fitted with the cavern wall displacement, will also be discussed. Liquid-based huge NNN detectors, such as JUNO and Hyper-K, need photosensors with high static pressure tolerance. Development of the high pressure tolerance PMTs and the shockwave prevention covers will be mentioned.

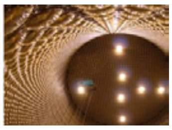
The ESSnuSB project and neutrino CP violation

M Dracos

University of Strasbourg, France

After measuring in 2012 a relatively large value of the neutrino mixing angle θ13, the door is now open to observe for the first time a possible CP violation in the leptonic sector. The measured value of **θ**13 also privileges the 2nd oscillation maximum for the discovery of CP violation instead of the usually used 1st oscillation maximum. The sensitivity at this 2nd oscillation maximum is about three times higher than for the 1st oscillation maximum inducing a lower influence of systematic errors. Going to the 2nd oscillation maximum necessitates a very intense neutrino beam with the appropriate energy. The world's most intense pulsed spallation neutron source, the European Spallation Source, will have a proton linac with 5 MW power and 2 GeV energy. This linac, under construction, also has the potential to become the proton driver of the world's most intense neutrino beam with very high potential to discover a neutrino CP violation. The physics performance of that neutrino Super Beam in conjunction with a megaton underground Water Cherenkov neutrino detector installed at a distance of about 500 km from ESS has been evaluated. In addition, the choice of such detector will extent the physics program to proton–decay, atmospheric neutrinos and astrophysics searches. The ESS proton linac upgrades, the accumulator ring needed for proton pulse compression, the target station optimization and the physics potential are described. In addition to neutrinos, this facility will also produce at the same time a copious number of muons which could be used by a low energy nuSTORM facility, a future neutrino factory or a muon collider. The ESS neutron facility will be fully ready by 2023 at which moment the upgrades for the neutrino facility could start.

This project is supported by the COST Action CA15139 "Combining forces for a novel European facility for neutrino-antineutrino symmetry-violation discovery" (EuroNuNet).



Posters

P1. Pre-supernova neutrino signal - 10 years of progress in modelling

A Odrzywolek

Jagiellonian University, Poland

Presentation will cover 10 years of progress in modelling of pre-supernova neutrino spectra. Role of stellar mass, time evolution sequence, thermal and nuclear processes, postprocessing method and neutrino oscillations will be discussed.

An attempt will be made to clarify the existing discrepancies in the existing results. Finally, TO-DO list for the future research in massive star theory with focus on future of neutrino astronomy will be revealed.

P2. Solar neutrino measurements at Super-Kamiokande

Y Nakajima

The University of Tokyo, Japan

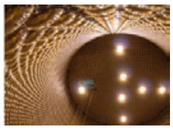
Super-Kamiokande, a 50-kton water Cherenkov detector, has been observing solar neutrinos through their electron recoils for more than 20 years. Its unprecedented statics allow us to precisely measure the solar neutrino oscillation parameters, to test the matter effect through the sun and the earth, and to search for possible periodicity of the solar neutrino flux. Currently, one of the largest source of the systematic uncertainties for the solar neutrino measurements is the energy scale uncertainty for electron recoils. In order to further reduce the uncertainty, we are improving the energy calibration method by precisely taking account for time variations of the detector responses. In this poster, I will present the latest results of solar neutrino measurements, as well as the status of improving the energy calibration at Super-Kamiokande.

P3. The large enriched germanium experiment for neutrinoless double beta decay (LEGEND)

Y Kermaidic

Max Planck Institute fur Kernphysik, Germany

The search for a neutrinoless double decay ($0\nu\beta\beta$) is a very sensitive tool for probing whether neutrinos are Dirac or Majorana particles. A potential discovery has far reaching consequences for particle physics and cosmology (leptogenesis). Current 76Ge based experiments, GERDA and MAJORANA DEMONSTRATOR, have achieved the lowest background in the field and benefit from a superior energy resolution. This demonstrates the feasibility of Germanium for a next generation experiment. The LEGEND (Large Enriched Germanium Experiment for Neutrinoless Δουβλε Βετα Decay) collaboration has been founded with the goal to build a ton scale experiment and boost the $0\nu\beta\beta$ half-life sensitivity by two orders of magnitude. The collaboration envisions a phased approach based on the GERDA and MAJORANA DEMONSTRATOR experience, starting with existing resources as appropriate to expedite physics results. This talk will present the general aspect of LEGEND and focus on the ongoing developments for the first 200 kg phase near the GERDA cryostat at LNGS.



P4. Detector design considerations for the WATCHMAN detector

T Marshall

AWE PLC for the WATCHMAN collaboration, UK

Watchman is a collaboration of scientists from universities and national laboratories across the United States and the United Kingdom. The goal is to construct a 1 kiloton gadolinium doped water Cherenkov detector for low-event detection of the on-off cycle of nuclear reactors using antineutrinos at a stand-off distance of 10-30km. The location of the detector will be at either Boulby mine in the UK, or Fairport mine in the US, which has an effect on its design to ensure it is as efficient as possible.

The work presented gives an overview of the project, the detector design and its ability to detect the switch on or off of a nuclear reactor. The ongoing simulations developed by the collaboration to determine the detector design will be explored. The time taken to detect a switch on or off of Hartlepool power station from Boulby using the current design will also be presented.

P5. ARIADNE: A photographic 1-ton two-phase liquid argon detector

J Vann, K Mavrokoridisdis

University of Liverpool, UK

ARIADNE is bringing photographic imaging to the future two-phase LAr neutrino experiments. A 1-ton two-phase LAr TPC, ARIADNE is capturing the secondary scintillation light produced in a THGEM with high imaging resolution at low energy thresholds. Advantages over current charge readout techniques include reduction or omission of charge read-out channels as well as ease of scalability, upgrade, installation and maintenance. Results will be presented that demonstrate imaging and linear track reconstruction of cosmic rays using an EMCCD camera. ARIADNE will mature and validate photographic readout technology and will be fully characterized at a charged particle beam line at CERN, including particle ID and argon cross-section studies. An overview and status of the project will be detailed.

ARIADNE is proudly sponsored by ERC. More details of the ARIADNE project can be found at: http://hep.ph.liv.ac.uk/ariadne/

P6. Low energy event reconstruction for the E61 detector

M Taani

University of Edinburgh, UK

Current long baseline neutrino experiments relate the experimental observables to the prediction of theoretical neutrino-nucleus interaction models. These models have a large uncertainty which needs to be reduced by the next generation of long baseline neutrino experiments in order to make precision measurements. To help with this Hyper-Kamiokande will have an intermediate water Cherenkov detector (E61) to measure the properties of the neutrino beam before oscillations have occurred. The E61 detector will be loaded with Gd to allow for neutron tagging and eventually neutrino/anti-neutrino event separation. Before the E61 detector is placed underground, the instrumented volume will be placed on the surface near ND280 to test the performance of the detector. Here we focus on the simulation studies carried out to test and tune the reconstruction of neutrons and low energy electrons.

P7. A study of charged kaon-nucleon total interaction cross section in liquid argon

E Gramellini

Yale University, USA

We present a study of the charged kaon-nucleus total interaction cross section in Liquid Argon (LAr) performed on LArIAT data. The kaon-nucleus total interaction cross section has never been measured in argon and it is a fundamental input to proton decay studies in future Liquid Argon Time Projection Chamber (LArTPC) experiments such as DUNE.

LArIAT, a small LArTPC deployed in a calibration test beam line at Fermilab, is the perfect venue to study kaons in a controlled environment. The LArIAT beam line detectors allow identification of kaons and measurement of their momentum before entering the TPC. The precise calorimetric energy reconstruction and excellent tracking resolution of the LArTPC technology enables the measurement of the total differential cross section for the tagged kaons as a function of their kinetic energy.

P8. The CERN neutrino platform

N Benekos

CERN, Switzerland

The long-baseline neutrino programme has been classified as one of the four highest-priority scientific objectives in 2013 by the European Strategy for Particle Physics. The Neutrino Platform is the CERN venture to foster and support the next generation of accelerator-based neutrino oscillation experiments.

Part of the present CERN Medium-Term Plan, the Neutrino Platform provide facilities to develop and prototype the next generation of neutrino detectors and contribute to unify the European neutrino community towards the US and Japanese projects.

A significative effort is made on R&D for LAr TPC technologies: two big LAr TPC prototypes for the DUNE far detector are under construction at CERN. Those detectors will be exposed in 2018 to an entirely new and NP-dedicated beam-line from the SPS which will provide electron, muon and hadron beams with energies in the range of sub-GeV to a few GeV.

Other projects are also presently under development: one can cite the refurbishing and shipping to the US of the ICARUS detector and the construction BabyMIND a magnetised muon spectrometer to be located on the T2K beam line.

In this talk the status of the CERN Neutrino Platform activities will be presented as well as an overview of the future projects currently under discussion.

P9. Dynamics of the positive ions in large scale liquid argon detectors and electron signal quenching

R Santorelli, L Romero

CIEMAT, Spain

A study of the dynamics of the positive charges in liquid argon has been carried out in the context of the future massive time projection chambers proposed for dark matter and neutrino physics. Given their small mobility coefficient in liquid argon, the ions spend a considerably longer time in the active volume with respect to the electrons. The positive charge density can be additionally increased by the injection, in the liquid volume, of the ions produced by the electron multiplying devices located in gas argon. The impact of the ion current on the uniformity of the field has been evaluated as well as the probability of the charge signal quenching due to the electron-ion recombination along the drift. The study results show some potential concerns for massive detectors with drift of many meters.

P10. The upgrade project of the T2K near detector

M Zito

CEA-Saclay, France

The upgrade project of the T2K near detector

The T2K neutrino oscillation experiment established the $\nu_\mu \rightarrow \nu_e$ appearance with only 10% of the original beam request of 7.8x10^{21} 30 GeV protons on target (p.o.t.). In view of the J-PARC program of upgrades of the beam intensity, the T2K-II proposal requires to run up to 20x10^{21} p.o.t., i.e. an increase of the exposure by more than a factor 10 aimed at establishing CP violation at 3 σ level for a significant fraction of the possible Δ_{CP} values. The Hyper-K proposal consists in a further increase by a factor 10 of the far detector mass. Facing the potential increase of statistics by two orders of magnitude, it is of great importance to undertake a vigorous program of near detector upgrades, with the aim of reducing the overall statistical and systematic uncertainties at the appropriate level of better than 4%.

Time Projection Chambers equipped with MPGD have been used with success for the T2K ND280 near detector and are proposed for the upgrade of the T2K near detector together with fine-grained scintillator-based targets and TOF detectors. The requirements of TPCs for neutrino detectors are quite specific. We envisage to use a very thin field cage, resistive Micromegas detectors for the charge readout and state-of-the-art electronics.

A project (CERN-SPSC-2017-002 and SPSC-EOI-015) combining the upgrade of the T2K near detector and the R&D for a High Pressure TPC has been recently launched. A High Pressure TPC would be a very sensitive detector for the detailed study of neutrino-nucleus interactions, a limiting factor for extracting the ultimate precision in long baseline experiments. High pressure TPCs are also being considered for future long-baseline experiments like Hyper-Kamiokande and DUNE.

We will report on the goals of this project and its development program including prototypes, beam tests, and projected performances.

A "nu" look at gravitational waves: The black hole birth rate from neutrinos combined with LIGO

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When a massive star reaches the end of its life it collapses in a violent supernova event, producing a neutron star or a black hole, and releasing vast amounts of energy into neutrinos. This poster will show that by measuring the diffuse supernova neutrino background, made up of all the neutrinos emitted by supernova in the universe, the birth rate of black holes can be inferred. When combined with measurements of the black hole merger rate from gravitational wave experiments such as LIGO, this reveals many aspects of black hole physics, such as the fraction of black holes which end up in merging binaries, or the formation history from birth to merger. This poster is based on work introduced in the paper JCAP07(2017)052(arXiv:1704.05073).

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