Supernova Neutrinos in the Multi-Messenger Era, SNEWS 2.0

Friday, 14 June 2019 - Monday, 17 June 2019

Other Institutes

Book of Abstracts

Contents

Contributed talks III / 1

SuperNova Detection through CEvNS

Author: Rafael Lang[1]

[1] *Purdue University*

Corresponding Author: rafael@purdue.edu

Coherent Elastic Neutrino Nucleus Scattering in direct dark matter experiments for supernova neutrino detection.

Contributed talks III / 2

Neutrino astronomy with supernova neutrinos

Author: Xunjie XU[1]

Co-authors: Vedran Brdar [1]; Manfred Lindner [1]

[1] *Max-Planck-Institut für Kernphysik*

Corresponding Author: xunjie.xu@gmail.com

[arXiv:1802.02577] Modern neutrino facilities will be able to detect a large number of neutrinos from the next Galactic supernova. We investigate the viability of the triangulation method to locate a core-collapse supernova by employing the neutrino arrival time differences at various detectors. We perform detailed numerical fits in order to determine the uncertainties of these time differences for the cases when the core collapses into a neutron star or a black hole. We provide a global picture by combining all the relevant current and future neutrino detectors. Our findings indicate that in the scenario of a neutron star formation, the supernova can be located with a precision of 1.5 and 3.5 degrees in declination and right ascension, respectively. For the black hole scenario, sub-degree precision can be reached.

Poster session and welcome dinner reception / 3

Supernova Neutrinos with nEXO

Authors: Soud Al Kharusi[1]; nEXO Collaboration[None]

[1] *McGill University*

Corresponding Author: soud.alkharusi@mail.mcgill.ca

The nEXO experiment is a proposed neutrino-less double beta decay ($0\nu\beta\beta$) search in the isotope Xe-136 anticipated to be located at SNOLAB. nEXO's stringent low-background requirements necessitate a water shield in order to reduce contributions from external radiation. Photomultiplier tubes inside the water will also measure Cherenkov light of passing muons; this active shield is referred to as the Outer Detector. We present the status of Monte Carlo simulations and discuss the Outer Detector's potential as a supernova neutrino observatory with a focus on the inverse beta decay interaction channel on hydrogen in the water.

Contributed talks III / 4

Supernova Neutrino Observation in the JUNO Experiment

Author: Huiling Li[1]

[1] *Institute of High Energy Physics*

Corresponding Author: lihuiling@ihep.ac.cn

The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment under construction in China, designed with a 20 kton liquid scintillator detector. For the next galactic core-collapse supernova (SN), JUNO is promising to register full flavors of SN burst neutrinos with quite high statistics and a low energy threshold down to 0.2 MeV. A SN trigger system with the real-time alert in JUNO is currently being designed and in the near future will be connected to astronomical alert communities, e.g. SNEWS. Along with other neutrino detectors, gravitational-wave detectors, and observations in various electromagnetic channels, a detailed and complete astrophysical multi-messenger picture will emerge and definitely help us to extend our understanding of SNe in frontiers of both astrophysics and particle physics.

Contributed talk I / 5

Neutrino Bursts from Type Ia and Pair-Instability Supernovae

Author: James Kneller[1]

[1] *NC State University*

Corresponding Author: jpknelle@ncsu.edu

In addition to core-collapse, a burst of neutrinos is also expected from the other two kinds of supernovae: Type Ia supernovae (SN-Iae) and pair-instability supernoave (PISNe). The leading hypothesis is that SN-Iae are the thermonuclear explosion of a carbon-oxygen white dwarf but the exact explosion mechanism is still a matter of debate. Pair-instability supernovae are the explosions of very massive stars with carbon-oxygen cores in the range of 64 $M_\odot$ to 133 $M_\odot$. Observation of either a Galactic SN-Ia or PISN would be of immense value in answering the many open questions related to these events and one potentially useful source of information is the neutrino signal.

In this talk I will present expected signals from both SN-Iae and PISNe which take into account the full time and energy dependence of the emission and the flavor oscillations through the mantle of the star, as well as investigating equation-of-state and line-of-sight differences. We then use SNOwGLoBES to process the computed neutrino fluxes at Earth through five different detectors chosen to represent the range of current or near-future technologies. I will show how the neutrino signal from both SN-Iae and PISNe possess unique features that distinguish them from each other and core-collapse supernovae, how the signals can determine the explosion mechanism for SN-Iae, and, finally, how we can also determine the neutrino mass ordering if the distance to the event is known.

Poster session and welcome dinner reception / 6

PREDICTIONS OF THE ONSET OF MINI ICE AGE IN THE 25TH SOLAR CYCLE

Author: Rajiv Kumar[1]

[1] *Government OFK College Jabalpur*

Corresponding Author: captainrajiv@live.com

Predictions of the irregularity in the 11 year heartbeat of the sun due to asynchronous of the two layered dynamo effect would result in mini ice age as in the Maunder minimum. The onset of this event is expected in the beginning of 25th solar cycle and would go to its maximum in the 26th solar cycle . The minimum temperature is expected in 2028 due to the fall of solar activity by 60 % termed as solar hibernation. The predictions are based on the observations obtained by the Royal Greenwich observatory since 1874.

Poster session and welcome dinner reception / 7

Real-time detection of Supernova Neutrinos in XENONnT

Authors: Ricardo Peres[1]; XENON collaboration[None]

[1] *University of Zurich*

Corresponding Author: rperes@physik.uzh.ch

The XENONnT experiment, which is projected to begin operation by early 2020 at the Laboratori Nazionali del Gran Sasso (LNGS), is a double-phase Time Projection Chamber with a 6 tonne liquid xenon target. Although primarily developed to detect Weakly Interactive Massive Particles (WIMPs) that scatter of xenon nuclei, the detector will also be sensitive to neutrinos coming from a supernova burst beyond the edge of the Milky Way, going past the Large Megallanic Clouds (with a significance of 3 sigma). Given its low background rate and neutrino flavour blindness properties of coherent elastic neutrino scatterings (CEvNS), XENONnT will be able detect supernova (SN) neutrino bursts in real-time. We describe the development of a framework to run an active SN trigger using XENONnT' s open-source processor (Strax), based on the continual counting of proportional scintillation signals (S2) induced by such SN neutrinos. With its tonne-scale target and low background rate, we show that XENONnT will be capable of actively contributing to the SuperNova Early Warning System (SNEWS).

Contributed talks III / 8

IceCube Supernova Detection and Contributions to SNEWS 2.0

Authors: Spencer Griswold[1]; Segev BenZvi[1]

[1] *University of Rochester*

Corresponding Authors: sybenzvi@pas.rochester.edu, sgriswold@ur.rochester.edu

The IceCube Neutrino Observatory is an anchor of the SuperNova Early Warning System (SNEWS). IceCube is comprised of 5160 digital optical modules (DOMs) instrumenting 1 km^3 of ice deep below the surface of the geographic South Pole. This large volume makes it sensitive to neutrinos generated by core-collapse supernovae (CCSNe) in the Milky Way at $>10\sigma$ for all progenitor models, and sensitive to neutrinos from CCSNe in the Magellanic Clouds at the 5σ level. Additionally, IceCube has good resolution on short timescales, making it sensitive to physics during the onset of the neutrino burst, and useful for triangulation with other neutrino experiments. IceCube's supernova trigger continuously searches for a collective rise in hit rates across the DOMs in a sliding window of several seconds. This trigger suffers from a substantial background of cosmic muon hits but has a high uptime (>99.5%), so the detector provides continuous coverage of the Milky Way. We will summarize the IceCube data currently sent to SNEWS, and discuss additional information that we may wish to implement in SNEWS 2.0 to improve source triangulation and studies of the burst onset. We will also discuss how IceCube's low-significance alerts could be used for testing the SNEWS pipeline.

Finally, we describe potential IceCube-Gen2 hardware upgrades that will improve IceCube's CCSN detection horizon and neutrino energy resolution.

Poster session and welcome dinner reception / 9

A Supernova Calibration Source for SNO+

Author: Janet Rumleskie[1]

[1] *Laurentian University*

Corresponding Author: jrrumles@snolab.ca

Only one supernova neutrino burst has ever been detected, and the detection of additional neutrinos from galactic core-collapse supernovae are expected to provide insight on the supernova explosion mechanism. One candidate for detecting supernova neutrinos is SNO+, a multipurpose ultra-low background particle detector. Within SNO+, a galactic supernova neutrino burst is expected to generate an unprecedented rate. Thus, it is necessary to stress-test and optimize the SNO+ data acquisition and electronics so that a supernova signal can be reliably read out. For this purpose, a Supernova Calibration Source is under development to mimic the light expected from supernova neutrino interactions [1]. Using one-dimensional simulated supernova neutrino datasets [2, 3], light profiles representing neutrino interactions are calculated and realised using a laser diode light source delivered into the detector via fibre optics and a deployed light diffuser. Here I focus on the software conversion of neutrino datasets to light profiles, which define the light intensity and timing in the calibration source.

[1] C. Darrach. The SNO+ Supernova Calibration Source: Development and Testing. MSc Thesis, Laurentian University, Sudbury, ON, Canada (2016)

[2] L. Hüdepohl, B. Müller, H.-T. Janka, A. Marek, and G. G. Raffelt. Phys. Rev. Lett. 104, 251101 (2010)

[3] A. Mirizzi et al. La Rivista del Nuovo Cimento 39(1-2) (2016)

Contributed talks VI / 10

High-Energy Neutrinos from Supernovae

Author: Kohta Murase[1]

[1] *Penn State University*

Corresponding Author: murase@psu.edu

Neutrinos from supernovae (SNe) are crucial probes of explosive phenomena at the deaths of massive stars and neutrino physics and high-energy neutrinos are produced through hadronic processes by cosmic rays. We point out that IceCube and KM3Net can detect about 100-1000 events from a SN II-P (and >100,000 events from a SN IIn) at a distance of 10 kpc. We provide new quantitative predictions of time-dependent high-energy neutrino emission from diverse types of SNe, which enable us to critically optimize the time window for dedicated searches for nearby SNe. A successful detection will give us a multienergy neutrino and multimessenger view of SN physics and new opportunities to study neutrino properties, as well as clues to the cosmic-ray origin.

Contributed talks II / 11

Borexino Supernova Alarm System 2.0

Author: Maxim Gromov[1]

[1] *SINP MSU, JINR*

Corresponding Author: gromov@physics.msu.ru

The Borexino experiment has been a member of the SNEWS group since 2009. Originally the Supernova Alarm System of the detector consisted of two modules (so-called supernova monitors) which allowed to register neutrino and antineutrino event bursts from the supernova explosion. Both monitors operated in the counting mode with the alarm rate of less than one in 10 days. No information about significance of a burst was provided by the old Borexino Supernova Alarm System. The updated version of the system has only one module which unites the functionality of previous monitors. Also the new system can sent out different types of alerts including the frequent signals to search for low-threshold coincidences. The last feature is a step towards the multimessenger astronomical studies such as the joint search for gravitational wave and low energy neutrino signals from core-collapse supernovae (GWNU).
Besides the update of the Borexino Supernova Alarm System a few software tools for prompt data checking in case of the high significant supernova alert and for offline analyses have been developed. The overview of these tools will be presented as well.
The research was supported by the grant of the Russian Foundation for Basic Research (project № 16-29-13014).

Contributed talks II / 12

Correlated multi-messenger signals from the landscape of core-collapse supernovae

Author: MacKenzie Warren[1]

Co-authors: Sean Couch [1]; Evan O'Connor [2]

[1] *Michigan State University*

[2] *Stockholm University*

Corresponding Author: mwarren@msu.edu

With the advent of modern neutrino and gravitational wave detectors, the promise of multi-messenger detections of the next galactic core-collapse supernova has become a certainty. These detections will give insight into more than just the core-collapse supernova mechanism: they may resolve longstanding questions about the structure of the progenitor star and fundamental neutrino physics. Using 1D CCSN simulations, I have explored multi-messenger neutrino and gravitational wave signals from the landscape of CCSN progenitors from 9-120 $M_{\odot}$. I have found that, with a joint detection of neutrino and gravitational waves, it may be possible to use correlations between the signals to determine information about the progenitor structure, explosion mechanism, and fundamental neutrino physics such as the mass hierarchy.

Poster session and welcome dinner reception / 13

Multi-messenger triggers with the Jiangmen Underground Neutrino Observatory

Author: Donglian Xu[1]

[1] *Tsung-Dao Lee Institute, Shanghai Jiao Tong University*

Corresponding Author: donglianxu@sjtu.edu.cn

A new era of multi-messenger astronomy has arrived with the detection of gravitational waves and high-energy astrophysical neutrinos. The successful coordination of near real-time follow-up campaigns by multi-wavelength and multi-messenger instruments of those events have largely extended our understanding of the most violent phenomena in the Universe. The Jiangmen Underground Neutrino Observatory (JUNO) is a 20-kiloton liquid scintillator neutrino detector under construction, it will be the world's largest of its kind when it turns on in 2021. JUNO will have highly competitive sensitivity to MeV-scale neutrino detection, and will be able to contribute to the nascent field of multimessenger astronomy, especially for the transient events where high radioactivity background can be easily bypassed. We will present a multi-messenger triggering and filtering system that aims to read out physics hits as much and as low-threshold as possible in JUNO, which can provide the widest broadband neutrino bursts realtime monitoring and possibly steady signal searches at the sub-MeV (as low as 20 keV) to sub-GeV energies.

Contributed talks II / 14

Supernova triggering and signals combination for the NOvA detectors

Author: Andrey Sheshukov[1]

[1] *JINR*

Corresponding Author: sheshuk@nusun.jinr.ru

NOvA experiment uses two segmented liquid scintillator detectors, designed to study neutrino oscillations in 2 GeV neutrino beam. However, these detectors can be used to detect neutrinos from the core collapse supernova. NOvA far detector is sensitive to the SN up to 12 kpc distance with false alarm rate of 1/week. However, using the combination of signal significance from two detectors, the sensitivity range can be extended.
We present the online system, which combines the supernova significance from NOvA detectors in real time, calculating the resulting significance every 5ms.
This system could be used for a a wider set of detectors and experiments. By construction, this system has a fixed background distribution of the combined significance, independent of the number of clients contributing to the system. This makes the false alarm rate very stable.

Contributed talk V / 15

Offline performance studies of Core Collapse Supernova neutrino detection with the KM3NeT neutrino telescopes

Authors: Marta Colomer Molla[1]; Massimiliano Lincetto[2]

[1] *APC/IFIC*

[2] *CPPM*

Corresponding Authors: lincetto@cppm.in2p3.fr, mcolomer@apc.in2p3.fr

The next observation of MeV neutrinos from a Core Collapse Supernova (CCSN) will provide important new probes on the physical mechanism driving these extreme phenomena of the Universe. The KM3NeT neutrino telescopes deployed in the Mediterranean Sea, with the multi-PMT optical module technology and a large instrumented volume, will be able to detect neutrinos from a Galactic CCSN as an overall increase on the PMT counting rate. The detection principle and expected performance will be presented in this contribution.
A detailed Monte Carlo simulation has been implemented to study the capability of the KM3NeT

detectors to resolve the neutrino light-curve, which can be of major importance. Exploiting the 31 directional PMTs of the KM3NeT Digital Optical Modules (DOMs) and using the correlation between the mean energy of incoming CCSN neutrinos and the number of PMTs observing light in coincidence, a preliminary result on the determination of the former will be shown.

Contributed talks VI / 17

First real-time results and CCSN alert triggering with the KM3NeT neutrino telescopes

Authors: Massimiliano Lincetto[1]; Marta Colomer Molla[2]

[1] *IN2P3/CPPM, Marseille*

[2] *APC/IFIC*

Corresponding Authors: mcolomer@apc.in2p3.fr, lincetto@cppm.in2p3.fr

The KM3NeT collaboration has started to build the ARCA and ORCA neutrino detectors in the Mediterranean Sea. With the most recent data from the first instrumented lines deployed at each site, a detailed characterization of the detector and background has been achieved. The technique for Core-Collapse Supernova neutrino detection and its implementation as a real time trigger have been refined and tested to be robust and effective on both sites. The first real time results, including the combination of the online data streams of the two detectors, as well as the perspectives for the integration of KM3NeT in the SNEWS network will be discussed.

Poster session and welcome dinner reception / 18

Pre-supernova neutrino monitor at KamLAND

Author: Koji Ishidoshiro[1]

[1] *Tohoku University*

Corresponding Author: koji@awa.tohoku.ac.jp

In the late stages of nuclear burning for massive stars, the pair production of neutrinos from positron-electron annihilation becomes a significant source of neutrino flux and therefore cooling. As the star evolves, the energy of these neutrinos increases and in the days preceding the supernova a significant fraction exceed the threshold for inverse beta decay. This is the golden channel for liquid scintillator detectors and Gd-doped water Cherenkov detectors because the coincidence signal allows for significant reductions in backgrounds. We find that KamLAND can detect these pre-supernova neutrinos from a star with a mass of 25 M_sun at < 660 pc with 3σ significance in the 48 hours before the supernova. This limit is dependent on the neutrino mass hierarchy and background levels. KamLAND takes data constantly and will provide a semi-realtime significance as a supernova alarm to the community.

Contributed talks VI / 19

Supernova Early Warning in the Daya Bay Reactor Neutrino Experiment

Author: Zhe Wang[1]

[1] *Tsinghua University*

Corresponding Author: wangzhe-hep@mail.tsinghua.edu.cn

A prompt warning of supernova burst neutrino signals is quite attractive. The Daya Bay Reactor Neutrino Experiment, with liquid scintillator, is sensitive to the inverse-beta-decay (IBD) process of electron-antineutrinos, and it can give a real-time measurement of the full supernova burst neutrino energy spectrum. The Daya Bay experiment has 8 isolated neutrino detectors, so that the experiment has a better rejection to muon spallation background than single-detector experiments. A fast supernova online trigger system embedded in the data acquisition system has been implemented to enable a prompt detection of a group of IBD coincidence signals for every sliding 10-second window. This trigger has gone through both offline data analysis and the online test. The single detector background rate, including the reactor neutrino background and the fast neutron background, has been understood. A simulation of supernova neutrino signals with mean energy around 15 MeV shows that about 70% detection efficiency can be achieved for one individual supernova neutrino IBD event in each detector. A golden trigger threshold, i.e. with a false alarm rate < 1/year, can be set for as low as 6 candidates among the 8 detectors, leading to a 100% detection efficiency to all the 1987a type supernova burst at the distance of the Milky Way center and 95% detection efficiency to the edge of the Milky Way. As a SNEWS group member experiment, a prompt, 10s latency, trigger signal can be sent to the SNEWS server, and the experiment starts stable data-taking from 2011 and plan to continue till 2020.

Poster session and welcome dinner reception / 20

The joint search for gravitational wave and low energy neutrino signals from core-collapse supernovae. Current status and future plans.

Authors: Maxim Gromov[1]; Andrey Sheshukov[2]

[1] *SINP MSU, JINR*

[2] *JINR*

Corresponding Authors: sheshuk@nusun.jinr.ru, gromov@physics.msu.ru

One of the possible scenarios of the multimessenger astronomical studies is the joint search for gravitational wave and low energy neutrino signals from core-collapse supernovae. This activity is pushing forward by the intercollaboration community called the GWNU group. The network includes six neutrino detectors and three gravitational wave observatories. The research is based on two principle approaches. They are an offline analysis of the shared archival data and the online or low-latency alarm system. For the moment the former has been continued since the end of 2014, the latter is under preparation and can be realized within the framework of the SNEWS 2.0 system. Aspects of both approaches are reviewed in the report. In particular, general requirements, common software, data formats, selection and coincidence search algorithms are described briefly. The possibilities of source localization in the sky and determination the distance to the collapsed star are discussed.
The research was partly supported by the grant of the Russian Foundation for Basic Research (project № 16-29-13014).

Poster session and welcome dinner reception / 21

Deep underwater particle searches in the Hades.

Author: Aliwen Delgado[1]

[1] *PUC*

Corresponding Author: aydelgado@uc.cl

A solid state detector (CCDs as DAMIC-CONNIE) in the deep ocean is proposed for an energy scale of MeV neutrinos. An instrument designed to be portable and operate in the depths can perform unique measurements of geo and supernova neutrinos, becoming the ultimate geoneutrino detector. Taking into account the positions of the detectors that form the SNEWS it was determined which would be the optimal positions of this new detector that will minimize the Earth shadowing probability as well as maximize the collective determination of the direction of the source. On the other hand the Atacama trench in the Pacific Ocean with a recorded depth of 8 km is an extremely low cosmic radiation environment with higher standards in that sense than the current underground laboratories. This would allow the detection of weakly interacting particles such as neutrinos or dark matter. The radiation conditions are analyzed as noise vs an hypothetical signal of neutrinos at the site. To compute the geoneutrino flux the CRUST 1.0 and PREM model was used to aproximatte the contribution of the richness of radioactive material present in different layers of the Earth. Elastic scattering with atomic nuclei and electrons is established as the most advantageous detection method for these particles focusing on a silicon lattice array for which the background is investigated. Cosmic radiation is also analyzed to try to simulate this interaction at the site.

Contributed talks III / 22

Supernova Pointing Resolution of DUNE

Author: AJ Roeth[1]

[1] *Duke University*

Corresponding Author: ajroeth110@gmail.com

One of the primary physics goals of the Deep Underground Neutrino Experiment (DUNE) is measuring the electron neutrino flux from a core-collapse supernova or black hole formation. If a neutrino burst were detected, an essential piece of information would be its source location, which would be shared via the Supernova Early Warning System (SNEWS). This would allow other astronomers to observe it and help determine which star collapsed, and thus its distance and history. Because of the importance of locating a neutrino burst's source, the pointing resolution of DUNE for neutrino bursts has been calculated using simulations in this study. The pointing resolution was first calculated for single electrons, then for neutrino-electron elastic scattering events, and finally for the expected supernova signal, looking only at elastic scattering events, since this type of event has the most directional signal. Using daughter tracks to determine primary track direction and a likelihood function to determine supernova direction were shown to improve pointing resolution. The model used in this study will be made more realistic by adding noise and the other supernova neutrino interaction modes in order to more accurately estimate DUNE's pointing resolution for supernovae.

Poster session and welcome dinner reception / 23

LIGO, Virgo, KAGRA and Beyond: The Future of Ground-Based Gravitational Wave Observatories

Author: Peter Shawhan[1]

[1] *University of Maryland*

Corresponding Author: pshawhan@umd.edu

The LIGO and Virgo gravitational-wave (GW) detectors confidently detected eleven GW signals during their first two observing runs, from 2015 to 2017. Ten of these were binary black hole mergers, with total system masses ranging from about 18 to 85 solar masses. The remaining event was the

spectacular binary neutron star merger GW170817, which was accompanied by a short-hard gamma-ray burst, a distinctive "kilonova" light curve signature traced out by UV/visible/IR telescopes around the world for weeks, and afterglow emission detectable in X-ray and radio for months. This event proved the rich possibilities of multi-messenger astronomy involving gravitational-wave events. The Advanced LIGO and Virgo observatories began their third observing run, O3, in April 2019, with better sensitivities and thus an expectation that many more GW events will be detected in this year-long run. Candidate events are being shared with the community in public alerts. The KAGRA detector in Japan is being commissioned with the goal of joining LIGO and Virgo for the later part of the O3 run.

Projects to upgrade LIGO and Virgo further (A+, AdV+) are now getting underway. Construction of a third LIGO observatory, in India, is scheduled to begin soon and the observatory is projected to come online in 2025. Thus, by the mid-2020s there will be five highly sensitive observatories operating as a coherent network. With a substantial rate of detected events, excellent all-sky response and good localization, this network will offer many opportunities for multi-messenger science with astronomical facilities on the ground and in orbit. Also, "third-generation" (3G) design studies are now exploring the benefits of new, larger observatories with advanced interferometer technologies which could reach an order of magnitude farther into the universe, sampling the cosmological evolution of GW sources and what they can tell us about stellar and galactic astrophysics over cosmic time. In all phases, multi-messenger science will significantly extend the scientific reach beyond what can be learned from gravitational waves alone.

Contributed talks VII / 24

MicroBooNE as a supernova neutrino detector: using the SNEWS alert as delayed trigger

Author: José I. Crespo-Anadón[1]

[1] *Columbia University Nevis Laboratories*

Corresponding Author: jcrespo@nevis.columbia.edu

MicroBooNE is a liquid argon time projection chamber (LArTPC) in the Booster neutrino beamline at Fermilab. In addition to the beam-related physics program, MicroBooNE features a dedicated readout for detection of core-collapse supernova neutrinos and associated R&D. Being a near-surface detector exposed to an intense cosmic ray flux, MicroBooNE does not attempt to self-trigger on the supernova neutrinos. Instead, a continuous readout of the detector has been developed, for which the data is stored temporarily in disk up to a few days, using the SNEWS alert as delayed trigger to initiate the permanent storage of the data. In order to handle the large data rates generated by the LArTPC, FPGA-based compression algorithms have been developed. This talk will describe the MicroBooNE continuous readout stream design and its performance.

Poster session and welcome dinner reception / 25

Observation of Supernova Neutrino Bursts via CEvNS

Author: Adryanna Smith[1]

[1] *Duke University*

Corresponding Author: adryanna.smith@duke.edu

Coherent elastic neutrino-nucleus scattering (CEvNS) is a neutral-current process in which a neutrino scatters off an entire nucleus, depositing a tiny recoil energy. The process is important in core-collapse supernovae and also presents an opportunity for detection of a burst of core-collapse super-

nova neutrinos in low-threshold detectors designed for dark matter detection. This talk will cover prospects for supernova burst detection via CEvNS in existing and future large detectors.

Poster session and welcome dinner reception / 26

Graphite Reflector in HALO- 1kT

Author: Divya Patel[1]

[1] *University of Regina*

Corresponding Author: diyapatel611@gmail.com

The Helium and Lead Observatory 1 Kiloton (HALO- 1kT) is a lead-based detector to study electron neutrinos emitted in supernova events. It is proposed to follow the same-purpose lesser sensitive HALO detector located at SNOLAB, Ontario, Canada. The sensitive to electron neutrinos make HALO-1kT (and also the current HALO detector)) unique in the sense that all other detectors with capability to detect supernova neutrinos are sensitive to anti-electron neutrinos through charged-current inverse beta-decay such as the Super-Kamiokande, LVD, IceCube and KamLAND.
HALO-1kT sensitivity to supernova neutrinos is larger than that for HALO due to
its proposed 12-fold target-mass increase relative to HALO and a more efficient neutron detection.

The detector will consist of 1 kt of lead (208Pb with 82 protons and 126 neutrons). Neutrinos from supernova will interact with the lead via inverse beta-decay process producing bismuth or lead in high-excited states (the excitation states depend on the income neutrino flauvor). The daughter nuclei emit neutrons during de-excitation. Polyethene moderator materials are used to slow down the neutrons which are then detected by 3He proportional counters. The outer most layer of lead consists of a reflector made of graphite due to lower neutron absorption cross section and thermalization efficiency. The purpose of this reflector is to recover neutrons that would other otherwise escape detector . The processes involved are
CC: υe + 208Pb ⟶ 207Bi + n + e- -10.3 MeV
υe + 208Pb ⟶ 206Bi + 2n + e- -18.4 MeV

NC: υx + 208Pb ⟶ 207Pb + n -7.4 MeV
υx + 208Pb ⟶ 206Pb + 2n -14.1 MeV

I am currently working on the design of the graphite layer which will work as moderator and reflector to redirect some of the neutrons back into the detector lead block. This will increase the detection efficiency by up to 50% (as an example, it is currently 28% in HALO). Geant4 simulations have been used to tune the thickness and grade of the graphite to be used. I found that the optimal thickness is ˜15 cm, and as for the graphite grade, it should, ideally, be of Nuclear-Reactor quality.

Poster session and welcome dinner reception / 28

NOvA as a Supernova Neutrino Observatory: Status and Prospects

Author: Justin Vasel[1]

[1] *Indiana University Bloomington*

Corresponding Author: justin.vasel@gmail.com

Detectors around the world are poised to measure the neutrino flux from the next galactic core-collapse supernova in unprecedented detail and to shed light on the hitherto poorly-understood dynamics involved in these explosions, and on the nature of the neutrinos themselves. The utility of such an observation is enhanced as the diversity of detectors and neutrino flavor sensitivity increases. NOvA is a long-baseline neutrino oscillation experiment designed to measure a neutrino beam with energies narrowly-peaked around 2 GeV. In the case of a 10 kpc supernova, several thousand MeV-scale neutrino interactions are expected to occur in NOvA's liquid scintillator near and far detectors. Measuring these neutrinos requires overcoming several challenges: the SN neutrino spectrum is close to detection threshold, the far detector is subject to a large cosmic muon rate, and each interaction generates a small number of depositions which can resemble electronic noise. Here I present recent work in overcoming these challenges in an effort to make measurement of the supernova neutrino flux with the NOvA detectors possible.

Invited talks I / 29

Core-Collapse Supernova Models

Corresponding Author: evan.oconnor@astro.su.se

Invited talks I / 30

SNEWS 1.0, Workshop Goals

Corresponding Author: ahabig@umn.edu

Invited talks I / 31

Supernova Neutrino Theory

Invited talks I / 32

Supernova Neutrino Detection

Corresponding Author: nakahata@suketto.icrr.u-tokyo.ac.jp

Invited talks I / 33

Science from a Prompt Multimessenger Alert

Invited talks II / 34

Multimessenger Observing Strategies

Invited talks II / 35

Presupernova Neutrinos

Invited talks II / 36

Non-Core-Collapse Transients

Invited talks II / 37

Pointing to a Supernova with Neutrinos

Corresponding Author: schol@phy.duke.edu

Invited talks I / 38

Welcome

Corresponding Author: cjv@snolab.ca

Invited talks II / 39

Pre-SN neutrino emission from massive stars and its importance for multi-messengers

Author: Chinami Kato[1]

[1] *Tohoku University*

Corresponding Author: chinami@heap.phys.waseda.ac.jp

Pre-supernova (pre-SN) neutrinos are emitted from a core of massive stars, which are supposed to be progenitors of core-collapse supernovae. Although it was seemed to be difficult to detect pre-SN neutrinos because of their low energy, detection of pre-SN neutrinos comes into view owing to the recent development of detectors. We believe that future detection of pre-SN neutrinos will give us a big impact as much as the historical neutrino events at SN1987A. In this talk, I will introduce two importance of pre-SN neutrino observations: evidence for the theory of stellar evolution and SN alarm. Especially, I focus on the latter. We may detect pre-SN neutrino signals only from our vicinity (< 1 kpc) and a Galactic SN rate is only once per a few hundreds of years, unfortunately, even if we extend the distance to 10 kpc. Therefore, we never miss the next nearby SN. A SN alarm triggered by detection of pre-SN neutrinos will give us an enough time to prepare for other types of observations with SN explosion and contribute to our understanding of SN explosions.

Contributed talks IV / 40

Pre-Supernova Neutrinos in Direct Detection Experiments

Author: Volodymyr Takhistov[1]

[1] *UCLA*

The next Galactic core-collapse supernova is a highly anticipated event. Even prior to collapse, massive dying stars shine copiously in 'pre-supernova' (pre-SN) neutrinos, which can potentially act as efficient SN warning alarms and provide novel information about the very last stages of stellar evolution. We explore the sensitivity to pre-SN neutrinos of large direct dark matter detection experiments, which, unlike dedicated neutrino telescopes, take full advantage of coherent neutrino-nucleus scattering.

Contributed talks IV / 41

HALO-1kT

Corresponding Author: stan@triumf.ca

42

Coffee Break

Workshop Summary / 43

Workshop Summary

Corresponding Authors: kearns@budoe.bu.edu, kearns@bu.edu

Panel I: Presupernova and Pointing Strategies / 44

Panel I

Corresponding Authors: koji@awa.tohoku.ac.jp, xunjie.xu@gmail.com, vfischer@fnal.gov, coleiro@apc.univ-paris7.fr, lwinslow@mit.edu

Panel II: Supernova Neutrino Early Alert Parameters / 45

Panel II

Corresponding Authors: cjv@snolab.ca, justin.vasel@gmail.com, rafael@purdue.edu, m19nakahata@gmail.com, wenlj@ihep.ac.cn, sybenzvi@gmail.com

Panel III: Supernova Neutrino Theory and Multimessenger Science / 46

Panel III

Corresponding Authors: jpknelle@ncsu.edu, mwarren@msu.edu, murase@psu.edu

Panel IV: Multimessenger Alert and Observing Strategies / 47

Panel IV

Corresponding Authors: peter.shawhan@ligo.org, ahabig@umn.edu