NF10 - Neutrino Detectors

Summary of Received LOIs

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- The Neutrino Detector Topical Working Group will examine a broad range of neutrino detection solutions, focusing on the interplay of physics drivers, new detector ideas, and relevant enabling technologies. Detectors capable of exploring neutrino physics across the full spectrum of possible energies will be considered, from eV to EeV.
  - Combination of a survey of **neutrino detectors world-wide** + **new enabling technologies** being developed for the future

- **NF10 Letters of Intent Summary:**
  - 157 LOIs referencing NF10 (53%)
  - 64 marked as ‘primary’, so we started there
    - Have grouped these into 15 categories
  - Additional 93 LOIs where NF10 is ‘secondary’ - still going through those to compile list of detectors and to identify novel ideas and R&D not captured in the ‘primaries’

NF10 LOI Categories	# of LOIs
New detectors and R&D: Noble element/TPCs	10
New detectors and R&D: WC/scintillator/WbLS	11
New detectors and R&D: Coherent ν detection	7
New detectors: Ultra-high energy detection	4
New detectors: Near detectors	1
New detectors: LHC forward nu detection	1
Dark matter/neutrino detectors	9
New instruments: ASICs	1
New instruments: Optics	1
New instruments: Pixels	3
Simulation packages	4
Analysis tools	5
Calibration and Test Facilities	2
Experimental Facilities	3
Novel detectors	2
TOTAL	**64**

New Detectors and R&D: Noble elements/TPCs

TITLE	Description
Dual-Readout Time Projection Chamber: exploring sub-millimeter pitch for directional dark matter and tau identification in $\nu\tau$ CC interactions	TPC with sub-millimeter pitch for direct dark matter and tau neutrinos.
Improving Large LArTPC Performance Through the Use of Photo-Ionizing Dopants	Photo-ionizing dopants to convert scintillation into directional ionization; signal enhancement, avoid anti-correlations of scint. vs. ionization, linear detector response.
Development of LArTPC Vertical Drift Solutions with PCB Anode Readouts for DUNE	Vertical drift design with PCB anode charge readout. ARAPUCA light detector on the cathode with optical fiber readout and power over fiber.
Low Background kTon-Scale Liquid Argon Time Projection Chambers	Precise timing photon detectors for proton decay (p->Kv) in a LArTPC.
Precision Calibration of Large LArTPC Detectors	Calibration strategies for large LArTPCs.
High-pressure xenon gas time-projection chambers for neutrinoless double-beta decay searches	R&D for HP gas xenon TPC for 0vbb. Replace PMTs with SiPMS (to reduce backgrounds) and explore gas mixtures to reduce diffusion.
Electron multiplication in liquid argon TPC detectors for low energy rare event physics	Charge amplification on LAr. Exploiting the different anodes geometry to quantify gain at different strengths of the electric field
Scintillating and Quenched Gas Mixtures for HPGTPCs	Systematic studies of gas mixture of argon, xenon, nitrogen, etc for HPGTPC for neutrino detection and dark matter searches.
Data Acquisition and Trigger Enhancements for Low-Energy Events in DUNE	Development of intelligent data selection tools and algorithms for enhancing physics program of DUNE. Target low energy (~MeV) single interactions for solar neutrinos, supernovae, astrophysics, and BSM searches.
Applications for Underground Argon	The Global Argon Dark Matter Collaboration (GADMC) is developing facilities for the extraction and purification of underground argon (UAr), which is depleted in 39Ar. Applicable in neutrinos for CEvNS, 0vbb, and DUNE.

New Detectors and R&D: WC/Scintillator/WbLS

TITLE	Description
Cherenkov/scintillation separation via spectral photon sorting with dichroicons for next-generation neutrino detectors	Dichroicon technology used to identify pure Cerenkov photons outside a scintillation spectrum
Alternative Design for Large Scale Liquid Scintillator Detectors: Stratified LIquid Plane Scintillator (SLIPS)	SLIPS --- floating liquid scintillator on glycol to save PMT costs, reduce external backgrounds
ANNIE Detector R&D	Upgrade of ANNIE detector with WbLS and add more LAPPDs for new neutron measurements.
Neutrino Physics and Nuclear Security Motivations for the Continued Development of Organic Scintillators with Pulse Shape Discrimination Capability and 6 Li-doping	Development of PS plastic scintillators doped with ^{6}Li for nuclear security motivations
An Application of Pulse Shape Sensitive Plastic Scintillator - Segmented AntiNeutrino Directional Detector (SANDD)	Development of PS plastic scintillators doped with ^{6}Li or ^{10}B to discriminate neutrons and gamma-ray
A kiloton-scale water-based liquid scintillator detection concept for the Advanced Instrumentation Testbed in Northern England	kton-scale anti-ν_e detection for the purpose of nuclear non-proliferation. Monitoring of nuclear power plant 25km away in a underground facility.
A Method to Load Tellurium in Liquid Scintillator to Study Neutrinoless Double Beta Decay	SNO+ collab. A method to dilute Te(OH)6 and butanediol with DDA in organic LS for $\nu 00\beta$ decay
T HEIA : Water-based Liquid Scintillator	Technology to separate Cerenkov and Scintillation light. Detection of geo-neutrinos and anti-ν_e neutrinos.
A 50 Ton Scale Water Cherenkov Test Platform in a Charged Particle Test Beam	Studies of performance and response of different detectors, Gd loading and WbLS, and calibration.
Antineutrino detection at THEIA	Large scale novel detector with the characteristic to discriminate cerenkov from scintillation light. Photon detector PMT or LAPPDs and Dichroicons. Detections of geo-neutrinos and anti-ν_e neutrinos.
Encapsulation of Photosensors in kton--Mton Scale Neutrino Detectors	Encapsulation of photosensors in kton–Mton neutrino detectors to prevent background contamination, and provides a chemically inert gaseous environment, enabling the deployment of calibration devices. This work is planned to be used in AIT–NEO, a reactor antineutrino detector.

New Detectors and R&D: Coherent ν detection

TITLE	Description
COHERENT LOI 5: Instrumentation Development	CEνNS with different technology: LAr detectors, High-purity Ge detectors, CsI(Na)
Towards Directional Nuclear Recoil Detectors: Tracking of Nuclear Recoils in Gas Argon TPCs	Gaseous argon TPCs to track nuclear recoils down to 10-100 um. Provides directionality - key feature. GEM-based GAr TPC.
Magnetic Microcalorimeters for CEvNS Detection	MMC for CEvNS, for sterile, non-standard interactions, neutrino magnetic moment,
Neutrino Physics with Noble Liquid Bubble Chambers	Liquid Xenon bubble chamber, sub-keV threshold for CEvNS detection, threshold goal: 100eV; prototype demonstrated 0.5keV threshold; 10kg detector under construction
Far-Future COHERENT physics program at the SNS	COHERENT far future: precision physics at lowE, low threshold to explore magnetic moment and light mediator searches, Ge detectors, cryogenic scintillators; large monolithic detectors.
Noble Liquids for the Detection of CEvNS from Artificial Neutrino Sources	Liquid noble detection of CEvNS with 100kg scale DM detectors at the SNS or reactors, physics: new physics with CEvNS + characterization of detectors for solar neutrino and DM detection beyond the neutrino floor
Reactor Neutrino Detection Experiment using Skipper CCDs.	Construction of a short-baseline neutrino program based on Skipper Charge Coupled Devices (Skipper-CCDs) at a nuclear reactor facility. Very low energy threshold ~eV.

New Detectors: Ultra-high energy

CPM session being organized (CF07, NF04, NF10).

TITLE	Description
The Beamforming Elevated Array for COsmic Neutrinos (BEACON)	Radio Antena array for detection cosmogenic tau neutrinos
A next-generation cosmic-ray detector to study the physics and properties of the highest-energy particles in Nature	40,000km^2 cosmic ray detector
IceCube-Gen2: The Window to the Extreme Universe	Upgrade of IceCube: increase event rate (factor 10), fainter sources (5 times), energy range (orders of mag).
An Andean Deep-Valley Detector for High-Energy Tau Neutrinos	TAMBO, a Deep-Valley air shower detector, possibly in Peru, for high-energy tau neutrino detection (1-100 PeV). Motivation is that it is complementary to ICECUBE etc that struggle with taus.

New Detectors: Near Detectors

TITLE	Description
3D-projection Scintillator Tracker (3DST) in SAND, a DUNE Near Detector Subsystem	3DST/SAND --- pixelated liquid scintillator, neutron detection capability

New Detectors: LHC Forward ν Detection

TITLE	Description
Neutrino / Dark Particle Detectors for the HL-LHC Forward Beam	FASER---emulsion or possible LArTPC detector for LHC neutrinos

Dark matter / neutrino detectors

TITLE	Description
Paleo Detectors	Direct WIMP detection in natural minerals
CYGNUS: A nuclear recoil observatory with directional sensitivity	Direct WIMP detection using MPGDs – Solar ν
Metastable Water: Breakthrough Technology for Dark Matter & Neutrinos	"PICO with ice", could work for CEvNS
Cryogenic Carbon Detectors for Dark Matter Searches	Low thresholds dark matter searches with diamond or sic crystal - CEvNS
A Strategy for Low-Mass Dark Matter Searches with Cryogenic Detectors in the SuperCDMS SNOLAB Facility	Direct WIMP detection – Solar ν / CEvNS
Phonon-Mediated KID-Based Detectors for Low-Mass Dark Matter Detection and Coherent Elastic Neutrino-Nucleus Scattering	KIDs (kinetic inductance detectors) for low-mass DM and neutrino coherent scattering.
Non-destructive readout in CMOS technology	Light Dark Matter detection with skipper CCD
BULLKID: Low-threshold Kinetic Inductance Detectors for neutrino and dark matter searches	DM and CEvNS. Detector based on the phonon-mediated KIDs.
The Neutrino Physics program of the Global Argon Dark Matter Collaboration	Neutrino program of the global argon Dark Matter collaboration. Multiple detectors can detect SN, CNO, ^{8}B, v00b decay with Xe doping in LAr.

New instruments: ASICs

TITLE	Description
Analog Photon Processor ASIC	"Analog Photon Processor": Readout electronics for photon sensors (low photon rate) focusing on number of photons and timing. Motivation: cost reduction (DAQ and storage), dynamic range, higher precision, analysis time. Aplications: large scale DM and neutrino experiments

New instruments: Optics

TITLE	Description
Spectral Photon Sorting With The Dichroicon	Dichroicon: Discrimination of scintillation and Cherenkov light, discrimination of backgrounds, Winston cones, filters grouped with PMT, SiPM or LAPPD; functionality demonstrated with prototypes, broad application, liq. scint + water-based liq. scintillator --> enabling technology

New instruments: Pixels

TITLE	Description
Pixels for charge+light in LArTPCs	Pixels for charge+light in LArTPCs
An R&D Collaboration for Scalable Pixelated Detector Systems	Scalable pixelated detector for neutrino and dark matter with LAr
Q-Pix: Kiloton-scale pixelated liquid noble TPCs	Qpix pixels for large-scale TPCs

Simulation Packages

TITLE	Description
Chroma Photon Ray Tracer for Large-Scale Detectors	Fast Optical MC simulation with massive parallel calculation inside GPU
Fast Simulations for Noble Liquid Experiments	Optimization of MC simulation for supercomputers to support several noble liquid experiments
The RAT(-PAC) simulation and analysis code base	Open source GEANT4 toolkit that offer to simulation capability and analysis tools for high precision event modeling, evaluation and characterization from small setups to large scale detectors.
NEST, The Noble Element Simulation Technique:	multi-collaboration effort LUX, XENON, nEXO, RED, COHERENT, DUNE, SBN, MicroBooNE, ICARUS, Global Argon; Pool of world data on techniques (light yield, charge yields), interactions, broad physics reach

Analysis Tools

TITLE	Description
Wire-Cell Toolkit	Wire-Cell Toolkit software
Machine Learning Techniques and Software for Neutrino Physics	Outlines main thrusts and challenges that has come from recent ML workshops involving many neutrino experiments.
Data Preservation at Minerva	Data Preservation at Minerva
Scalable, End-to-End Optimizable Data Reconstruction and Physics Inference Techniques for Large-scale Particle Imaging Neutrino Detectors	Optimization of data reconstruction
IceCube and IceCube-Gen: Quantum Computing Opportunities	Draws attention to possible future QC applications to simulation and data analysis in IceCube (and other expts)

Calibration and Test Facilities

TITLE	Description
CHESS	CHESS is a testing facility for fast photodetectors and liquid scintillator properties located at LBNL. Particularly applicable to future large LS detectors such as THEIA.
Nuclear Recoil Calibration Techniques for Dark Matter and Neutrino Experiments	Overview and discussion on nuclear recoil calibration techniques

Experimental Facilities

TITLE	Description
The Sanford Underground Research Facility	Detailed description of Sanford Underground Research Facility (SURF). "Applications from new experiments are welcome!"
An Ultralow Background Facility to Support Next Generation Rare Event Physics Experiments	Joining forces from DM, neutrino, chemists, radiochemists, materials scientists, mechanical+electrical engineers.
Solution-mined salt caverns as sites for underground physics experiments	Propose to use a existing salt caverns for underground small detectors. CLUSO (Ohio)

Novel Detectors

TITLE	Description
Neutrino Detector Spacecraft	Idea to run neutrino detector in space, detector operated unshielded in space, delayed timing pulse coincidence technique to reduce backgrounds, science goals: solar neutrinos with high rate in close solar orbit, DM searches without solar neutrino background in high orbits.
LiquidO: a Novel Approach to Detecting Neutrinos	Neutrino detector with an opaque scintillator and optical fibers allows for imaging of the events down to the MeV

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- If you submitted an LOI not listed here that you would like to make sure is addressed by our group, please **email us** to draw it to our attention.

- Once we complete the review of all LOIs (incl. secondary), will use these inputs for the planning of **Neutrino Detectors Workshops** (after the Snowmass CPM and before the NF meeting in March) where these ideas can be shared within the community.

- Will also be looking to solicit **White Papers**, possibly that group several related categories, as preparation for (and supporting documents to) the eventual Snowmass Report.

- To be sure to receive announcements, can join the topical group mailing list: SNOWMASS-NF10-DETECTORS@fnal.gov