CPAD Instrumentation Frontier Workshop 2021

Gaseous Detectors Parallel Sessions & Track (version - 12.03.2021)

Thursday, 18 March 2021, Session – I (12:00 – 13:40 US EST)
Session Chair: Sven Vahsen (University of Hawaii, USA)

12:00 – 12:20 (#37) TPC Development by the LCTPC Collaboration for the ILD Detector at ILC – Jochen Kaminski (University Bonn, Germany)

12:20 – 12:40 **(**#148) Status and prospects of TPC module and prototype R&D for CEPC - Huirong Qi (Institute of High Energy Physics, CAS, China)

13:00 – 13:20 **(**#31) Options for gain elements and gas mixtures in a high rate EIC Time Projection Chamber - Dr Bob Azmoun (BNL, USA)

13:00 – 13:20 **(**#95) A novel TPC concept for a fast tracker for MAGIX - Stefano Caiazza (KPH Institute - JGU Mainz, Germany)

13:20 – 13:40 **(**#108) NEWS-G: Search for Light Dark Matter with Spherical Proportional Counters - Konstantinos Nikolopoulos (University of Birmingham, UK)

Thursday, 18 March 2021, Session – I (14:00 – 16:00 US EST)
Session Chair: Maxim Titov (Irfu, CEA Saclay, France)

14:00 – 14:20 **(**#71) Detecting neutrinos and measuring nuclear quenching factors with spherical proportional counters - Marie Vidal (Queen's University, UK)

14:20 – 14:40 **(**#110) Recent advancements on the spherical proportional counter instrumentation for NEWS-G - Ioannis Katsioulas (University of Birmingham, UK)

14:40 – 15:00 **(**#170) CYGNUS: Imaging of low-energy nuclear recoils in gas TPCs - Sven Vahsen (University of Hawaii, USA)

15:00 – 15:20 **(**#75) Vector tracking in low-energy nuclear recoils - Peter Lewis (University of Bonn, Germany)

15:20 – 15:40 **(**#60) The CYGNO TPC: Optical Readout for Directional Study of Rare Events - Davide Pinci (INFN - Sezione di Roma, Italy)

15:40 – 16:00 (#128) Electroluminescence studies for CYGNO - Directional Dark Matter search with an optical TPC - Dr Cristina M B. Monteiro (Department of Physics, University of Coimbra, Portugal)

Friday, 19 March 2021, Session – I (12:00 – 13:40 US EST)
Session Chair: Sven Vahsen (University of Hawaii, USA)

12:00 – 12:20 (#82) Performance and stability of a High Granularity Resistive Micromegas at high particle rates - Massimo Della Pietra (University of Naples "Federico II"/INFN, Italy)

12:20 – 12:40 (#149) The CGEM-IT of the BESIII experiment: preliminary results of the cosmic data taking - Giulio Mezzadri (INFN-IHEP Fellow, Italy/China)

12:40 – 13:00 (#147) Gaseous Time Projection Chamber for Ultra-low Radioactive Material Screening - Haiyan Du (Shanghai Tong University, China)

13:00 – 13:20 (#97) Towards studying photonuclear reactions with active-target TPC - Mateusz Fila (University of Warsaw, Poland)

13:20 – 13:40 (#47) A High-Pressure Gaseous-Argon TPC as a Component of DUNE Near Detector - Dr Tanaz Mohayai (Fermilab, USA)

Friday, 19 March 2021, Session – I (14:00 – 15:10 US EST)
Session Chair: Maxim Titov (Irfu, CEA Saclay, France)

14:00 - 14:20 (#178) Gas-filled Neutron Imager Operating in Ionization Mode - Graham Smith (BNL, USA)

14:20 - 14:40 (#80) A Low Energy Recoil Tracker Hyperbolic Drift Chamber - Lucien Causse (IJCLab, France)

14:40 - 15:00 (#160) Lessons from Mu2e Tracker Construction and Mu2e-II Tracker Opportunities - Daniel Ambrose (University of Minnesota, USA)

If you are a speaker, please also be sure to check the official schedule directly in Indico as we get close to the conference, in case there are schedule changes:
https://indico.fnal.gov/event/46746/sessions/17781/#all

Gaseous Detectors Track & Session:

31 - Options for gain elements and gas mixtures in a high rate EIC Time Projection Chamber

Speaker - Bob Azmoun (BNL)

In order to investigate options for a future high rate TPC we have tested various gas gain structures and gas mixtures. Our goal was to focus on crucial TPC parameters: ion back flow, energy resolution (dE/dx), electron and ion drift speed, electron diffusion (in E- and B-fields), and stability. We concentrated on two options for the gain structure: 4 GEMs and MMG+2GEMs. For the hybrid option we achieve simultaneously an ion back flow below 0.3% and an energy resolution better than 12% for 55Fe X-rays at a gain of ≈2000 in a variety of gas mixtures. A few gas mixtures that we studied haven't typically been used in a TPC, but appear promising, and further testing is recommended. Additionally, we investigated a potential instability (especially for MMGs) that occurs primarily from a high voltage (HV) power supply (PS) voltage drop in reaction to a discharge. It was demonstrated that a resistive protection layer on a pad / strip readout structure reduces the HV PS voltage drop after a spark to practically negligible levels. The hybrid micro-pattern gas amplification stage allows for a TPC design that can operate in a continuous mode, serves as a viable option to limit space charge distortions in high-rate TPCs, and guarantees that dE/dx, ionization cluster space reconstruction resolution, drift parameters and detector stability will not be compromised.

37. TPC Development by the LCTPC Collaboration for the ILD Detector at ILC

Speaker – Jochen Kaminski (University of Bonn)

A large, worldwide community of physicists is working to realise an exceptional physics program of energy-frontier, electron-positron collisions with the International Linear Collider (ILC). The International Large Detector (ILD) is one of the proposed detector concepts at the ILC. The ILD tracking system consists of a Si vertex detector, forward tracking disks and a large volume Time Projection Chamber (TPC) embedded in a 3.5 T solenoidal field. An extensive research and development program for a TPC has been carried out within the framework of the LCTPC collaboration. A Large Prototype TPC in a 1 T magnetic field, which allows to accommodate up to seven identical Micropattern Gas Detector (MPGD) readout modules of the near-final proposed design for ILD, has been built as a demonstrator at the 5 GeV electron test-beam at DESY. Three MPGD concepts are being developed for the TPC: Gas Electron Multiplier, Micromegas and GridPix. Successful test beam campaigns with different technologies have been carried out between 2014 and 2019. Fundamental parameters such as transverse and longitudinal spatial resolution and drift velocity have been measured. In parallel, a new gating device based on large-aperture GEMs have been produced and studied in the laboratory. In this talk, we will review the track reconstruction performance results and summarize the next steps towards the TPC construction for the ILD detector.

47. A High-Pressure Gaseous-Argon TPC as a Component of DUNE Near Detector

Speaker - Tanaz Mohayai (Fermilab)

The main goals of the Deep Underground Neutrino Experiment (DUNE) are to measure CP violation in the lepton sector, to make precise measurements of neutrino oscillation parameters, to observe supernova burst neutrinos, and to detect rare processes such as proton decay. To fulfill these goals, DUNE will use a highly capable suite of near detectors with several components, one of which is the high-pressure gaseous-argon TPC (HPgTPC) surrounded by a calorimeter and a magnet. As a fine-grained tracker with a low detection threshold, HPgTPC is capable of measuring one of the most crucial sources of systematic uncertainties in neutrino oscillation measurements: nuclear effects in argon at the neutrino interaction vertex. In this talk, an overview of the HPgTPC design and the on-going R&D efforts will be presented

60. The CYGNO TPC: Optical Readout for Directional Study of Rare Events

Speaker - Davide Pinci (INFN - Sezione di Roma)

CYGNO is a project realising a cubic meter demonstrator to study the scalability of the optical readout concept for a large-volume, GEM-equipped TPC, to be employed as directional detectors for rare events detection. The combined use of high-granularity sCMOS and fast sensors for reading out the light produced in GEM channels during the multiplication processes was shown to allow reconstructing 3D direction of the tracks, offering accurate energy measurements and sensitivity to the source directionality. This type of detector has demonstrated a high particle identification capability, very useful to distinguish nuclear from electron recoils. Performance of the large prototype (50 litres sensitive volume, 50 cm drift gap, 1000 cm2 readout plane) will be shown and discussed.

71. Detecting neutrinos and measuring nuclear quenching factors with spherical proportional counters

Speaker - Marie Vidal (Queen's University)

NEWS-G (New Experiments With Spheres-Gas) is a rare event search experiment using Spherical Proportional Counters (SPCs). Primarily designed for the direct detection of dark matter, this technology also has appealing features for Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) studies and, potentially, searches for neutrinoless double beta decay. A study to assess the feasibility of observing CEvNS at a nuclear reactor will be presented.

Both direct dark matter detection and CEvNS consist of nuclear recoils from elastic scatters. The nuclear quenching factor, defined as the ratio of the measured energy induced by a nuclear recoil and an electronic recoil of the same energy, is a property of the target material and must be determined. Nuclear quenching factor measurements in a neon based gas mixture were performed at TUNL (Triangle Universities Nuclear Laboratory) using a neutron beam and preliminary results will be presented.

75. Vector tracking in low-energy nuclear recoils

Speaker - Peter Lewis (University of Bonn)

Gaseous Time Projection Chambers (TPCs) can be used in Directional Dark Matter (DDM) searches to unambiguously identify a galactic origin for Dark Matter candidates. Directional sensitivity at low recoil energies is limited by diffusion, dispersion during amplification, and digitization effects such as charge pileup. We discuss a new algorithm that models and partially removes these effects for a model TPC based on current technology. Furthermore, we show that it is possible to largely recover the primary 3D ionization charge distribution, leading to a reduction in reconstruction errors. These results have implications for the next generation of DDM detectors, which we will briefly discuss.

80. A Low Energy Recoil Tracker hyperbolic drift chamber

Speaker - Mr Lucien Causse (IJCLab)

A Low Energy Recoil Tracker (ALERT) experiment will occur in Hall B at Jefferson Laboratory, Virginia, USA. It will study the partonic structure of bound nucleons in He-4. The ALERT detector must track and identify low energy nucleons and light nuclei of momenta ranging from 70 MeV/c to 250 MeV/c at a rate up to 60 MHz. It will be used in tandem with the already installed CLAS12 spectrometer in Hall B to detect the scattered electrons.

ALERT is composed of a tracker and a time of flight detector (TOF). The tracker is designed to minimize the amount of material before the particles reach the TOF. This talk will present the ALERT Hyperbolic Drift Chamber developed for the tracker suitable for the high counting rate, high acceptance, and resolution needs of the experiment. After showing the wire support evolution, the mechanical challenges and mounting procedure of the wires that are 2 mm apart will be detailed. I will then present the performance of a prototype obtained during beam tests performed at a local facility (ALTO) in Orsay, France.

82. Performance and stability of a High Granularity Resistive Micromegas at high particle rates.

Speaker - Massimo Della Pietra (University of Naples "Federico II" and I.N.F.N.)

Nowadays Micromegas (MM) are being used as tracking detectors in HEP experiment upgrades as in ATLAS experiment at LHC. Nevertheless, next experiments at very high energy and intensity accelerators will demand stable and efficient operations up to particle fluxes of few orders of magnitude higher. To fulfill such requirements, we are developing the MM technology to increase its rate capability up to 10 MHz/cm2.

In resistive MM, the anodic readout elements are overlayed by a resistive protection layer to reduce the spark probability. We tested several MM prototypes with a high-granularity readout plane, with 1x3 mm2 size pads, and different resistive protection schemas exploiting a pad-patterned layer or two uniform DLC layers. To cope with the high number of readout channels and allow for the size scalability of the detector avoiding dead areas, we are studying the integration of the readout electronics in the back of the detector. Characterization and performance studies of many detectors have been carried out by means of radioactive sources, X-Rays, and test beam. A comparison of the performance obtained with the different resistive layout is presented, in particular focusing on the response under high irradiation and high-rate exposure

95. A novel TPC concept for a fast tracker for MAGIX

Speaker - Stefano Caiazza (KPH Institute - JGU Mainz)

MAGIX is a new precision experiment, currently being developed at the Johannes Gutenberg University in Mainz, that will explore fundamental nuclear and particle physics at energies up to 100 MeV at the MESA high intensity electron beam.

To achieve its goals, MAGIX requires two short-drift, low material budget TPCs. Those detectors will feature a novel open field-cage concept to reduce the material budget and will be among the first major users of the new SRS+VMM3 readout system which will allow them to achieve readout rates above 100 kHz.

In this work, we will illustrate the most innovative aspects of this project and present the results of the first measurement campaigns.

97. Towards studying photonuclear reactions with active-target TPC

Speaker - Mr Mateusz Fila (University of Warsaw)

Stellar evolution modeling requires knowledge of the mechanism and cross-section of nuclear reactions. Given the conditions in the stellar interior, the stellar reactions occur predominantly within relatively narrow energy ranges well below the Coulomb barrier.

For many (α,γ), (p,γ) reactions important for stellar nucleosynthesis the measurement of their cross-sections at the relevant energies is impossible with present experimental conditions. Among these reactions is the 12C(α,γ)16O reaction, which determines the carbon to oxygen ratio at the end of stellar helium burning — a paramount importance problem in nuclear astrophysics.

Thanks to the availability of intense, monochromatic γ-ray beams, to obtain accurate cross-sections at relevant energies, the time-reversal photodisintegration reactions can be investigated instead. Given the time-invariance of the strong and electromagnetic interactions, the cross-sections of (α,γ), (p,γ) reactions can be calculated according to the detailed balance principle from the cross-section of the corresponding time-reversal photodisintegration. The photodisintegration approach has the advantage of larger cross-section, lower background, and different systematic uncertainties.

A detector capable of measuring the low energy products of such photonuclear reactions — an active-target Time Projection Chamber with electronic readout (ELITPC) — is being developed at the University of Warsaw. Full kinematic reconstruction of the charged reaction products will be possible. The flagship experiment of the detector is the measurement of the cross-section of 16O(γ,α)12C photodisintegration reaction down to the energy of 1 MeV using γ-ray beams of HIγS, USA and ELI-NP, Romania.

In my talk, I will present the design of the ELITPC detector and describe its experimental program. Within the ELITPC collaboration, my main contribution is the development of event reconstruction software using classic computer vision algorithms and dedicated detector control system.

108. NEWS-G: Search for Light Dark Matter with Spherical Proportional Counters

Speaker - Konstantinos Nikolopoulos (University of Birmingham)

The NEWS-G collaboration is searching for light dark matter candidates using a novel detector concept, the spherical proportional counter. Access to the mass range from 0.05 to 10 GeV is enabled by the combination of low energy threshold, light gaseous targets (H, He, Ne), and highly radio-pure detector construction. Initial NEWS-G results obtained with SEDINE, a 60 cm in diameter spherical proportional counter operating at LSM (France), excluded for the first time WIMP-like dark matter candidates down to masses of 0.5 GeV. The construction and

on-going commissioning of a new, 140 cm in diameter, spherical proportional counter constructed at LSM using 4N copper with 500 um electroplated inner layer will be presented. The detector is scheduled to collect data in SNOLAB (Canada) later this year. The design and construction of ECUME, a 140 cm in diameter spherical proportional counter fully electroformed underground will be discussed. The potential to achieve sensitivity reaching the neutrino floor in light Dark Matter searches, with a next generation detector are also summarised.

110. Recent advancements on the spherical proportional counter instrumentation for NEWS-G

Speaker - Ioannis Katsioulas (University of Birmingham)

NEWS-G (New Experiments With Spheres-Gas) is an innovative experiment aiming to shine a light on the dark matter conundrum with a novel gaseous detector, the spherical proportional counter. It uses light gases, such as hydrogen, helium, and neon, as targets, to expand dark matter searches to the 0.05 - 10 GeV/c2 mass region. NEWS-G produced its first results with a detector -60 cm in diameter- installed at LSM (France), excluding cross-sections above 4.4 ⋅ 1037 cm2 for 0.5 GeV/c2 WIMP using neon gas. Currently, a larger detector -140 cm in diameter- is being installed at SNOLAB (Canada) and the commissioning is expected to commence in March 2021, before operation later this year. In this talk, I present developments incorporated in this new detector: a) sensor technologies using resistive materials and multi-anode read-out that allow high gain - high-pressure operation, b) gas purification techniques to remove contaminants (H2O, O2) and radon impurities, c) reduction of 210Pb induced background through copper electroforming methods, d) utilisation of UV-lasers for detector calibration, detector response monitoring and estimation of gas-related fundamental properties, e) field correction electrodes to achieve a homogenous response from the whole detector volume. This next experimental phase of NEWS-G will allow searches for low mass dark matter with unprecedented sensitivity. Finally, ideas on future R&D for spherical proportional counter sensor instrumentation, aiming at high-pressure operation in larger volumes are outlined.

128. Electroluminescence studies for CYGNO - Directional Dark Matter search with an optical TPC

Speaker - Dr Cristina M B. Monteiro (Department of Physics, University of Coimbra)

CYGNO (a CYGNus TPC with Optical readout) is a gaseous TPC Dark Matter directional experiment, to be hosted at Laboratori Nazionali del Gran Sasso, Italy. It fits into the context of the wider CYGNUS international proto-collaboration, for the development of a Galactic Nuclear Recoil Observatory at the ton-scale with directional sensitivity, having as the main goal the probing of the DM hypothesis below the Neutrino Floor and perform Solar Neutrino Physics.

In the CYGNO-TPC, the output signal results from the electroluminescence produced in the avalanches which develop in the strong electric fields inside the holes of the micropattern-type structures used for charge multiplication, and is collected by suitable photosensors. For the purpose of the experiment, the best gas and gas mixtures are being optimized, aiming at best performance in terms of the most relevant parameters, including identification of nuclear recoils and their direction.

We will present results for electroluminescence yield, charge gain and energy resolution for several gas mixtures of interest to the CYGNO project, namely He-CF4 mixtures and He-CF4-isobutane mixtures. The measurements were performed in a gaseous detector, equipped with a GEM for charge multiplication of the ionization signal and a Large Area Avalanche Photodiode to readout the electroluminescence produced in the electron avalanches.

147. Gaseous Time Projection Chamber for Ultra-low Radioactive Material Screening

Speaker - Mrs Haiyan Du (Shanghai Jiao Tong University)

Ultra-low radioactive material screening is becoming a key requirement for a successful rare event search experiment such as dark matter and neutrinoless double beta decay searches. We proposed a low-background, large-area, and high-granularity gaseous time projection chamber (TPC) with Micromegas readout plane for surface alpha/beta contamination measurements. With the unique tracking capability, the gaseous TPC is able to distinguish the origin of events and identification of particle types. In this presentation, we will describe the conceptual design of the TPC, the screening sensitivity, and the preliminary test of a prototype.

148. Status and prospects of TPC module and prototype R&D for CEPC

Speaker - Dr Huirong Qi (Institute of High Energy Physics, CAS)

To meet the high precision physical goals in the future e+e− circular collider (CEPC), the high resolution tracker detector for the particle track reconstruction (<100μm) and particle identification are demanded. Time Projection Chamber (TPC) is one of the main concept option of the central tracker detector. On behalf of the track detector subgroup in CEPC, the status and update R&D results of TPC module and prototype for the specific requirements will be presented in this talk. TPC module will could suppress the ions in chamber continuously running in the different gains (2000-5000) and T2K mixture gases, and TPC prototype with MPGD detector module integrated the narrow laser calibration tracks system. the update results of the spatial resolution, dE/dx will be presented too, and the update results of the requirements, simulation and consideration will be given according to the pad and pixel TPC detector concepts will operate at the high luminosity Z pole at CEPC.

149. The CGEM-IT of the BESIII experiment: preliminary results of the cosmic data taking

Speaker - Giulio Mezzadri (INFN-IHEP Fellow)

Since 2008, the BESIII (Beijing Spectrometer III) experiment is running at the leptonic collider BEPCII (Beijing Electron Positron Collider II), hosted at the Institute of High Energy Physics of Beijing, PRC. A 10-year extension of the BESIII operations has been approved recently, and both the detector and the collider are now upgrading to cope with the extended physics program. One of the main upgrades is the replacement of the present inner tracker with a new detector based on Cylindrical GEM (Gas Electron Multipliers). The CGEM-IT (Cylindrical GEM Inner Tracker) detector is composed of three layers of cylindrical triple-GEMs and it will be read-out by the ASIC TIGER, which will allow to have simultaneous time and charge information for the hits. At present time, in Beijing, two of the final layers are collecting cosmic data to finalize the commissioning while waiting for the final later to be shipped from Italy. In this presentation, an overview of the CGEM-IT project will be presented, with a focus on the preliminary results from cosmic data taking.

160. Lessons from Mu2e Tracker Construction and Mu2e-II Tracker Opportunities

Speaker - Dr Daniel Ambrose (University of Minnesota)

The Mu2e experiment at Fermilab will search for the neutrinoless conversion of a muon into an electron in the field of an Al nucleus, with a sensitivity improvement of four orders of magnitude over previous measurements. Observation of this process would be unambiguous evidence for physics beyond the Standard Model. The signature of muon to electron conversion is a monoenergetic electron with energy nearly equal to the muon mass. Precise tracking with minimal energy loss or multiple scattering is paramount to this measurement. The Mu2e tracker will consist of 20,000 thin-walled straw tubes operating in a vacuum of 10−4 torr. The construction process of the tracker has imparted many lessons and techniques which have improved functionality and building efficiency of the detector. These lessons will help to improve the design for future detectors, such as the tracker required for Mu2e-II, a proposed upgrade to the Mu2e experiment. In this talk, we will discuss the Mu2e tracker, lessons learned during the ongoing construction process, as well as Mu2e-II tracker options and opportunities for improvement.

170. CYGNUS: Imaging of low-energy nuclear recoils in gas TPCs

Speaker - Sven Vahsen (University of Hawaii)

With some leading direct dark matter detection experiments now observing background events and WIMP-nucleon scattering limits approaching the neutrino floor, there is renewed interest in constructing an observatory capable of detecting and distinguishing WIMP and coherent elastic neutrino-nucleus scattering (CEvNS) via directionality. CYGNUS aims to deploy gas-target time projection chambers (TPCs) capable of event-by-event nuclear recoil imaging. Smaller, near-term detectors with this capability would enable new precision measurements, including of the Migdal effect, searches for beyond the Standard Model (BSM) physics, and measurements of solar neutrinos. A large detector could establish the galactic origin of a dark matter signal, and subsequently be used to map the local WIMP velocity distribution and explore the particle phenomenology of dark matter. Therefore, there exists an opportunity to develop a long-term, diverse, and cost-effective experimental program around directional detection of nuclear recoils in gas TPCs at different scales. I will discuss the different technological approaches being pursued in CYGNUS, with a focus on activities in the US.

178. Gas-filled Neutron Imager Operating in Ionization Mode

Speaker - Graham Smith (BNL)

We describe the development of a new position-sensitive detector for neutrons that uses He-3 as the neutron sensing element and operates in ionization mode, without any electron multiplication. The electrons created by the thermal neutron - He3 interaction are collected by discrete anode pads, each connected to an input channel of an ASIC mounted on the back of the anode pad plane. The custom 64 channel ASICs and their readout board can process events up to 25k/s. Using this concept, we have designed and constructed a large area detector for small angle neutron scattering with nearly 40,000 channels, yielding a total count rate of 10**8 cps over an area of 1m x 1m. Early results demonstrate excellent, stable performance for small-angle scattering. The detection technique also allows the observation of ionizing tracks from recoil nuclei created by fast neutrons.

Early Career Track (related to Gaseous Detectors)

150. The URANIA-V project: thermal neutron detection for radioactive waste and borders monitoring

Speaker - Giulio Mezzadri (INFN-IHEP Fellow)

The applications of neutron detection are growing also outside the particle physics community: radioactive waste management (RWM), radioactive portal monitoring (RPM), and imaging are some of the most active fields. Due to the shortage of He3, it is necessary to find reliable and effective alternatives. One of the most promising techniques is to use a Boron-coated gas detector: the neutrons convert into alpha particles (or Lithium ions) that can be later detected. The project μRANIA-V (μRwell Advanced Neutron Identification Apparatus) aims to detect thermal neutrons by means of the innovative μRwell gas detector. In particular, μRANIA-V is based on three pillars: increasing the neutron detection efficiency by introducing mesh and a grooved cathode; advance the technological transfer to industry, to reduce the production costs; prepare and test electronics to count the neutrons from the signals produced in the amplification stage. The optimization of the neutron detection technique, the first part of the study, has been developed within the EU-ATTRACT call. In this presentation, an overview of the project will be presented.

151. Monte Carlo simulation of CYGNO, an optical readout TPC for directional Dark Matter search

Speaker - Flaminia Di Giambattista (GSSI & INFN)

The CYGNO experiment aims at making use of the directionality of nuclear recoils produced in the sensitive volume of a gaseous TPC with optical readout to uniquely identify Dark Matter signals, whose direction would point to the Cygnus constellation.

As one of the steps towards the CYGNUS-TPC network of underground observatories for directional DM search at the ton scale, CYGNO collaboration is working at a 1 m3 demonstrator operated with a He:CF4 gas mixture at atmospheric pressure at Laboratori Nazionali del Gran Sasso. Light produced in a triple-GEM stack is read by a set of sCMOS cameras, providing the 2D projection of the track on the GEM plane, and photomultiplier tubes, to use the signal time structure to determine the component along drift direction. This readout approach will allow to exploit the topological signatures of the events providing a very good background rejection capability.

A complete Monte Carlo simulation based on results obtained from different software packages as Garfield, SRIM, GEANT4 has being developed as a crucial tool for the comprehension and optimization of detector performance. Latest results will be shown along with a detailed comparison with experimental data obtained with CYGNO prototypes.

187. Liquid Argon Time Projection Chamber Trigger Development with MicroBooNE and SBND

Speaker - Daisy Kalra (Columbia University)

The MicroBooNE and Short Baseline Near Detector (SBND) experiments are Liquid Argon Time Projection Chamber (LArTPC) neutrino detectors that have been collecting or will soon be collecting neutrino and cosmic data in the Fermilab Booster Neutrino Beam. They collectively aim to perform ν-Ar cross-section measurements, explore the low-energy excess in the νe spectrum reported by the MiniBooNE experiment, and search for sterile neutrino oscillations as part of three LArTPCs that make up the Short Baseline Neutrino (SBN) Program at Fermilab. Both detectors provide a unique opportunity for the implementation and testing of TPC-based triggers as R&D towards Deep Underground Neutrino Experiment (DUNE). One of the technical challenges that these studies aim to address is that of efficient self-triggering of a LArTPC utilizing TPC signal information. This capability will enable searches for rare processes in the DUNE, such as neutrino interactions from a potential galactic supernova burst, or baryon number violating nucleon decays. This talk will describe the MicroBooNE and SBND TPC readout systems and ongoing R&D efforts to develop and demonstrate TPC-based triggering.

Photon Detectors Track (also related to Gaseous Detectors)

79. MPGD-based detectors of Cherenkov photons in COMPASS and for future applications

Speaker - Fulvio Tessarotto (INFN Trieste and CERN)

The RICH-1 detector of the COMPASS Experiment at CERN has been upgraded in 2016 with four MPGD-based photon detectors covering a total active area of 1.5 m2. They consist in a hybrid combination of two THGEM layers and a Micromegas and convert VUV photons in a CsI layer on one THGEM. The anode is segmented in square pads of 8 mm pitch and the signal is read out via capacitive coupling by an APV-25 based FEE system. The new photon detectors operated stably with an effective gain of 14000, with a stability better than 5%, and an ion back-flow rate smaller than 3%. They provided about 11 photons per ring at saturation, with a single photon angular resolution of 1.8 mrad. The characteristics and the performance of the COMPASS MPGD-based photon detectors will be described in detail.

An R&D effort to improve this technology to cope with the challenging requirements of the high-momentum hadron PID at the EIC is ongoing. To validate a modular design with high anode granularity (pads of 3x3 mm2), a prototype has been built and tested in laboratory and in a test beam. The prototype, the results of the tests and the perspectives of this study are illustrated.

A dedicated R&D exploratory study of a new VUV photoconverter, more robust than CsI, has provided promising first results: hydrogenated diamond nanograins have been sprayed on THGEM samples and showed to be compatible with the operation of the THGEM as an electron multiplier.

This R&D programme and the preliminary results are presented and discussed.

125. Development Towards a Camera Readout and Barium Tagging Optical TPC,or CRAB-OTPC, for the NEXT Collaboration

Speaker - Nicholas Byrnes

Neutrinoless double beta decay (0νββ) is an extremely rare nuclear decay that occurs when two neutrons in a nucleus simultaneously beta decay without producing any antineutrinos. If observed, 0νββ would be the rarest decay process observed, and long target half lives of 1028 years necessitate development of new background suppression and signal identification methodologies. The NEXT experiment uses gaseous 136Xe and is pursuing an aggressive R&D campaign to implement Barium Tagging, detection of single daughter ions via super resolution fluorescence microscopy. This technique, if implemented with stringent energy cuts and topological identification, could effectively reduce experimental backgrounds to zero at the multi-ton scale. This talk will summarize R&D toward barium tagging in NEXT, with a particular focus 1) a novel class of switch-on fluorescence sensors that have enabled dry single barium dication detection for the first time; 2) progress toward implementation of topological event reconstruction using high speed optical cameras that would allow incorporation of a barium sensing plane in a xenon gas TPC, via the CRAB (camera readout and barium tagging) concept.

Noble Elements Track (also related to Gaseous Detectors)

48. A Digital Tension Measurement Device for Multi-Wire Particle Detectors

Speaker - Shion Kubota (Harvard University)

Description

We present s a novel and efficient device to measure wire tensions in particle physics detectors. Traditionally, a common method was to physically pluck each wire and detect its natural frequency with a laser.

In this new method, an alternating electric field across the neighboring wires vibrates the test wire in the middle. Due to the corresponding change in capacitance, a bipolar resonance in current amplitude can be detected when the wire's oscillation reaches its natural frequency.

This device can test multiple wires in parallel, and combined with the automation of the oscillation, it enables to considerably shorten the time taken by the quality check of the detectors.

137. High pressure gas TPC technology for neutrinoless double beta decay searches: The NEXT program

Speaker - Jonathan Haefner (Harvard University)

The NEXT experiment is a neutrino physics program searching for neutrinoless double beta decay using a high pressure gaseous xenon time projection chamber (HPGXeTPC). The HPGXeTPC technology offers several advantages, including excellent energy resolution, topological event discrimination, and low background. NEXT excels on each of these fronts, achieving 1% FWHM energy resolution at 2.6 MeV and a background rejection factor of 27 at 57% signal efficiency for 1.6 MeV electron-positron pairs. The resolution and event discrimination, along with our very radiopure detector, work together to allow us to achieve a background index of 4·10−4 counts/(keV·kg·yr). We will discuss these strengths of the technology for the detection of rare events, as well as the performance of the current iteration NEXT-White detector and plans for future detectors. As discussed in this talk, the intrinsically excellent energy resolution and topological event discrimination of the technology requires continuous Kr83m calibration throughout the active volume of the detector in order to be realized in practice.

Low Background / Low Threshold Detectors (also related to Gaseous Detectors)

103. Ba-tagging with fluorescence bicolor molecules for background-free $0\nu\beta\beta decay experiment.

Speaker - Rubén González Moreno (DIPC)

The next generation of neutrinoless double beta decay searches aims to reach sensitivities in the half-life of the process up to 1028 years. This will require tonne scale detectors with essentially no background in their region of interest. One of the most promising solutions, which may be implemented by gas or liquid xenon TPCs, is the possibility of tagging the daughter ion produced in the decay. The NEXT collaboration is currently involved in an intense R&D program based on fluorescent molecular indicators able to capture the Ba++ cation, changing their spectral response when chelated. In this talk, I will present one of the NEXT R&D lines, called BOLD, which proposes the use of fluorescent bicolor indicators (FBI). I will show the latest results based on the spectral shift of the emission fluorescence of this molecule after Ba++ capture in dry media. The emission light must be scrutinized to differentiate the signal of one chelated molecule among a background of non-chelated ones. I will show our current approach to the problem for Single-Molecule Fluorescence Imaging (SMFI) and the strategy to achieve the goal, i.e. integration of detection technique into a pressurized xenon gas detector.

115. A Quasi-Monoenergetic Neutron Beam for Calibrating Dark Matter Detectors

Speaker - Jean-François Caron (Queen's University)

At the 8 MeV proton accelerator of the Queen's University Reactor Materials Testing Laboratory, we are establishing a quasi-monoenergetic beam of neutrons. These neutrons will be used to induce nuclear recoils of known energy in the dark matter detectors of the NEWS-G experiment. This is needed to to measure the quenching factors of the various gases used, in particular in proton-rich gases such as methane and at lower recoil energies where no data exist. The quenching factor is ratio of detector response from a nuclear recoil compared to an

electronic recoil of the same energy (see Marie Vidal's contribution for more details). Beyond NEWS-G, access to the neutron beam will be opened up to other dark matter experiments or other users.

163. Dark side of afterglow: nuclear recoils and relaxation avalanches.

Speaker - Sergey Pereverzev (LLNL)

Metastable excitations in materials can store energy longer than equilibration time for the rest of the system. This disequilibrating can arise from a many sources - ionizing radiation, electric breakdown, mechanical stress, changes in temperature, and changes in electric or magnetic fields. Relaxation of stored energy leads to afterglow in gases or temperature stimulated luminescence, exaelectron emission and conductivity in solids (TSL,TSEE and TSC effects). Similar effects are present in liquids, on surfaces of dielectrics and semiconductors, in films on metal surfaces, etc. Such metastable excitations can undergo a range of transformations –they can interact and diffuse in materials, form clusters, accumulate around defects and on surfaces and interfaces. Accumulation of these interacting excitations leads to possibility of avalanche relaxation events. A well-known example is self-organized criticality dynamics; it results in a noise power spectral density that is close to 1/f, and spectrum of avalanches energies decreasing polynomially with energy. Such avalanche relaxation events can mimic low-energy interactions with particles: several photons can be produced in scintillators, or several electrons in ionization detectors. Yet un- explained low energy background (few photons or electrons events) in scintillators, dual-phase noble liquid detectors and some solid-state detectors hint that avalanche relaxation of accumulated energy may be a culprit.

While quantitative ab -initio description of these effect is difficult, we discuss qualitative experiments that can help to identify these effects, what material mechanisms can be involved in scintillators and noble liquids, and how parasitic effects can be suppressed or mitigated.