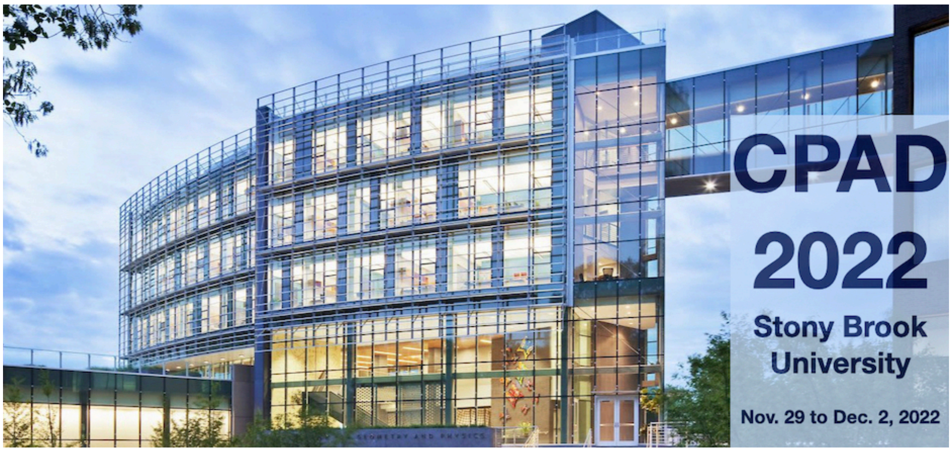
CPAD Workshop 2022



Report of Contributions

https://indico.bnl.gov/e/17072

Contribution ID: **1** Type: **Contribution Talk**

Nano-CMOS photon imager

Wednesday, 30 November 2022 14:55 (20 minutes)

Overview of the "Co-design and integration of nano-sensors on CMOS" project of the Microelectronics Co-Design Research DOE program. This is a 3-year multi-disciplinary development. The aim is to produce a demonstrator device using a pixellated CMOS ASIC as a back end upon which nano-materials are deposited to achieve single photon detection at LN2 or higher temperature, with high quantum efficiency, low dark counts, and with spectral information for every photon. The concept for this device evolved out of work previously presented at CPAD: https://agenda.hep.wisc.edu/event/1391/contributions/6971/

Primary authors: NONAKA, Andy (LBNL); TIKHOMIROV, Grigory (UC Berkeley); Dr FRANÇOIS, Léonard (Sandia NL); GARCIA-SCIVERES, Maurice (LBNL); RAJA, Archana (LBNL); PAPADOPOULOU, Katerina (LBNL); YOUNG, Mi (LBNL); MEI, Yuan (LBNL)

Presenter: GARCIA-SCIVERES, Maurice (LBNL)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **2** Type: **Contribution Talk**

Use of Diamond Sensors for High Radiation, Flux and Repetition Rate Applications

Thursday, 1 December 2022 08:30 (20 minutes)

Funded by its Office of the President, a consortium of University of California affiliated institutions has been exploring the use of electronic-grade diamond sensors for applications in extreme environments, including settings involving high fluences of hadronic particles (in excess of 10^16 Neq/cm^2), high instantaneous flux (approaching 100 J / cm^2 of deposited energy) and/or high repetition rate (approaching 10 GHz). Results are presented on the rate and efficiency of charge collection as a function of the electron-hole plasma density induced by the XPP beamline X-Ray laser beam at SLAC's LCLS. Additional studies on the intensity and position resolution of the XPP beam with a quadrant sensor capable of running at 50 MHz are also presented. Finally the results of a real-time charge-collection degradation study, performed at the Crocker Nuclear Laboratory on the UC Davis campus, for a hadronic fluence reaching 4x10^16 protons per cm^2, are presented.

Primary author: NIZAM, M (University of California Santa Cruz)

Co-authors: GONZALEZ, E (SCIPP, UCSC); KACHIGUINE, S (SCIPP, UCSC); MARTINEZ-MCKINNEY, F (SCIPP, UCSC); Dr MAZZA, S (SCIPP, UCSC); NORVELL, N (SCIPP, UCSC); PADILLA, R (SCIPP, UCSC); POTTER, E (SCIPP, UCSC); RYAN, E (SCIPP, UCSC); Prof. SCHUMM, B (SCIPP, UCSC); TARKA, M (SCIPP, UCSC); WILDER, M (SCIPP, UCSC); JACOBSON, B (SLAC National Accelerator Laboratory); MACARTHUR, J (SLAC National Accelerator Laboratory); SILVA TORRECILLA, I (SLAC National Accelerator Laboratory); BOHON, J (Los Alamos National Laboratory); GRACE, C (Lawrence Berkeley National Laboratory); HARRIS, C.T (Sandia National Laboratory); PRAKASH, T (Lawrence Berkeley National Laboratory); PREBYS, E (University of California, Davis); STUART, D (University of California, Santa Barbara)

Presenter: NIZAM, M (University of California Santa Cruz)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **3** Type: **Contribution Talk**

Fast Timing With Silicon Carbide Low Gain Avalanche Detectors

Tuesday, 29 November 2022 16:20 (20 minutes)

4H-Silicon Carbide, when considered as a material for the fabrication of Low Gain Avalanche Detectors for particle timing and position measurement, offers potential advantages over Silicon, including faster response and higher temperature operation. We discuss an ongoing study of this material aimed at the fabrication and test of prototype fast timing sensors. Recently we have fabricated our first devices and will present preliminary results on their behavior. This work is well aligned with technical directions identified in the recent Department of Energy study, "Basic Research Needs for High Energy Physics Detector Research and Development".

Primary authors: Mr SEKELY, Benjamin (North Carolina State University); HABER, Carl (Lawrence Berkeley National Laboratory); Mr ALLION, Greg (North Carolina State University); Prof. MUTH, John (North Carolina State University); Mr CERULLO, Marcio (North Carolina State University); Dr BARLETTA, Philip (North Carolina State University); Dr HOLLAND, Stephen (Lawrence Berkeley National Lab)

Presenter: HABER, Carl (Lawrence Berkeley National Laboratory)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **4** Type: **not specified**

Summaries of last night's roundtables

Session Classification: Closing Plenary

Contribution ID: **5** Type: **not specified**

WG1 Summary

Friday, 2 December 2022 09:30 (15 minutes)

Presenter: LI, Xuan (Los Alamos National Laboratory)

Session Classification: Closing Plenary

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **6** Type: **not specified**

WG2 Summary

Friday, 2 December 2022 09:45 (15 minutes)

Presenter: BORNHEIM, Adi (Staff@caltech.edu)

Session Classification: Closing Plenary

Track Classification: WG2: Calorimetry

Contribution ID: **7** Type: **not specified**

WG3 Summary

Friday, 2 December 2022 10:00 (15 minutes)

Presenter: GRAMELLINI, Elena (Fermi National Accelerator Laboratory)

Session Classification: Closing Plenary

Track Classification: WG3: Noble Element Detectors

Contribution ID: **8** Type: **not specified**

WG4 Summary

Friday, 2 December 2022 10:40 (15 minutes)

Presenter: JEWELL, Michael (Yale University)

Session Classification: Closing Plenary

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **9** Type: **not specified**

WG5 Summary

Friday, 2 December 2022 10:55 (15 minutes)

Presenter: GARG, Prakhar (Stony Brook University)

Session Classification: Closing Plenary

Track Classification: WG5: MPGDs

Contribution ID: **10** Type: **not specified**

WG6 Summary

Friday, 2 December 2022 11:10 (15 minutes)

Presenter: PARAMONOV, Alexander (Argonne National Laboratory)

Session Classification: Closing Plenary

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **11** Type: **not specified**

WG7 Summary

Friday, 2 December 2022 09:15 (15 minutes)

Presenter: OTTE, Nepomuk (Georgia Institute of Technology)

Session Classification: Closing Plenary

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **12** Type: **not specified**

Workshop Summary

Friday, 2 December 2022 11:40 (15 minutes)

Presenter: HEEGER, Karsten (Yale University)

Session Classification: Closing Plenary

Contribution ID: **13** Type: **not specified**

Welcome

Tuesday, 29 November 2022 08:45 (15 minutes)

Presenter: DESHPANDE, Abhay (Stony Brook University)

Session Classification: Opening Plenary

Contribution ID: **14** Type: **not specified**

Workshop Overview

Tuesday, 29 November 2022 09:00 (10 minutes)

Presenter: HEEGER, Karsten (Yale University)

Session Classification: Opening Plenary

Contribution ID: **15** Type: **not specified**

Highlights from the Snowmass Instrumentation Frontier

Tuesday, 29 November 2022 09:10 (25 minutes)

Presenter: MERKEL, Petra (Fermilab)

Session Classification: Opening Plenary

Contribution ID: **16** Type: **not specified**

Outcomes of the ECFA Roadmap

Tuesday, 29 November 2022 09:35 (25 minutes)

Presenter: DALLA TORRE, Silvia (INFN, Trieste)

Session Classification: Opening Plenary

Contribution ID: **17** Type: **not specified**

Detectors for the EIC

Tuesday, 29 November 2022 10:50 (40 minutes)

Presenter: ULLRICH, Thomas (BNL)

Session Classification: Opening Plenary

Contribution ID: **18** Type: **not specified**

AIDAinnova: collaborative R&D in Europe

Tuesday, 29 November 2022 10:00 (25 minutes)

Presenter: GIACOMELLI, Paolo (INFN Bologna)

Session Classification: Opening Plenary

Contribution ID: **19** Type: **Contribution Talk**

Design and construction of the sPHENIX TPC

Tuesday, 29 November 2022 13:50 (20 minutes)

The sPHENIX experiment at RHIC will be starting its operations in early 2023. It is designed to study heavy ion and proton-proton collisions by measuring hard QCD processes. The Time Projection Chamber (TPC) is used in the sPHENIX detector as one of the main tracking detectors. The Time Projection Chamber (TPC) is used in the sPHENIX detector as one of the main tracking detectors. It is designed for operation in a 1.4 T magnetic field and high luminosity to provide a rapidity coverage of $|\eta|<1.1$ and over the full azimuth.
The sPHENIX TPC design involves optimization of the gas mixture for fast operation in a 1.4 T magnetic field to reduce ion backflow (IBF) and provide sufficient amplification with a quadruple-GEM gain structure. Signals will be collected with zigzag patterned readout pads, and processed with the SAMPA ASIC. Two laser systems are designed to calibrate the static and dynamic distortions.
We will present the final design of the sPHENIX TPC along with the R&D results that drove the decisions.

Primary authors: SHULGA, Evgeny (Stony Brook University); SPHENIX COLLABORATION (sPHENIX collaboration)

Presenter: SHULGA, Evgeny (Stony Brook University)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **20** Type: **Contribution Talk**

Stress Induced Backgrounds in Cryogenic Crystal Calorimeters

Wednesday, 30 November 2022 13:35 (20 minutes)

A number of low mass dark matter direct detection experiments have observed an excess rate of events, rising sharply below energies of around 100 eV. A similar source of background energy has been observed to shorten the coherence time of superconducting quantum bits by creating excess quasiparticles in the qubit circuit. The relaxation of stress in detector materials has been shown to cause low energy backgrounds in previous dark matter experiments, and has been proposed as a source of the current "low energy excess." By comparing detectors in high and low stress states, we have shown that stressing silicon detectors can cause excess event rates of over 80 Hz/gram below 20 eV, compared to a rate of under 0.5 Hz per gram in a low stress calorimeter. Measurements of the background rate as a function of time will be described, as well as implication for the design and operation of future cryogenic low threshold calorimeters.

Primary authors: ROMANI, Roger (UC Berkeley); SPICE/HERALD COLLABORATION

Presenter: ROMANI, Roger (UC Berkeley)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **21** Type: **Contribution Talk**

The Snowball Chamber: Supercooled Water for Dark Matter, Neutrinos, and General Particle Detection

Wednesday, 30 November 2022 11:35 (20 minutes)

The snowball chamber is analogous to the bubble and cloud chambers in that it relies on a phase transition, but it is new to high-energy particle physics. The concept of the snowball chamber relies on supercooled water (or a noble element, for scintillation for energy reconstruction), which can remain metastable for long time periods in a sufficiently clean and smooth container (on the level of the critical radius for nucleation). The results gleaned from the first prototype setup (20 grams) will be reviewed, as well as plans for the future, with an eye to future deployment of a larger (kg-scale) device underground for direct detection of dark matter WIMPs, with a special focus on low-mass (GeV-scale) WIMPs, capitalizing on the presence of H, which could potentially also lead to world-leading sensitivity to spin-dependent-proton interactions for O(1 GeV/c^2)-mass WIMPs and CEvNS. Supercooled water also has the potential advantage of a sub-keV energy threshold for nuclear recoils, but this remains an atmospheric chemistry prediction that must be verified by careful measurements.

Primary author: SZYDAGIS, Matthew (The University at Albany, SUNY)

Presenter: SZYDAGIS, Matthew (The University at Albany, SUNY)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **22** Type: **Contribution Talk**

Performance of novel VUV-sensitive Silicon Photo-Multipliers for nEXO

Wednesday, 30 November 2022 16:00 (20 minutes)

Liquid xenon time projection chambers are promising detectors to search for neutrinoless double beta decay ($0\nu\beta\beta$), due to their response uniformity, monolithic sensitive volume, scalability to large target masses, and suitability for extremely low background operations. The nEXO collaboration has designed a five-tonne time projection chamber that aims to search for $0\nu\beta\beta$ of \ce{^{136}Xe} with projected half-life sensitivity of 1.35×10^{28}~yr. To reach this sensitivity, the design goal for nEXO is ≤ 1\% energy resolution at the decay Q-value (2458.07 ± 0.31~keV). Reaching this resolution requires the efficient collection of both the ionization and scintillation produced in the detector. The nEXO design employs Silicon Photo-Multipliers (SiPMs) to detect the vacuum ultra-violet, 175 nm scintillation light of liquid xenon. In this talk, we will show results on the characterization of the newest vacuum ultra-violet sensitive SiPMs by Fondazione Bruno Kessler, the VUVHD3 devices specifically designed for nEXO. We will also present measurements on new test samples of previously characterised Hamamatsu VUV4 Multi Pixel Photon Counters (MPPCs). Various SiPM and MPPC parameters, such as dark noise, gain, direct crosstalk, correlated avalanches and photon detection efficiency were measured as a function of the applied over voltage and wavelength at liquid xenon temperature (163~K). The results from this study are also used to provide updated estimates of the achievable energy resolution at the decay Q-value for the nEXO design.

Primary author: GALLINA, Giacomo (member@princeton.edu;staff@princeton.edu;employee@princeton.edu)

Presenter: GALLINA, Giacomo (member@princeton.edu;staff@princeton.edu;employee@princeton.edu)

Session Classification: Early Career Plenary

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **23** Type: **Contribution Talk**

Kiloton-scale xenon detectors for neutrinoless double beta decay

Tuesday, 29 November 2022 13:30 (20 minutes)

If neutrinoless double beta decay ($0\nu\beta\beta$) is not observed in the upcoming generation of ton-scale detectors, future detectors at the kiloton-scale may be required to probe the majority of the remaining parameter space for the decay. Gas or liquid phase xenon time projection chambers (TPCs) provide a possible path to reaching $0\nu\beta\beta$ half-life sensitivities as long as 10^{30} years. A key challenge to enabling such experiments is the procurement of the required xenon, and possible avenues for acquisition of kiloton-scale quantities of xenon that avoid existing supply chains will be described.

Primary author: MOORE, David (Yale University)

Presenter: MOORE, David (Yale University)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **24** Type: **Contribution Talk**

A 3ps Cryogenic Time-to-Digital Converter for Time-Correlated Single Photon Counting

Thursday, 1 December 2022 08:30 (20 minutes)

We present a time-to-digital converter (TDC) that simultaneously achieves very low power and picosecond timing resolution when operated in a cryogenic (4K) environment. Such a TDC is an enabling technology for quantum secure direct communications which require high bandwidth time-correlated single photon counting. The proposed TDC uses a two-step architecture in which the input time delay is first coarsely digitized through a ring-oscillator based counter, and the residue is then finely digitized by a Vernier delay line "fine TDC." The TDC is implemented in an FD-SOI process, and back-gate tuning is used both to correct threshold variation due to cryogenic operation and to enable tuning of the fine TDC delay elements with very little overhead. Simulations show a fine TDC resolution of 2.7 ps with a dynamic range of > 50 ns at ½ LSB rms jitter, with power consumption of < 500 μW per channel. A prototype chip has been fabricated and is currently undergoing test.

Primary authors: QUINN, Adam (Fermilab); BRAGA, Davide (Fermilab)

Presenter: QUINN, Adam (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **25** Type: **Contribution Talk**

Quantum Capacitance Detectors with sub-eV resolution for astroparticle applications

Tuesday, 29 November 2022 13:50 (20 minutes)

Sub-eV threshold particle detectors are an area of burgeoning interest, driven in part by needing to probe the increasingly theoretically relevant sub-GeV mass dark matter parameter space. One promising technology to use is Quantum Capacitance Detectors (QCDs), which are superconducting quantum mechanical circuitry that have heritage in the quantum computing world. QCDs have been demonstrated in previous literature as excellent far-IR photon counters with NEP of $< 10^{-20}$ W/$\sqrt{\text{Hz}}$. We seek to extend their applicability by directly coupling the QCD to interaction induced athermal phonons generated within a crystalline silicon substrate. Such a scheme will enable the literal counting of quasiparticles (broken Cooper-pair electrons) within the QCD superconducting absorber, as produced by single meV phonons. In this talk we will discuss preliminary design progress and challenges and lay out a two-year R&D roadmap for demonstrating eV and subsequently lower energy resolution.

Primary author: RAMANATHAN, Karthik (Postdoctoral Fellow)

Co-authors: Prof. GOLWALA, Sunil (California Institute of Technology); Dr ECHTERNACH, Pierre (NASA Jet Propulsion Laboratory)

Presenter: RAMANATHAN, Karthik (Postdoctoral Fellow)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **26** Type: **Contribution Talk**

A Cryogenic Readout IC with 100 KSPS in-Pixel ADC for Skipper CCD-in-CMOS Sensors

Thursday, 1 December 2022 08:50 (20 minutes)

The Skipper CCD-in-CMOS Parallel Read-Out Circuit (SPROCKET) is a mixed-signal front end design for the readout of Skipper CCD-in-CMOS image sensors. SPROCKET is fabricated in a 65 nm CMOS process and each pixel occupies a 45µm × 45µm footprint. SPROCKET is intended to be heterogeneously integrated with a Skipper-in-CMOS sensor array, such that one readout pixel is connected to a multiplexed array of nine Skipper-in-CMOS pixels to enable massively parallel readout. The front end includes a variable gain preamplifier, a correlated double sampling circuit, and a 10-bit serial successive approximation register (SAR) ADC. From simulation, the circuit achieves a sample rate of 100 ksps with 0.48 e − rms equivalent noise at the input to the ADC. SPROCKET achieves a maximum dynamic range of 9,000 e − at the lowest gain setting (or 900 e − at the lowest noise setting). The circuit operates at 100 Kelvin with a power consumption of 40 µW per pixel. A SPROCKET test chip was submitted in September 2022.

Primary authors: QUINN, Adam (Fermilab); BRAGA, Davide (Fermilab); FAHIM, Farah (Fermilab); VALENTIN, Manuel Blanco (Northwestern University); MEMIK, Seda (Northwestern University); LI, Shaorui; ZIMMERMAN, Tom (Fermilab)

Presenter: QUINN, Adam (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **27** Type: **Contribution Talk**

A high-granularity calorimeter insert based on SiPM-on-tile technology for the EIC

Wednesday, 30 November 2022 09:50 (20 minutes)

A high-granularity calorimeter insert based on SiPM-on-tile technology for the EIC

One of the key requirements for EIC detectors is to have tracking and full calorimetry up to η=4.0. The forward region (3<η<4) poses multiple challenges, including those arising from the EIC beam-crossing angle. We present a design for a calorimeter insert (CALI) that is based on the SiPM-on-tile technology. The CALI maximizes the detector acceptance close to the beampipe (3<η<4), while solving challenges arising from the beam crossing angle, and mechanical integration with the rest of the endcap detectors. Simulation studies show that the CALI response is compensated and its resolution exceeds the requirements for EIC detectors even with basic reconstruction algorithms. In this talk, I will present the CALI design and simulated performance (summary of arXiv:2208.05472) and describe recent R&D including measurements of light yield, cross-talk, and time resolution.

Primary author: ARRATIA, Miguel (University of California, Riverside)

Presenter: ARRATIA, Miguel (University of California, Riverside)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **28** Type: **Contribution Talk**

Status and Results of the Water-based Liquid Scintillator R&D facility at Brookhaven National Lab

Tuesday, 29 November 2022 16:00 (20 minutes)

Water-based liquid scintillators (WbLS) are attractive neutrino detector materials because they allow the separation of Cherenkov and scintillation signals. Using WbLS large-scale neutrino experiments can benefit from both directional reconstruction and enhanced low-energy efficiency. Brookhaven National Lab (BNL) has long-standing expertise in developing WbLS and metal-doped liquid scintillators. We recently constructed and commissioned a 1-ton WbLS detector with excellent photo-sensor coverage and a capable data acquisition system. We will use this detector as a testbed for WbLS R&D. In this talk I will give a brief overview of the BNL WbLS R&D program, followed by an exhibit of the early data and results from the 1-ton detector. The 1-ton detector also serves as a testbed for the next 30-tonne WbLS demonstrator currently under construction at BNL.

Primary author: XIANG, Xin (BNL)

Presenter: XIANG, Xin (BNL)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **29** Type: **Contribution Talk**

A Hybrid 3D/2D Field Response Calculation for Liquid Argon Detectors with PCB Based Anode

Wednesday, 30 November 2022 09:50 (20 minutes)

The Liquid Argon Time Projection Chamber (LArTPC) is one of the main neutrino detection techniques. It enables highly detailed reconstruction of neutrino events with high spatial precision and low energy threshold. The field response, which describes the induced current on the anode-plane readout for the drifting ionization electrons, is a crucial input to the overall LArTPC event processing and reconstruction procedure. The ideal field response simulation should be done in 3 dimensions to simulate the electric field and electron behavior near the anode properly. Still, the required computation in the full 3 dimensions is too big for a realistic calculation. We developed a new package that calculates field response for newly proposed printed circuit board (PCB) anodes. The package combined 3D and 2D field simulations utilizing the finite-difference method to achieve fast and precise field response calculation. The simulated field response was compared against data from the recent CERN Vertical Drift detector prototype, which demonstrated sub 5% uncertainty. In this talk, we will review the package's technical aspects and its performance on data.

Primary authors: VIREN, Brett (BNL); MARTYNENKO, Sergey (BNL); PIETROPAOLO , Francesco (CERN, INFN); TUFANLI, Serhan (CERN); QIAN, Xin (BNL)

Presenter: MARTYNENKO, Sergey (BNL)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **30** Type: **Contribution Talk**

Development of a Single Phase Liquid Xenon Detector for Reactor Antineutrino Detection

Tuesday, 29 November 2022 13:50 (20 minutes)

The purely electron antineutrino source and high flux makes nuclear power reactors an attractive place to set up a detector for reactor monitoring and searches for neutrino interactions. One such interaction is Coherent Elastic Neutrino Nucleus Scattering (CEνNS), which is one of the lowest energy processes predicted by the standard model, and has drawn experimental interest in recent years. CEνNS has been detected by the COHERENT collaboration [1][2] at the spallation neutron source, but has yet to be detected from the low energy antineutrinos from a nuclear reactor.
Liquid Xenon (LXe) detectors are capable of detecting sub-keV nuclear recoils [3], which reactor antineutrinos are able to produce via CEνNS. In addition, LXe detectors can be scaled up to large masses, making them capable of acquiring a large amount of statistics in a short amount of time. We estimate that a LXe detector placed 25m away from a 3GW power reactor can see O(100) events/100kg/day from CEνNS [4]. Dual phase LXe detectors used for dark matter experiments detect events via prompt scintillation light produced in the liquid, and ionization electrons which are converted to scintillation light by drifting these electrons through a gas gap under high electric fields – called electroluminescence. Such a dual-phase LXe detector was recently used to search for reactor neutrino CEvNS [5]. However, this design is known to have a large and long lasting single electron background following a large ionization signal [6][7]. This background is possibly due to impurities within the Xenon, but it may also be due to delayed extraction of electrons trapped at the liquid-gas interface. As such, we are developing a single-phase liquid xenon detector, capable of producing electroluminescence in liquid, named NUXE. Our goal is to be sensitive to single electrons in order to detect CEvNS from a power reactor.
In this talk, we will present our progress with this detector development. First we will discuss the physical motivations for building such a detector as outlined above. Next, we will present our recent results from a prototype detector, as well as a model for liquid phase electroluminescence. Finally, we will end with our future plan to upgrade our prototype, with SiPMs and a better light collection efficiency.

References
[1] COHERENT Collaboration. First measurement of coherent elastic neutrino-nucleus scattering on argon. Physical Review Letters, 126(1), jan 2021.
[2] COHERENT Collaboration. Measurement of the coherent elastic neutrino-nucleus scattering cross section on CsI by COHERENT. Physical Review Letters, 129(8), aug 2022.
[3] Brian Lenardo, Jingke Xu, Sergey Pereverzev, Oluwatomi A. Akindele, Daniel Naim, James Kingston, Adam Bernstein, Kareem Kazkaz, Mani Tripathi, Connor Awe, Long Li, James Runge, Samuel Hedges, Peibo An, and Phil S. Barbeau. Measurement of the ionization yield from nuclear recoils in liquid xenon between 0.3 – 6 kev with single-ionization-electron sensitivity, 2019.
[4] Kaixuan Ni, Jianyang Qi, Evan Shockley, and Yuehuan Wei. Sensitivity of a liquid xenon detector to neutrino–nucleus coherent scattering and neutrino magnetic moment from reactor neutrinos. Universe, 7(3), 2021.
[5] D. Yu. Akimov, I. S. Alexandrov, R. R. Alyev, V. A. Belov, A. I. Bolozdynya, A. V. Etenko, A. V. Galavanov, E. M. Glagovsky, Y. V. Gusakov, A. V. Khromov, S. M. Kiselev, A. M. Konovalov, V. N. Kornoukhov, A. G. Kovalenko, E. S. Kozlova, A. V. Kumpan, A. V. Lukyashin, A. V. Pinchuk, O. E. Razuvaeva, D. G. Rudik, A. V. Shakirov,

G. E. Simakov, V. V. Sosnovtsev, and A. A. Vasin. The red-100 experiment, 2022.
[6] A. Kopec, A.L. Baxter, M. Clark, R.F. Lang, S. Li, J. Qin, and R. Singh. Correlated single- and few-electron backgrounds milliseconds after interactions in dual-phase liquid xenon time projection chambers. Journal of Instrumentation, 16(07):P07014, jul 2021.
[7] LUX Collaboration. Investigation of background electron emission in the lux detector. Phys. Rev. D, 102:092004, Nov 2020.

Primary author: QI, Jianyang (UCSC)

Presenter: QI, Jianyang (UCSC)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **32** Type: **Contribution Talk**

LZ Electron Recoil Calibrations and NEST-Based Simulations

Wednesday, 30 November 2022 08:30 (20 minutes)

The LUX-ZEPLIN experiment recently announced its first, world-leading exclusion limits in the search for WIMP dark matter, with spin-independent and spin-dependent results. These results are supported by high-statistic, high-quality calibrations. For electron recoils, tritiated methane is used to produce beta decays up to 18.6 keV, Rn-220 for energies out to 100+ keV, and Kr83m and Xe131m/Xe129m for position reconstruction, 3D corrections, and detector stability monitoring. The use of these sources will be discussed in depth, along with comparisons of the SR1 (Science Run 1) tritium calibration to LZ simulations based on NEST, the Noble Element Simulation Technique. An unprecedented 1%-level agreement on means and O(10%) level on widths was observed with no tuning of free parameters, using a version of NEST predating LZ, while an unprecedented 0.1% level of agreement on means, and O(1%) on widths, was rapidly achieved through a simple tuning of mainly detector parameters, within their uncertainties.

Primary author: SZYDAGIS, Matthew (The University at Albany, SUNY)

Presenter: SZYDAGIS, Matthew (The University at Albany, SUNY)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **33** Type: **Contribution Talk**

Searching for Light Dark Matter with Narrow-Gap Semiconductors: The SPLENDOR Project

Wednesday, 30 November 2022 14:15 (20 minutes)

Understanding the particle nature of dark matter, which makes up approximately 85\% of the matter content in the universe, remains one of the biggest open questions in the fields of particle physics and cosmology. After decades of null results in searches for weakly interacting massive dark matter candidates, experimental and theoretical efforts have shifted towards lighter mass dark matter candidates with masses below $\mathcal{O}(\mathrm{MeV})$. These light mass dark matter particles present a substantial detection challenge, as their relatively low kinetic energy limits the energy deposited in a target to be sub-eV. The low momentum interactions are also highly delocalized, and a detailed understanding of the collective modes of the target material is critical to predicting DM scattering rates.

The SPLENDOR project (Search for Light Dark Matter with Narrow-Gap Semiconductors) proposes to use narrow-bandgap single-crystal semiconductors as ionization detectors to search for this light dark matter. We have developed a series of magnetic Zintl semiconductors and charge-density-wave semiconductors with electronic bandgaps on the order of $1-100$ meV, which would allow for sensitivities to fermionic dark matter with sub-MeV masses and bosonic dark matter with sub-eV mass. The detectors will be operated at mK temperatures, with the excited charge signal being read out with low-noise cryogenic HEMT based amplifiers. In this talk I will give an overview of the SPLENDOR project, and discuss our recent progress in the material growth and characterization, as well as the progress we have made in realizing the low noise charge readout. I will also touch on potential applications beyond dark matter searches, such as far-IR and THz photon detection.

Primary author: Dr FINK, Caleb (Los Alamos National Laboratory)

Presenter: Dr FINK, Caleb (Los Alamos National Laboratory)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **34** Type: **Contribution Talk**

Development of cryogenic optical beam steering for characterization of novel dark matter detectors

Wednesday, 30 November 2022 17:40 (20 minutes)

A major hurdle in searches for sub-GeV particle-like dark matter is demonstrating sufficiently low energy detection thresholds in order to detect recoils from light dark matter particles. Many detector concepts have been proposed to achieve this goal, which often include novel detector target media or sensor technology. A universal challenge in understanding the signals from these new detectors and enabling discovery potential is characterization of detector response near threshold, as the calibration methods available at low energies are very limited. We have developed a device capable of cryogenic optical beam steering for robust calibration of any photon-sensitive detector over the energy range of 0.62 - 6.89eV. This device can be used to scan over a detector and deliver short, collimated pulses of small numbers of photons in a way that limits parasitic backgrounds, allowing for exploration of a variety of science targets including position sensitivity of detector configurations, phonon transport in materials, and the effect of quasiparticle poisoning on detector operation. In this talk, I will present the design overview and specifications, along with current status of the testing program.

Primary author: STIFTER, Kelly (Fermilab)

Presenter: STIFTER, Kelly (Fermilab)

Session Classification: Early Career Plenary

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **35** Type: **Contribution Talk**

Cryogenic SOC for reconfigurable machine learning in 22nm using ESP and HLS4ML

Thursday, 1 December 2022 09:10 (20 minutes)

We present our design experience of a prototype System-on-Chip (SoC) for machine learning applications that run in a cryogenic environment to evaluate the performance of the digital backend flow. We combined two established open-source projects (ESP and HLS4ML) into a new system-level design flow to build and program the SoC. In the modular tile-based architecture, we integrated a low-power 32-bit RISC-V microcontroller (Ibex), 200KB SRAM-based scratchpad, and an 18K-parameter neural-network accelerator. The network is an autoencoder working on audio recordings and trained on industrial use cases for the early detection of failures in machines like slide rails, fans, or pumps. For the hls4ml translation, we optimized the reference architecture using quantization and model compression techniques with minimal AUC performance reduction. This project is also an early evaluation of Siemens Catapult as an HLS backend for hls4ml. Finally, we fabricated the SoC in a 22nm technology and are currently testing it. We intend to present cryogenic performance at 7K.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **36** Type: **Contribution Talk**

Neural network accelerator for quantum control

Tuesday, 29 November 2022 11:30 (15 minutes)

Efficient quantum control is necessary for practical quantum computing implementations with current technologies. However, conventional algorithms for determining optimal control parameters are computationally expensive, mainly excluding them from use outside of the simulation. Furthermore, existing hardware solutions structured as lookup tables are imprecise and costly. A more efficient method can be produced by designing a machine-learning model to approximate the results of traditional tools. Such a model can then be synthesized into a hardware accelerator for quantum systems. Our study demonstrates a machine-learning algorithm for predicting optimal pulse parameters. This algorithm is lightweight enough to fit on a low-resource FPGA and perform inference with a latency of 175ns and pipeline interval of 5ns with gate fidelity greater than 0.99. In the long term, such an accelerator could be used near quantum computing hardware where traditional computers cannot operate, enabling quantum control at a reasonable cost at low latencies without incurring large data bandwidths outside the cryogenic environment.

Primary authors: XU, David (Columbia University); OZGULER, A. Baris (Fermilab); VALENTIN, Manuel Blanco (Northwestern University); DI GUGLIELMO, Giuseppe (Fermilab); PERDUE, Gabriel (Fermilab); TRAN, Nhan (Fermilab); CARLONI, Luca (Columbia University); FAHIM, Farah (Fermilab)

Presenter: DI GUGLIELMO, Giuseppe (Fermilab)

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **37** Type: **Contribution Talk**

Searching for axions and dark photons with superconducting nanowire single photon detectors (SNSPDs) in the BREAD experiment

Wednesday, 30 November 2022 14:55 (20 minutes)

The BREAD(Broadband Reflector Experiment for Axion Detection) experiment searches for axions and wave-like dark matter using a novel dish resonator which allows to utilize state-of-the-art high-field solenoidal magnets. The axion target mass extends from ~⍰eV to eV, this large mass range makes it difficult to scale traditional resonator setups to the required volume. However, metallic surfaces in a high magnetic field dark matter axions can convert to photons regardless of axion mass. These photons can then be focused by a parabolic focusing reflector onto a low noise single photon counting detector. One of the single photon counting detectors that can be used for the BREAD experiment is superconducting nanowire single photon detectors (SNSPDs) that are sensitive to 0.1 to 1 eV axions and dark photons, due to its sensitivity to 1-10um photons.

In this talk, we present the progress towards a first stage dark photon pilot experiment with a focus on SNSPDs. We show the progress on characterizing the SNSPDs for the pilot experiment and outline the sensitivity estimates for BREAD with SNSPDs and other single photon counting detectors.

Primary author: WANG, Christina (Caltech)

Presenters: WANG, Christina (Caltech); PEÑA, Cristián (Fermilab)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **38** Type: **Contribution Talk**

Calorimetry for the Electron Ion Collider

Wednesday, 30 November 2022 08:30 (20 minutes)

The Electron Ion Collider (EIC) is a new facility that has been proposed in the US to study the structure of nuclear matter in the gluon dominated regime of QCD using Deep Inelastic Scattering (DIS) with precision electromagnetic probes. The EIC will utilize the existing RHIC collider and a new Electron Storage Ring to provide beams of polarized electrons in the energy range from 2.5-18 GeV to collide with hadron beams in the energy range from 40-275 GeV/c. It will require major new detector systems to measure the scattered electron with high precision and full calorimeter, tracking and particle id systems to reconstruct the overall event. This contribution will focus on the various calorimeter technologies that are being developed for the EIC, including the calorimeter systems currently being planned for the first main EIC detector, EPIC, as well as a future second detector. These include both electromagnetic as well as hadronic calorimeter technologies. A wide variety of technologies are being considered for the EMCAL, which include W-powder/SciFi, Pb/SciFi, Pb and W shashlik, PWO crystals, and a new scintillating glass, and a steel/scintillating tile with WLS fiber readout for the HCAL. The current status and future plans for the development of these technologies, as well as their role in the physics measurements at the EIC, will also be discussed.

Primary author: WOODY, Craig (BNL)

Presenter: WOODY, Craig (BNL)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **39** Type: **Contribution Talk**

Detector and electronics integration for the CGEM Inner Tracker

Wednesday, 30 November 2022 11:15 (20 minutes)

The CGEM inner tracker (CGEM-IT) consists of three coaxial layers of triple GEM and is designed to replace the current inner drift chamber of BESIII (BEijing Spectrometer,IHEP, CN), which is suffering from aging.
The tracker is expected to restore efficiency, improve z-determination and secondary vertex position reconstruction with a resolution of 130 μm in the xy-plane and better than 300 μm along the beam direction

A special readout system has been developed. Signals from the detector strips are processed by TIGER (Torino Integrated Gem Electronics for Readout), a custom 64-channel ASIC that provides an analog charge readout over a fully digital output up to about 50 fC and less than 3 ns jitter. TIGER continuously transmits data over thresholds in triggerless mode to an FPGA-based readout module, called GEM Read Out Card, which organizes the incoming data by creating the event packets when the trigger arrives. Since the readout system is versatile, it can be connected to other MPGDs.

Two of the three CGEM layers are in operation in Beijing since January 2020 remotely controlled. Due to the pandemic situation, the integration team has continued its work on triple GEM planar detectors and a test beam with the final electronics configuration has been conducted at CERN.
In this presentation, the general status of the CGEM-IT project is presented, with a particular focus on the preliminary results of the test beam, which show that performance is in line with expectations.

Presenter: BALOSSINO, Ilaria

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **40** Type: **Contribution Talk**

First performance of Triple-GEM detectors in the CMS muon system with cosmic rays and LHC collisions

Wednesday, 30 November 2022 10:55 (20 minutes)

During the next collisions runs, the Large Hadron Collider (LHC) will deliver instantaneous luminosity in the range 5×10^{34} cm^{-2} s^{-1} to 7×10^{34} cm^{-2} s^{-1}, up to 7 times higher than the nominal value. To cope with the higher background rates and to improve the trigger capabilities in the forward region, the muon system of the Compact Muon Solenoid (CMS) experiment was upgraded with a new station of detectors, called GE1/1, and based on triple-GEM technology. The system was installed between 2019 and 2020 and consists of 72 ten-degree Super Chambers, each made up of two layers of triple-GEM detectors. GE1/1 provides the CMS muon system with two additional hit measurements to improve muon tracking and triggering performance. It will suppress the muon trigger rate to an acceptable level without increasing the threshold on muon transverse momentum. This contribution will present the results of the commissioning phase of the detectors, including initial performance for cosmic-ray events and with LHC collisions. Detector and readout electronics operation will be discussed, with particular focus on their stability and performance.

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Presenter: VAI, Ilaria (Università di Pavia & INFN Sez. di Pavia)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **41** Type: **Contribution Talk**

Real-Time Object Detection and Identification for DUNE's Data Selection System

Wednesday, 30 November 2022 11:35 (15 minutes)

Modern-day particle and astro-particle physics experiments call for detectors with increasingly higher imaging resolution to be deployed in often inaccessible, remote locations, e.g., deep underground, or in-flight on balloons or satellites. The inherent limitations in available on-detector power and computational resources, combined with the need to operate these detectors continually, which produces an exorbitant amount of data, demand fast, efficient, and accurate data processing to detect usually rare features of interest from the data, and save only them for further, offline processing and physics analysis. Real-time data processing using machine learning algorithms, such as convolutional neural networks, provides a promising solution to this challenge. This talk reviews ongoing R&D to demonstrate such capability for the case of the future Deep Underground Neutrino Experiment (DUNE).

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Presenter: CLAIR, Judicael (Columbia University)

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **42** Type: **Contribution Talk**

Front-End Evaluation for Pixelated Liquid-Argon Particle Detectors

Wednesday, 30 November 2022 15:15 (20 minutes)

Front-End Evaluation for Pixelated Liquid-Argon Particle Detectors

The physics reach and performance of high energy physics experiments based on multi-kiloton scale noble element time projection chambers, could benefit significantly from the development of a pixellated, large scale low power readout electronics.
As part of the Q-Pix collaboration, we investigated a low power front-end in a 65nm CMOS process, for operation in liquid Argon (-189°C).

Introduction

Large-scale noble element time projection chamber (TPC) detectors play a prominent role in existing and planned high-energy physics experiments, by virtue of their high detection efficiency, background rejection, and spatial and temporal resolution.
The current design for multi-Kiloton scale liquid Argon (LAr) TPCs, such as those being developed for the far detectors of the Deep Underground Neutrino Experiment [], rely on meter-scale sensing wires.
Conversely, a fully pixellated readout, as demonstrated for the smaller DUNE near detector \cite{LarPixConcept2020}, could lead to improved low-energy threshold and directional reconstruction, as well as easier module assembly.

The Q-Pix collaboration \cite{AsaadiSupernova,Nygren2018} aims at addressing the ensuing large channel count, higher data rate, and power constraints, by developing a self-triggering front end with free-running clocks and dynamically established data networks robust against single-point failure.

The Q-Pix collaboration is nearing completion of a first front-end prototype ASIC in a 180nm CMOS process.
In this paper, we present the results of a parallel effort to investigate Q-Pix front-end design in a 65nm CMOS technology, the same used for the existing ASICs for the wire LAr TPC detector of the DUNE experiment \cite{CDP12019,GRACE2022}.
The process has been validated for operation in LAr, and would allow the collaboration to leverage existing resources, including device models for operation in LAr (-189°C), a fully characterized custom digital library with more than 300 standard cells, and a number of proven IPs \cite{BRAGA202136}.

The following sections describe the pixel design architecture and simulation results.

Front-End Design Architecture
Two analog front-end architectures were investigated. The first being dynamic vision sensing (DVS), which has increased dynamic range and reduced redundancy of information in controlled light environments such as noble element TPCs. DVS designs have demonstrated low power consumption as well as low latency \cite{MOEYS2017}.

The second front-end that was investigated is a charge replenishment architecture. This front-end works on the principle of detecting accumulated charge and is the focal point of this article.

Dynamic Vision Investigation
Dynamic vision sensing is investigated in the context of sensing the rate of change of charge, rather than accumulated charge. A transimpedance amplifier drives a switched capacitor differentiator, followed by a set of comparators for discrimination between positive or negative changes at the pixel.

%The minimum current detected, i_{min}, can be set by the threshold of the comparators by calculating the gain of the preamplifier and the gain of the charge sensitive amplifier:

%$\Delta V_{threshold} = (-\frac{C_i}{C_f})(i_{min}R_f)$

It was concluded that this front-end was particularly attractive for photon detection within the Q-Pix array. However, for charge detection, we focused on the charge replenishment scheme.

Charge Replenishment Evaluation The charge replenishment front-end consists of a preamplifier, comparator, digital feedback control, and a switched capacitor charge replenisher. Ultimately, the digital feedback control will also feed a time-to-digital converter (TDC). This is illustrated in the front-end block diagram in Fig.
reffig:qpix$_frontend$.

Preamplifier

A minimum detectable charge, Q_{min}, is chosen such that a comparator trigger will be generated and time-stamped by the TDC. This triggering event will subsequently controls the replenishment of the pixel charge. This causes the eventual de-triggering of the comparator in order to reset the replenishing capacitor, $C_{replenish}$, and effectively resetting the front-end.

The preamplifier is configured as an integrating amplifier. We define ΔQ_{pix} as the change in charge at the pixel. The voltage at the output of the integrating preamplifier is given as:

$\Delta V_{integrator} = (-\frac{1}{C_f})(\Delta Q_{pix})$

Comparator and Charge Replenishment

The comparator threshold is determined by the minimum amount of detectable charge and the amplification of the integrating preamplifier. We define the threshold of the comparator to be when ΔQ_{pix} reaches Q_{min}:

$\Delta V_{threshold} = (-\frac{1}{C_f})(Q_{min})$

We define two modes of operation with respect to the feedback control.

• Accumulation mode • Replenishment mode

When the control block is in the accumulation mode, the switched capacitor is said to be accumulating charge. This charge can be calculated and should be equal to the minimum detectable charge Q_{min}.

Q$_{accumulate} = C_{replenish}(V_{accumulate} - V_{accumulate,ref})$

It is worth noting that this implementation has the added benefit of controlling whether to accumulate holes or electrons by simply calibrating $V_{accumulate}$. The voltage $V_{accumulate,ref}$ is a reference voltage that should be equal to the quiescent voltage of the integrating preamplifier for proper operation.

When the control block is in the replenishment mode, the charge that is accumulated during the accumulation mode is now deposited onto the pixel thereby replenishing the charge that was detected.

Conclusions

Simulation results of the charge replenishment front-end can be seen in Fig. reffig:rtd$_patterns.Thisincludesthegenerationofreset-time-delays(RTDs)andthesignalreconstruction.$

A power consumption summary of the charge replenishment front-end can be seen in Table reftab:performance. The ENC was simulated to be approximately $385e^{-}$ at the integrator output when operating at $27°C$. The ENC is projected to be approximately $50e^{-}$ at the integrator output when operating at $-189°C$. This investigation demonstrates a promising path forward towards a scalable pixellated front-end architecture in a 65nm CMOS technology.

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Co-author: BRAGA, Davide (Fermilab)

Presenter: WOODWORTH, Kyle (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **43** Type: **Contribution Talk**

In-Pixel AI: From Algorithm to Accelerator

Thursday, 1 December 2022 10:35 (20 minutes)

Ptychography is a technique for imaging an object by reconstructing the diffraction of coherent photons. By measuring these diffraction patterns across the whole of the object, small-scale structures can be reconstructed. In pixel detectors used for these measurements, the maximum frame rate is often limited by the rate at which data can be transferred off the device. In this talk, we will present an implementation for lossy data compression through a neural network autoencoder and principal component analysis integrated into a pixel detector. The 50x - 80x data compression is undertaken by integrating the signal processing and data processing in the pixelated area. We addressed major tradeoffs in area, latency, and congestion typical in such systems. The flow from algorithm specification in a high-level language, to High-Level Synthesis hardware implementation in a 65nm technology, will be detailed. The improvements from these machine learning-based data compression will be compared to prior implementations of full readout and zero-suppressed readout, also implemented in the same technology.

Primary authors: DILIP, Priyanka (Stanford University / Fermilab); VALENTIN, Manuel Blanco (Northwestern University); NOONAN, Daniel (University of Kansas); DI GUGLIELMO, Giuseppe (Fermilab); HUANG, Panpan; JACOBSEN, Chris; MEMIK, Seda (Northwestern University); TRAN, Nhan (Fermilab); FAHIM, Farah (Fermilab)

Presenter: DILIP, Priyanka (Stanford University / Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **44** Type: **Contribution Talk**

Design of a skipper CCD-in-CMOS active pixel sensor

Wednesday, 30 November 2022 13:55 (20 minutes)

The Skipper-in-CMOS Application Specific Integrated Circuit (ASIC) is an image sensor prototype fabricated in a 180nm CMOS imaging process and intended for a wide range of scientific applications such as low-mass dark matter searches, deep measurement of dark energy and dark matter signatures or single-photon quantum sensing.

The goal of this prototype is to integrate the non-destructive readout capability of skipper Charge Coupled Devices (CCDs) with a high conversion gain pinned photodiode on a CMOS imaging process, while taking advantage of in-pixel signal processing.
Our prototype integrates a 200x200 pixel matrix with 18 different CCD-in-CMOS pixel structures, connected to 10 analog readout channels. The pixel matrix is readout in a rolling shutter scheme. The different pixel designs will allow the study of several process parameters like PPD to CCD charge transfer, conversion gain, CCD charge transfer and full well capacity.
Each readout channel consists of a pre-amplifier, a 20:1 analog MUX with differential track / hold capabilities and a differential buffer to drive an off-chip ADC. The channels have 4-bit gain settings, 2-bit trimmable bandwidth. The simulated equivalent noise charge for a single readout is 1.6e-. Sub-electron noise can be achieved by reading out multiple samples of the same charge packet using the skipper technique and averaging the output signal. A high-speed readout with a minimum integration time of 250ns is possible and the unity-gain linear dynamic range is 11,000e-.

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Presenters: PARPILLON, Benjamin (Fermi Lab); Dr ROTA, Lorenzo (SLAC)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **45** Type: **Contribution Talk**

Leveraging Quantum Sensors for Dark Matter Detection

Wednesday, 30 November 2022 14:15 (20 minutes)

Developments over the last decade have pushed the search for particle dark matter to new frontiers, including the keV-scale lower mass limit for thermally-produced dark matter. Galactic dark matter at this mass is kinematically matched with the energy needed to break a Cooper pair (~meV), making quantum sensors ideally-suited for dark matter detection applications. At Fermilab, we are constructing QUIET, a dedicated, underground quantum sensor test facility, which will be used as part of the Quantum Science Center to deploy quantum detectors in a low-background environment. I will discuss the current state of the field as well as plans to leverage this facility for dark matter detection down to the lower mass limit for thermal production in the early universe.

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Presenter: BAXTER, Daniel (Fermi National Accelerator Laboratory)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **46** Type: **Contribution Talk**

Timing Performance of an Ultra Compact Radiation-Hard Calorimeter Concept: RADiCAL

Wednesday, 30 November 2022 18:00 (20 minutes)

We are conducting R&D on advanced calorimetry techniques based on scintillation and wavelength-shifting technologies and photosensor (SiPM and SiPM-like) technology. In particular, we are focusing our attention on ultra-compact radiation hard EM calorimeters, based on modular structures (RADiCAL modules) consisting of alternating layers of very dense absorber and scintillating plates, read out via radiation hard wavelength shifting (WLS) solid fiber or capillary elements to photosensors positioned either locally or remotely, depending upon their radiation tolerance. The RADiCAL modules provide the capability to measure simultaneously and with high precision the position, energy and timing of EM showers. The application of this concept will address the challenges of providing high performance calorimetry in future hadron collider experiments under conditions of high luminosity and high radiation (FCC-hh environments).
In this talk we show the results obtained for the performance in timing resolution under an electron test beam of 28 and 16 GeV energies conducted in Dec'21 and upcoming in Jun'22 at Fermi National Laboratory (Fermilab) using several capillary technologies.

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Session Classification: Early Career Plenary

Track Classification: WG2: Calorimetry

Contribution ID: **47** Type: **Contribution Talk**

CrystaLiZe: A Solid Future for LZ

Wednesday, 30 November 2022 10:35 (20 minutes)

We propose the crystalline xenon time projection chamber(TPC) as a promising novel technology for next-generation dark matter search. We expect it to exclude and tag radon-chain backgrounds while maintaining the instrumental benefits of liquid xenon TPC. We have built and successfully operated a crystalline/vapor dual-phase xenon TPC in Berkeley Lab. This talk will discuss its instrumental performance as well as recent results to demonstrate the radon exclusion power of crystalline xenon with respect to liquid xenon.

Primary authors: CHEN, Hao (Lawrence Berkeley National Laboratory); SORENSEN, Peter (Lawrence Berkeley National Laboratory); GIBBONS, Ryan (Lawrence Berkeley National Laboratory, University of California, Berkeley); HASELSCHWARDT, Scott (Lawrence Berkeley National Laboratory); KRAVITZ, Scott (Lawrence Berkeley National Laboratory); XIA, Shilo Qing (Lawrence Berkeley National Laboratory)

Presenter: CHEN, Hao (Lawrence Berkeley National Laboratory)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **48** Type: **Contribution Talk**

An On-Chip Low-Power Low-Noise Arbitrary Waveform Generator for Portable Optical Trapped-Ion Atomic Clocks

Thursday, 1 December 2022 10:55 (20 minutes)

Lab-scale optical atomic clocks have achieved absolute inaccuracy below the 10^(-18) level, a precision expected to allow beyond-standard-model physics searches with improved sensitivity. Space-based constellations of optical atomic clocks, if they can be made to reach similar precision, have the potential to detect ultra-light dark matter under multiple scenarios. The integration of electronic and photonic technology into chip-scale trapped-ion systems is a promising route to truly portable, high-performance optical clockwork to address these goals. Here we demonstrate the miniaturization of trap-electrode voltage control electronics suitable for hybrid integration at the chip level. The voltages on sensor electrodes are set by electrical charges on capacitors, so that their values are changed by injecting charging/discharging currents into the corresponding capacitors. The current sources are based on the concept of steering current, so fast waveforms can be generated when active signals are needed to move the trapped ions. When a clean dc voltage is demanded to minimize perturbations to the ion's motional state, on the other hand, the current sources can be isolated for minimal noise and power consumption. The first prototype of this design has been fabricated in a 22 nm Fully depleted SOI process, utilizing High Voltage LDMOS and BOXFET transistors. The 3 × 3mm2 chip consists of 18 channels of arbitrary waveform generators operating at ~ 100MSPS, providing voltages between +/- 3.5V. A Serial-to-Parallel (SPI) interface programs the chip. We will report the concept, the implementation, and the initial test results of this design.

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Presenter: SUN, Hongzhi (Fermi National Accelerator Laboratory)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **49** Type: **Contribution Talk**

Capabilities of the SBND Trigger System

Thursday, 1 December 2022 10:35 (20 minutes)

The Short Baseline Neutrino program in Fermilab's Booster Neutrino Beam will search for eV-scale sterile neutrinos with multiple detectors at different baselines locations. Located 110 meters downstream from the neutrino target, the Short Baseline Near Detector (SBND) will have an unprecedented rate of ~5000 neutrino interactions per day enabling a broad physics program that includes detailed measurements of neutrino-argon interactions and searches for new physics beyond-the-standard model. The SBND trigger combines information from accelerator complex, the photon detection system and the cosmic ray tagger (CRT), the latter of which is available at the trigger level for the first time for a liquid argon time projection chamber (LArTPC) detector in a neutrino beam. The trigger system has many enhanced capabilities, beyond those typically available in neutrino experiments, including data streams customized for individual calibration measurements and low energy final states particles. Trigger commissioning data with beam and CRT signals in 2022 and preparations for the start of data taking in 2023 will be presented.

Primary author: STANCARI, Michelle (Fermilab)

Presenter: STANCARI, Michelle (Fermilab)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **50** Type: **Contribution Talk**

Progress Towards HeRALD: The Helium Roton Apparatus for Light Dark Matter

Wednesday, 30 November 2022 15:15 (20 minutes)

The HeRALD experiment uses the unique properties of superfluid ^{4}He to study dark matter-nucleon scattering in the sub-GeV mass range. In particular, HeRALD uses quantum evaporation from vibrational quasiparticles as well as singlet and triplet electronic excitations to determine the energy and nature of particle interaction in the detector. In this talk I will present progress towards the observation of the quantum evaporation signal using an athermal phonon detector. I will also discuss the broader R&D program, with an emphasis on the helium and materials physics we will study to refine the detector and push the nuclear recoil detection threshold as low as possible.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **52** Type: **Contribution Talk**

Application of a DD-Neutron Source for Low-Energy Nuclear Recoil Calibrations in the LZ Experiment

Wednesday, 30 November 2022 08:50 (20 minutes)

The LUX-ZEPLIN (LZ) experiment is a direct detection dark matter experiment that uses a dual-phase time-projection chamber (TPC) containing 7 tonnes of active xenon with a 5.6 tonne fiducial volume. In LZ, precision nuclear recoil (NR) calibrations are critical to understanding the signal response of dark matter interactions with the liquid xenon inside the detector. Monoenergetic 2.45 MeV neutrons from an Adelphi Technologies, Inc. deuterium-deuterium (DD) neutron generator were used for absolute NR calibrations during LZ's first science run. DD neutrons enable in-situ measurements of the detector's scintillation and electroluminescence response to NRs, and provide a data-driven method for acquiring signal efficiencies of the LZ event trigger and reconstruction. Additionally, calibrations with the DD generator will assist in other rare-event searches, and allow for sub-keV measurements of the charge and light yields of the detector. In this talk, I will present preliminary results of the utilization of DD neutrons, and discuss their application as a key NR calibration source in LZ

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **53** Type: **Contribution Talk**

The Array of Saturated-Gain Avalanche Diode (ASGAD) concept

Wednesday, 30 November 2022 10:55 (20 minutes)

We are introducing a new detector concept that we are labeling Array of Saturated-Gain Avalanche Diode (ASGAD) for the detection of charged particles and individual scattering processes associated with neutrons and possible "dark matter" particles. This concept leverages recent progress in the development of the photon to digital converter technology under the leadership of the Universite de Sherbrooke (QC, Canada). PDCs are an assembly of silicon sensor chip, an array of Single Photon Avalanche Diodes (SPAD), and a readout chip assembled in 3D. The readout chip includes for each SPAD a comparator and a quenching circuit that are used to detect and control the Geiger-mode avalanche. The comparator output is associated with Time to Digital Converter and a counter on the same chip. Single photon timing resolution of 20ps has been achieved. The PDCs should be sensitive to Minimum Ionizing Particle going through its roughly 20 microns of silicon; however, a MIP and a thermal carrier create the same signal and therefore the rate of fake signal is huge, on the order of 100kHz/mm^2. In the ASGAD concept we are proposing to add a layer of silicon above the layer of silicon where the avalanche takes place. In the case of MIP detection the layer is tuned to enhance lateral electron diffusion such that several diodes fire for every MIP. In this concept, the timing signal is generated by the electrons created in the high field region and its resolution should be as good if not better than photon's, which has been demonstrated to be 20ps f(FWHM) for PDCs. We are expecting that ASGADs will have better timing resolution than LGADs. The rate of thermally induced background can be simulated and it is a competition between diffusion induced avalanches and thermally induced avalanches with additional avalanches due to light emission (internal cross-talk). The ASGAD concept can then be extended by making the top layer of silicon thicker in order to offer a significant mass of silicon for "dark matter" particle to scatter. The advantage of ASGADs compared to CCDs (DAMIC and SENSEI) is the ability to correlate interaction in time, i.e. a cosmic ray or gamma ray producing infra-red photons for example. In this talk, we will described the ASGAD concept including high level simulation showing that it is a promising solution for charged particle and dark matter detection.

Primary author: RETIERE, Fabrice (TRIUMF)

Presenter: RETIERE, Fabrice (TRIUMF)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **54** Type: **Contribution Talk**

Tests of an MCP-PMT with an Active Ion Barrier

Thursday, 1 December 2022 11:55 (20 minutes)

Micro Channel Plate (MCP) Photomultiplier Tubes (MCP-PMTs) are photon detectors with many useful characteristics, such as high gain, single photon detection efficiency, precise timing resolution, and the capability of operating in strong magnetic fields without performance degradation. The quantum efficiency of the photocathode of the MCP-PMTs, however, is known to degrade due to "positive-ion feedback," positive ions liberated from the pores and accelerated back towards the photocathode. Coating the MCP pores using Atomic Layer deposition has shown tremendous potential in prolonging the MCP-PMT lifetime. Here, we report on tests of an alternate method of reducing positive-ion feedback developed by Photonis, Inc.–an active ion barrier grid that redirects the liberated positive ions toward the MCP using an opposing electric field.

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Presenter: Prof. BRANDT, Andrew (University of Texas, Arlington)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **55** Type: **Contribution Talk**

Quality control assessment of silicon detector construction using deep learning

Tuesday, 29 November 2022 12:10 (15 minutes)

The wire-bond between the silicon sensor and the circuit board is the primary mode to collect the signal in many silicon detectors. Hence, the clean and unbroken bond is one of the vital demands in the silicon module during construction. Each of these bond holes needs to be inspected at least three times during the assembly i.e., before and after wire-bonding, and after encapsulation. Depending on the size of the detector, the number of holes to be quality checked are on the order of million. The small dimension of the bond holes and the thickness of the wires pose an additional challenge in quality control. As manually checking each hole would be cumbersome and prone to human errors, we have been exploring and testing deep learning based computer vision to automate this quality control (QC). In particular, the image classification technique with the convolutional neural networks to identify the quality of the bond hole. We present the case study of using image classification with CNN for quality control of the construction steps of the silicon detector. In addition, the implementation of the transfer learning and image segmentation techniques will be discussed.

Primary author: LAMICHHANE, Kamal (Texas Tech University)

Presenter: LAMICHHANE, Kamal (Texas Tech University)

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **56** Type: **Contribution Talk**

Smart pixels with data reduction at source

Wednesday, 30 November 2022 16:20 (20 minutes)

Highly granular pixel detectors allow for increasingly precise measurements of charged particle tracks, both in space and time. A reduction in pixel size by a factor of four in next-generation detectors will lead to unprecedented data rates, exceeding those foreseen at the High Luminosity Large Hadron Collider. Signal processing within one bunch crossing clock cycle and smart data reduction within the pixelated region of the detector will improve the accuracy and efficiency of event selection for triggering and analysis. Using the shape of charge clusters deposited in arrays of small pixels, the physical properties of the traversing particle can be extracted by locally customized neural networks. Data from the sensor will be processed with a custom readout integrated circuit designed on 28 nm CMOS technology capable of operating in extreme radiation environments. This talk will present several promising methods of on-chip data reduction, including the application of a momentum selection, as well as reconstruction of particle hit position and incident angle.

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Presenter: DICKINSON, Jennet (Fermilab)

Session Classification: Early Career Plenary

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **57** Type: **Contribution Talk**

Hadron damage investigation of FBK and HPK Low Gain Avalanche Detectors

Wednesday, 30 November 2022 11:15 (20 minutes)

The upgrade of the current Large Hadron Collider (LHC) to the High Luminosity Large Hadron Collider (HL-LHC) will increase the luminosity of the LHC by a factor of 10. Therefore, fast timing detectors with high radiation tolerance are required. Low gain avalanche detectors (LGADs) are promising candidates with timing resolutions within tens of picoseconds. Hamamatsu Photonics K.K. (HPK) and Fondazione Bruno Kessler (FBK) LGADs have been irradiated with 400 and 500 MeV protons respectively at FNAL and LANL at several fluences up to 1.5e15. Characterization measurements of these devices including IV, CV and timing resolution measurements have been performed as a function of the dose received.

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Presenter: SI, Jiahe (University of New Mexico)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **58** Type: **Contribution Talk**

Recent Results from PICOSEC:Sub-25 Picosecond MPGD based charged particle timing

Wednesday, 30 November 2022 10:35 (20 minutes)

(for the PICOSEC Collaboration)
PICOSEC was launched as an RD51 "common project" in 2015 with the goal of providing a cost effective, robust solution to charged particle and photon timing for applications with modest track densities. For instance, this is meant to address the "barrel" coverage in future collider experiments at eIC or FCC-ee. In the past year our collaboration has demonstrated a scalable implementation that currently covers 100 cm^2 area in 1 cm^2 pixels. Testbeam measurements with pion and muon beams achieved 17 picosecond MIP timing and single photon timing to better than 50 picoseconds.

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Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **59** Type: **Contribution Talk**

Signal Processing for SiPM timing applications in the presence of High Dark Count Rate.

Tuesday, 29 November 2022 16:00 (20 minutes)

Although SiPMs have become an attractive photodetector for LHC and future HL-LHC detector systems, the levels of radiation exposure (ie up to 2 e14 neq/cm^2 in the case of the CMS Barrel timing layer) have motivated significant R&D on mitigating the consequences of increased leakage current/Dark Counts. The challenge for signal processing is that ~GHz levels of Dark Counts result in a noise background which, in the frequency domain, has similar characteristics to the signal (so-called "1/f noise"). We demonstrate a technique for mitigating the degradation of time resolution that could be applied to the CMS LYSO/SiPM design, due to this noise term.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **60** Type: **Contribution Talk**

Characterization Measurements of Small-Pitch 3D Silicon Sensors for Particle Physics Applications

Wednesday, 30 November 2022 13:35 (20 minutes)

Silicon sensors in particle physics experiments like those at the Large Hadron Collider must be able to withstand extreme radiation doses. 3D sensor technology is one of the most promising radiation-hard silicon detector technologies. 3D sensors are currently used in the ATLAS detector, but even more radiation-hard sensors must be developed for future collider experiments. Characterization measurements made as a function of fluence for a set of small-pitch 3D sensors that could be used in future particle physics experiments will be presented.

Primary author: GENTRY, Andrew Donald (University of New Mexico)

Co-authors: SEIDEL, Sally (University of New Mexico); Dr SI, Jiahe (University of New Mexico); Dr DALLA BETTA, Gian Franco (University of Trento); Mr BOSCARDIN, Maurizio (Fondazione Bruno Kessler)

Presenter: GENTRY, Andrew Donald (University of New Mexico)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **61** Type: **Contribution Talk**

The GAPS Instrument: An Antarctic Balloon Search for Cosmic Antinuclei

Wednesday, 30 November 2022 10:35 (20 minutes)

The General Antiparticle Spectrometer (GAPS) is the first experiment optimized to identify low-energy (≤0.25 GeV/n) cosmic antinuclei, in particular antideuterons from dark matter annihilation or decay. Using a novel detection approach which relies on exotic atom formation and decay, the GAPS program will deliver an unprecedented sensitivity to cosmic antideuterons, an essentially background-free signature of various dark matter models, as well as a high-statistics antiproton spectrum in an unexplored energy range and leading sensitivity to cosmic antihelium. The GAPS instrument consists of a tracker of >1000 custom Si(Li) detectors; a precision-timing, large-area time-of-flight system; and a novel oscillating heat pipe thermal system. GAPS is currently under integration and preparing for the first Antarctic balloon flight in late 2023 while two follow-up flights are planned.
In this contribution, we will present the custom-developed GAPS instrument technology, including the design principle, commissioning of the GAPS functional prototype, and integration and testing of GAPS full payload, with special focus on the construction of the Si(Li) tracker.

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Presenter: XIAO, Mengjiao (MIT)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **62** Type: **Contribution Talk**

Fast MAPS for Timing Capabilities at Future Colliders

Tuesday, 29 November 2022 17:40 (20 minutes)

The detectors at future e+e- linear colliders will need unprecedented precision on Higgs physics measurements. These ambitious physics goals translate into very challenging detector requirements on tracking and calorimetry. High precision and low mass trackers, as well as highly granular calorimeters, will be critical for the success of the physics program. To develop the next generation of ultralight trackers, a further reduction of dead material can be obtained by employing Monolithic Active Pixel Sensor (MAPS) technology. In MAPS, Si diode charged particle sensors and readout circuitry are combined in the same pixels, and can be fabricated with commercial CMOS processes. Currently MAPS are widely used in different applications in High Energy Physics (HEP), and also in astronomy and X-ray imaging.

Recently, CERN has developed a process modification for the TowerSemi 180 nm CMOS imaging sensor process with extremely low capacitance (in the order of a few fF). This results in a reduced readout noise and power consumption of the front-end electronics, resulting in a reduced need for cooling and enabling light interconnection circuits and mechanical support structures. This technology has been utilized for the Inner Tracking System Upgrade (ITS2) of the ALICE experiment at the LHC.

The CERN WP1.2 collaboration is investigating the possibility of realizing wafer-scale MAPS devices on the novel TowerSemi 65 nm CMOS imaging process. This novel technology offers four-times higher density for circuits, higher spatial resolution, better timing performance and lower power consumption. All these features make the TowerSemi 65 nm process the current state-of-the-art technology for the development of new generation MAPS.

The present work focuses on the development of fast MAPS with improved timing resolution, from the current ~1μs state of the art to ~1 ns, leveraging the collaboration with the CERN's WP1.2. The improved timing resolution must be achieved with a low power consumption to allow for gas cooling, and to offer the possibility of realizing wafer-scale sensors. Therefore, the pixel design will rely on an efficient power-pulsing technique where the sensor's electronics are turned on only during a small window of time, taking advantage of the low duty cycle of e+e- linear colliders. Moreover, the pixel's sampling and noise cancelation techniques will be synchronized with the bunch crossing, to achieve a high signal to noise ratio while maintaining a low power consumption.

A first MAPS prototype was submitted this year in TowerSemi 65 nm technology. The prototype has a dimension of 1.5 ⊠⊠ × 1.5 ⊠⊠ with a pixel pitch of 25 ⊠⊠ ×100 ⊠⊠. This prototype serves to set the baseline for the sensor and the electronics performance. Following the characterization of this prototype, a second prototype will be designed with more emphasis towards meeting the required specifications.

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Presenters: HABIB, Alexandre (SLAC National Accelerator Laboratory); Dr VERNIERI, Caterina (SLAC National Accelerator Laboratory)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **63** Type: **Contribution Talk**

The DarkSide experimental program: dark matter direct detection with dual-phase argon TPCs

Tuesday, 29 November 2022 14:10 (20 minutes)

A vast body of astrophysical and cosmological observations point at the existence of Dark Matter (DM). A well motivated DM candidate is a weakly interacting massive particle, or WIMP, a thermal relic of the Big Bang, which has sub-electroweak-scale self-annihilation cross section and mass up the TeV/c^2-range. The motion of galactic halo WIMPs relative to a detector on Earth could result in WIMP-nucleus elastic collisions detectable by a low-background, low-energy-threshold detector capable of unambiguously identifying a small number of nuclear recoils from WIMP collisions over the course of a very large exposure. Thanks to its excellent ionization response and unique scintillation light emission characteristics, liquid argon can provide excellent sensitivity for WIMP nuclear collisions and strong background suppression.
Building upon its experience with liquid argon detectors, the DarkSide Collaboration, now Global Argon Dark Matter Collaboration, is building a new generation experiment featuring 50 tonnes of liquid argon as active target for DM interactions hosted in a dual-phase time projection chamber. This experiment, DarkSide-20k, extends the cross section vs. mass range sensitivity in the search for dark matter to $7.4x10^{-48}$ cm^2 for a 90% C.L. exclusion for a 1 TeV/c^2 WIMP with a 200 tonne yr run. This talk will describe the essential elements that allow DS-20k to achieve this goal: low argon target activity; use of the scintillation light signal for energy measurement and pulse shape discrimination (PSD) against backgrounds; event position reconstruction using the ionization signal; an active neutron veto surrounding the LAr TPC; and excellent shielding from background radiation by an active muon veto. These techniques are implemented by a combination of new and proven technologies, including low-radioactivity argon from underground sources, SiPM-based cryogenic photosensors, a ProtoDUNE-like cryostat filled with atmospheric argon (AAr), and a LAr TPC constructed from low-background acrylic.

Primary author: SAVARESE, Claudio (Princeton University)

Presenter: SAVARESE, Claudio (Princeton University)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **64** Type: **Contribution Talk**

Light detection in DarkSide-20k with Silicon Photomultipliers

Tuesday, 29 November 2022 17:00 (20 minutes)

The DarkSide program aims to a WIMP direct detection using a dual phase argon time projection chamber. The next generation experiment, DS-20k, will be a detector in excess of 20 tonnes of fiducial mass. A pivotal aspect to the sensitivity of the experiment is its light detection technology. The DarkSide collaboration decided to adopt a new family of photo-sensors called Silicon Photomultipliers (SiPMs). The talk will introduce the design of a DarkSide Photo Detector Module (PDM), a 25cm^2 array of SiPMs read-out as a single unit. The PDM's performances in terms of photon detection efficiency, dark count rate, and correlated noises will be outlined, including an overview of the detailed characterization of the detector's signal-to-noise ratio and its time resolution. Furthermore, the signal extraction strategy will be discussed. Finally, an overview of the silicon packaging techniques will be introduced, with updates on the status of the mass-production of the 13000 PDMs, to the material selection and to the high radio-purity result achieved.

Primary author: SAVARESE, Claudio (Princeton University)

Presenter: SAVARESE, Claudio (Princeton University)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **65** Type: **Contribution Talk**

The LUX-ZEPLIN Data Acquisition and Real Time Monitoring System

Wednesday, 30 November 2022 11:15 (15 minutes)

The LUX-ZEPLIN (LZ) direct-detection dark matter experiment has been deployed at the Sanford Underground Research Facility (SURF), has successfully completed it's first science campaign, and boasts world leading sensitivity. The LZ signal chain comprises of 1395 photomultiplier and auxiliary channels. These signals are digitized on custom FPGA-based digitizers with custom firmware. Digital filters operating on these digitizers provide the ability to carry out real time zero suppression and event selection. Additional sets of filters have been implemented to provide real time monitoring for the health of the signal chain and detector. In this talk, we will provide an overview of the LZ data acquisition system and will highlight features that have been valuable during LZ's commissioning and first science campaigns.

Primary author: KHAITAN, DEV ASHISH

Presenter: KHAITAN, DEV ASHISH

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **66** Type: **Contribution Talk**

LoLX : Studying light in liquid xenon using SiPMs

Tuesday, 29 November 2022 16:40 (20 minutes)

The Light-only Liquid Xenon (LoLX) experiment is designed to study the properties of light emission and transport in liquid xenon (LXe) using Hamamatsu VUV4 Silicon Photo Multiplier (SiPM) modules. LoLX is also being used to investigate the timing structures of scintillation and Cherenkov light production in LXe and provide a better understanding of the effects of external cross-talk between neighboring SiPM modules. LoLX is currently being upgraded to investigate the long-term stability and performance of the Hamamatsu VUV4 SiPMs in LXe environment as well as measure the performance of FBK VUV-HD3 SiPMs. Understanding cross-talk in large SiPM arrays and validating photon transport simulations are important for low background LXe experiments such as nEXO that will search for the neutrinoless double beta ($0\nu\beta\beta$) decay of Xe-136. In this talk, I will present the status of LoLX as well as preliminary results and discuss future plans of the collaboration.

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Co-authors: BRUNNER, Thomas (McGill University); RETIERE, Fabrice (TRIUMF); VIEL, Simon (Carleton University); TETRAULT, Marc-André (Université de Sherbrooke); AL KHARUSI, Soud (McGill University); CHANA, Bindiya (Carleton University); DE. ST. CROIX, Austin (TRIUMF); EGAN, Eamon (McGill University); FRANCESCONI, Marco (INFN); GALLACHER, David (McGill University); GALLI, Luca (INFN); GIAMPA, Pietro (SNOLAB); MARGETAK, Peter (TRIUMF); MARTIN, Juliette (TRIUMF); NOWICKI, Sarah (McGill University); RUDOLPH, Lisa (McGill University); XIE, Liang (TRIUMF)

Presenter: REBEIRO, Bernadette Maria (McGill University)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **67** Type: **Contribution Talk**

Progress towards sub-keV Nuclear Recoil calibration

Thursday, 1 December 2022 09:30 (20 minutes)

We will discuss recent progress in making sub-keV nuclear recoil calibrations practical in a university lab environment. First, we will describe a 124SbBe (gamma,n) neutron source in which a novel Fe shielding method suppresses the outgoing gamma flux while allowing the unmoderated escape of the 24keV neutrons. Second, we will describe a method to moderate and then filter neutrons from a pulsed Deuterium-Tritium (DT) generator, enabling a pulsed keV-scale neutron source. And lastly, we will describe work towards large area neutron capture based backing detectors required for such low energy nuclear recoil calibration of dark matter experiment targets.

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **68** Type: **Contribution Talk**

Transition edge sensor developments for the TESSERACT project

Thursday, 1 December 2022 10:35 (20 minutes)

Developing transition edge sensors (TES) with low energy thresholds is a central focus of the TESSERACT (TES with Sub-EV Resolution And Cryogenic Targets) project. The goal is to develop a TES-based sensor that can serve light dark matter experiments with different targets, including GaAs, Al2O3, SiO2, and superfluid helium. The sensor uses Aluminum (Al) collection films to convert athermal phonons to quasiparticles and Tungsten (W) TESs coupled to the Al to trap and sense the quasiparticles.
Lowering the TES's critical temperature (Tc) can significantly reduce the energy threshold. The TES energy resolution scales with Tc^(3/2). We established microfabrication processes to deposit 40nm W films on Si with Tc's around 20mK. The 20mK Tc films can be patterned into sub-eV resolution, O(10) gram dark matter detectors with crystal targets, which will have unprecedented sensitivity to O(10) MeV nuclear recoil dark matters. Further, we are looking for a process that produces low film stress to reduce the microfracture events, which is a possible candidate for the low-energy excess background in our detector. Meanwhile, we are trying to reduce parasitic noise power in the system to operate our most sensitive TESs with O(1) fW bias powers.
Finally, I'll talk about the performance of a 10g Si cryogenic photon detector with 51mK Tc TESs and a world-leading 2.26eV resolution running at UMass Amherst.

Primary authors: LI, Xinran (Member@lbl.gov;Staff@lbl.gov;Other@lbl.gov); Dr SUZUKI, Aritoki (Lawrence Berkeley National Laboratory); Prof. PYLE, Matt (University of California, Berkeley); SORENSEN, Peter (Lawrence Berkeley National Laboratory); GARCIA-SCIVERES, Maurice (LBNL); Prof. HERTEL, Scott (University of Massachusetts Amherst); Prof. MCKINSEY, Daniel (University of California, Berkeley, Lawrence Berkeley National Lab,); VELAN, Vetri (Member@lbl.gov;Staff@lbl.gov;Other@lbl.gov); ROMANI, Roger (UC Berkeley); Dr PLATT, Mark (Texas AM University); PINCKNEY, Doug (Member@umass.edu)

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **69** Type: **Contribution Talk**

Performance of MCP-PMT and LAPPD in Magnetic Field for RICH Detectors

Wednesday, 30 November 2022 14:55 (20 minutes)

Various ring imaging Cherenkov sub-systems are being proposed in EIC detector for hadron identification with momenta up to 50 GeV/c. It is critical to have a reliable highly pixelated readout sensor working in the high magnetic field environment. Optimization of the photosensor design for high magnetic field tolerance, precision timing resolution, and pixelated readout was performed at Argonne National Laboratory with $6 \times 6\ cm^2$ microchannel plate photomultipliers (MCP-PMT). Large area picosecond photodetector (LAPPD) with $20 \times 20\ cm^2$ size was commercialized and the geometry was redesigned to reach the requirement of EIC Cherenkov detectors.

Argonne MCP-PMT and Incom LAPPDs were recently tested using the Argonne g-2 magnet. Measurements of these devices' performance in the magnetic field will be discussed. The ANL MCP-PMT shows a performance of over 1.5 Tesla with 10 μm microchannels and optimized design. The LAPPD with 20 μm microchannels also show good performance up to 0.9 Tesla. Although gain was reduced when the magnetic field strength was increased to ~1 T or more, or tipped away from normal to the window, the gain could be recovered by increasing the MCP voltage. Due to the effect of magnetic field on electron amplification, we noticed the moving motion of the final electron cluster on the LAPPD strips. This motion needs to be calibrated for detector application.

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Presenter: XIE, Junqi (ANL)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **70** Type: **Contribution Talk**

Development of ultrafast silicon sensors for precision timing and 4D tracking

Wednesday, 30 November 2022 16:40 (20 minutes)

Low Gain Avalanche Detectors (LGADs) are thin silicon detectors with moderate internal signal amplification, providing time resolution of <20 ps for minimum ionizing particles. LGADs are the key silicon sensor technology for the timing detectors of the CMS and ATLAS experiments in the High-Luminosity LHC. In addition, their fast rise time and short full charge collection time (as low as 1 ns) is suitable for high repetition rate measurements in photon science and other fields. However, while radiation hardness and fabrication of such sensors on a larger scale are maturing, electric field termination structures remain a major restricting factor for spatial resolution as they currently limit the granularity of LGAD sensors to the mm scale.

New ultrafast silicon sensors, produced e.g. by HPK, FBK, BNL and other vendors, are studied with C-V/I-V measurements, red and IR laser scans, radioactive sources and charged particle test beams. The results are used to recommend base-line sensors for near-future large-scale detector applications like the Electron-Ion Collider, where simultaneous precision timing and position resolution is required. The studies also serve research and development of silicon sensors for other future colliders.

AC-LGADs, also referred to as resistive silicon detectors, are a more recent variety of LGADs based on a sensor design where the multiplication and n+ layers are continuous, and only the metal layer is patterned. This simplifies sensor fabrication and reduces the dead area on the detector, improving the hit efficiency while retaining the excellent fast timing capabilities of LGAD technology. In AC-LGADs, the signal is capacitively coupled from the continuous, resistive n+ layer over a dielectric to the metal electrodes. A high spatial precision on the few 10's of micrometer scale is achieved by using the information from multiple pads, exploiting the intrinsic charge sharing capabilities provided by the common n+ layer. A balance between all tunable parameters (comprehending location, the pitch and size of the pads, as well as the doping concentrations) has to be identified for future uses of AC-LGADs: the sensor design can be optimized for each specific application to achieve the desired position and time resolution compromised with the readout channel density. Their precise temporal and spatial make AC-LGADs primary candidates for future 4-D tracking detectors, and they are currently the chosen technology for near-future large-scale application like the Electron-Ion Collider EPIC detector at BNL, or the PIONEER experiment at the Paul Scherrer Institute in Switzerland.

Another type of sensor design aimed at reducing the inactive area is the trench-insulated (TI-)LGAD, in which the gain regions are isolated from each other by etching narrow trenches into the silicon substrate between segments. TI-LGADs provide an improved fill factor and negligible charge sharing.
Finally, the fabrication of first prototypes of LGADs with a continuous, but buried gain layer (deep-junction, DJ-LGADs) and initial results on these sensors are reported.

In all aforementioned varieties of LGADs, the contribution of Landau energy transfer fluctuations on the timing resolution are sought to be reduced by decreasing the substrate thickness, from a typical 50 µm to 25-35 µm and less, to approach a timing resolution of ultimately around 10 ps.

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Session Classification: Early Career Plenary

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **71** Type: **Contribution Talk**

The stability of HPK VUV4 SiPMs following a large dose of VUV radiation

Wednesday, 30 November 2022 11:55 (20 minutes)

nEXO is a next-generation neutrinoless double-beta decay experiment that is searching for this decay in 5-tonnes of liquid xenon (LXe) enriched in the isotope 136Xe. Silicon-photomultipliers have been selected to measure the vacuum ultraviolet (VUV) scintillation light from interactions within the LXe. Although candidate SiPMs from Hamamatsu (HPK) and FBK have been characterised within the collaboration and shown to meet nEXOs performance requirements, the long-term stability of their detection efficiency, gain, and correlated noise under VUV exposure has not been thoroughly reported. To investigate long term effects under VUV exposure, a sample of HPK VUV4 SiPMs were irradiated with a flash lamp. The performance of the SiPMs were then reevaluated following repeated VUV exposure. This process was repeated with increasing dose until far exceeding the expected exposure from 10 years of nEXO run time. I will report on the stability of the PDE, gain, and correlated noise for a sample of HPK VUV4 SiPMs following a large dose of VUV radiation.

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **72** Type: **Contribution Talk**

Eos: a prototype for next-generation neutrino detectors

Tuesday, 29 November 2022 16:40 (20 minutes)

Hybrid neutrino detectors, capable of leveraging both Cherenkov and scintillation signals simultaneously, have the potential to revolutionize the field of low- and high-energy neutrino detection, offering unprecedented event imaging capabilities and resulting background rejection. These performance characteristics would substantially increase sensitivity to a broad program of fundamental physics, as well as reactor signals for potential nonproliferation applications. Eos is a planned few-ton scale prototype detector, designed to demonstrate the impact of cutting-edge neutrino detection technology. Leveraging novel scintillating materials, new, fast photon detectors and spectral sorting, Eos will be used to explore the impact of detector configuration choices on the potential for hybrid neutrino detection.

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **73** Type: **Contribution Talk**

TCAD simulation studies for the development of LGADs and AC-LGADs

Tuesday, 29 November 2022 16:40 (20 minutes)

Low Gain Avalanche Detectors (LGADs) are very thin silicon detectors with modest internal gain. LGADs are characterized by an extremely good time resolution (down to 17ps), a fast rise time (~500ps for 50 μm thickness) and a very high repetition rate (~1ns full charge collection). In a broad array of fields, including particle physics (4-D tracking) and photon science (X-ray imaging), LGADs are a promising new sensor options. For example, LGADs are used for upgrade projects at the HL-LHC in the High Granularity Timing Detectors (HGTD) in ATLAS and the Endcap Timing Layer (ETL) in CMS. LGADs are also proposed as candidate for the Active Stopping Target (ATAR) in the PIONEER experiment. The variant design of LGADs, the so-called AC-coupled LGADs (AC-LGADs), are also a promising detector technology for the Electron-Ion collider (EIC) and for PIONEER.

In this talk, we will focus on the TCAD simulation studies for the development of LGADs and AC-LGADs. For large energy deposition from particle injection, where the generated e/h pairs density is large, the gain of LGADs is significantly reduced. Such gain suppression effect has been observed experimentally with Laser and alpha particles (with energy of ~5 MeV) injection. In order to reduce the gain suppression effect, we use TCAD simulation to characterize the cause of gain suppression and provide guidance for improving the LGAD design. We will also present lab measurements with alpha and Laser injection to cross check with the simulation results.

In addition, the performance and signal formation of AC-LGADs are related to the electrode geometry and charge sharing within the resistive n+ layer. We will present TCAD simulation for AC-LGADs with various strip length, inter-strip capacitance, and n+ layer resistivity.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **74** Type: **Contribution Talk**

Spectrometer based on SPAD linear array with sub-nanosecond timing resolution and single photon sensitivity for quantum-assisted optical interferometers.

Wednesday, 30 November 2022 08:30 (20 minutes)

Improved quantum sensing of photons from astronomical objects could provide high resolution observations in the optical benefiting numerous fields in astrophysics and cosmology. It has been recently proposed that stations in optical interferometers would not require a phase-stable optical link if instead sources of quantum-mechanically entangled pairs could be provided to them, enabling extra-long baselines, and potentially improving the astrometrical precision by orders of magnitude. The basic observational event will be the registration of two photons in the system close enough together in time and frequency to be in the same temporal mode, and so be indistinguishable. This will require spectrometers with sub-nm spectral and sub-ns timing resolution with single photon sensitivity.

In this contribution we describe the initial characterization of such a spectrometer based on a linear array of 512 SPAD pixels, LinoSPAD2, produced in EPFL, Switzerland. We employ a thermal argon source with narrow spectral lines to measure the scale, linearity and spectral resolution of the spectrometer and use a spontaneous parametric down-conversion source of simultaneous single photon pairs to measure the timing resolution and energy correlations of the two photons. The achieved spectral and timing resolutions are correspondingly 0.1 nm and 50 ps. Preparations are in progress to test the spectrometer on a telescope using starlight.

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Presenter: NOMEROTSKI, Andrei (BNL)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **75** Type: **Contribution Talk**

Measurement of material performance under incremental radiation dose for LHC – Phase II High Luminosity Upgrade

Thursday, 1 December 2022 09:50 (20 minutes)

The high luminosity Large Hadron Collider (HL-LHC) will collide particles at unprecedented rates to search for new physics and make high precision measurements to challenge the standard model. The increase in granularity of the detectors and the background rates pose high demands for the materials of charged particle tracking detector support structures. Tracking detectors at current (and future) colliders are typically exposed to a high-radiation environment where carbon fiber composite materials are employed to design and build the mechanical support structures of silicon detectors because of their high thermal conductivity, strength to mass ratio and radiation tolerance. The Phase-II CMS upgrade is expected to have an accumulated radiation dose near the interaction point for the polymeric and carbon composite support structures upto $1.5\,\mathrm{GRad}$ $(3000\,\mathrm{fb}^{-1})$ along with thermal cycling between -35℃ to room temperature while installing and maintenance operations. Flexural response testing and dynamic mechanical analysis (DMA) temperature-frequency sweeps are used to measure the radiation effect on elastic, storage, and loss moduli of these materials. Optical microscopy results are presented on pre- and post- irradiated samples for evaluating defects like de-gassing and crack propagation. A method for measuring thermal conductivity is presented and the results show no decrease or degradation on the thermal conductivity of the materials. Future direction of research for using terahertz time domain spectroscopy for evaluating thermal and mechanical strains in a composite material is presented.

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **76** Type: **Contribution Talk**

The upgrade of the versatile data acquisition system - CaRIBOu

Wednesday, 30 November 2022 10:55 (15 minutes)

Developing new detectors requires the design of an adequate readout and control system. Such a system typically consists of hardware in form of a readout board containing programmable logic to provide an interface to the detector chip, power supplies for biasing the sensor, as well as DACs and ADCs for setting and measuring operation parameters, generating test pulses, etc. The CaRIBOu system, a generic hardware, firmware and software platform for the quick development of a read-out solution for detector R&D activities [1] [2] has been designed. This system is designed to promote re-usability and sharing of code between users to reduce development time when integrating new sensor readout ASIC or connecting to larger detector systems like beam telescopes [3]. Various monolithic pixel sensors (e.g., HV-CMOS/HV-MAPS CCPD, H35DEMO and ATLASPix) have been characterized in the test beam with the current CaRIBOu system and FELIX-based readout at CERN, FNAL and DESY [4]-[6]. Due to its versatility, this platform is being adopted by a large community such as CERN EP-DT, RD50 Collaboration, IPHC Strasbourg, DESY, and NASA for their ongoing R&D [7]-[11]. An upgraded CaRIBOu system development will take advantage of progress in FPGA technology, using commercial SOM to optimize the system cost for easy deployment in different experiments. The user community is being expanded with collaboration of the CERN EP R&D program, EU H2020 Innovation Pilot program, in addition to the collaboration on advanced monolithic silicon sensors studies with RD50, CLIC, ALICE, and NASA [12] [13].

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Presenter: TANG, Shaochun (BNL)

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **77** Type: **Contribution Talk**

Stimulated Light Emission of Silicon Photomulipiers Devices

Wednesday, 30 November 2022 08:50 (20 minutes)

Silicon PhotoMultipliers (SiPMs) are increasingly used in next-generation, large area particle physics experiments to achieve single-photon resolution [1, 2, 3]. An array of Single Photon Avalanche Diodes (SPADs) within the SiPM reacts to incident photons through an avalanche process that creates a measurable current flow. This avalanche process generates secondary photons which must be characterized to understand the correlated noise between SPADs (internal cross talk) and between SiPMs (external cross talk). We developed the Microscope for the Injection and Emission of Light (MIEL) to measure this emitted light both passively and through stimulated emission at cryogenic temperatures. Imaging and spectroscopy of the Hamamatsu VUV4, FBK VUV-HD, and DarkSide FBK SiPMs have been completed, and recent light emission characterization of a Photon to Digital Converter designed by U.Sherbrooke and implemented at Teledyne-DALSA will inform the design of next-generation backside illuminated (BSI) digital SiPMs.

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **78** Type: **Contribution Talk**

The Quantum Capacitor Detector – counting single photons in the far-infrared

Tuesday, 29 November 2022 14:10 (20 minutes)

The Quantum Capacitance Detector (QCD) is a high-sensitivity direct detector under development for low background applications such as far-infrared spectroscopy from a cold space telescope. The QCD has demonstrated an optically-measured noise equivalent power of 2x10-20 W·Hz1/2 at 1.5 THz, making it among the most sensitive far-infrared (IR) detectors systems ever demonstrated. It has demonstrated the ability to count single far-infrared photons in single pixel and large array formats. As such, The QCD is an excellent candidate as the detector of choice for applications such as search for hidden sector dark matter and dark energy radiation. A brief overview of the operating principle and current status will be given.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **79** Type: **Contribution Talk**

Quantum Entangled Network of Magnetometers

Wednesday, 30 November 2022 09:30 (20 minutes)

Distributed quantum sensing promises paths to accelerate the development of time synchronization [1], sensing capabilities of gravity gradients and magnetic fields [2], and to advance the search of new physics [3,4]. Classical networks of magnetometers are already in place for the search of dark matter axions [5]. However, it is still an open question how to best entangle a large network of sensors to improve sensitivity and also obtain spatial information during the measurement. We report on the development of a multiplexed entangled network of atomic magnetometers. These room-temperature Electromagnetically Induced Transparency (EIT)-based magnetometers are tailored to be compatible with the quantum memories of the currently-under-construction Long Island Quantum Information Distribution Network (LiQuIDNet). We present the expected gains for such distributed sensing protocol when compared to a classical network, and the advances towards a distributed large-scale network.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **80** Type: **Contribution Talk**

Measuring Quasiparticle Diffusion in Superconducting Al Films with a TES and Microscopic Laser-Scanning Technique

Thursday, 1 December 2022 10:55 (20 minutes)

We present preliminary data from a laser-scanning microscopy-based technique for measuring 100μm-scale quasiparticle (QP) diffusion in superconducting Al films. QP are produced at a localized origin in the Al film using a focused 1550nm laser coupled to a single-mode optical fiber mounted on piezoelectric nanopositioners. The resulting QP propagation can then be monitored using a transition edge sensor (TES), and described using a simple diffusion model.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **81** Type: **Contribution Talk**

A Generic Data Acquisition System for Multidisciplinary Detector R&D

Wednesday, 30 November 2022 10:35 (15 minutes)

Time-domain triggering on a raw stream of data, where the triggering is generally threshold-based or randomly acquired, is critical for many scientific applications from rare-event searches to condensed matter system characterization to high-rate high-energy physics experiments. Generic data acquisition (DAQ) systems that quickly and efficiently process such data are thus necessary for effective detector R&D. In the SPLENDOR Collaboration, we are developing the Python-based SPLENDAQ package for this exact purpose—it offers two main features for offline analysis of continuous data: a threshold-triggering algorithm based on the time-domain optimal filter formalism and an algorithm for randomly choosing nonoverlapping segments for noise measurements. Furthermore, we are developing an online FPGA triggering algorithm for a DAQ system called the Moku, a product created by Liquid Instruments. Using MATLAB Simulink and machine-generated HDL code, we can create and compile a live version of the same algorithm. Here, we discuss the underlying principles of this generic DAQ package and give concrete examples of its utility in various applications.

Research presented in this presentation was supported by the Laboratory Directed Research and Development program of Los Alamos National Laboratory under project number 20220135DR.

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Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **82** Type: **Contribution Talk**

Performance of Highly Irradiated SiPMs Coupled to LYSO:Ce Crystals for the CMS MTD Barrel Timing Layer

Tuesday, 29 November 2022 17:40 (20 minutes)

The MIP Timing Detector (MTD) is a new detector being developed for the CMS upgrade for the High-Luminosity LHC era. The detector will bring the capability of precisely measuring the production time of particles produced in proton-proton collisions. In particular, the MTD will allow for the disentangling of the estimated 200 nearly simultaneous pileup vertices occurring in the interaction diamond at each bunch crossing during high-luminosity operation. The central Barrel Timing Layer of this detector will consist of an array of LYSO:Ce crystals coupled to SiPMs providing unprecedented timing resolution under such conditions. We report on the preliminary performance results of time resolution of the detector prototype measured in the laboratory and with test beam.

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **83** Type: **Contribution Talk**

Additives manufacturing of scintillators: Status and Opportunities

Tuesday, 29 November 2022 16:20 (20 minutes)

Advances in additive manufacturing (AM) techniques, such as 3D printing, can provide an attractive solution for addressing the instrumentation needs for the next generation of HEP experiments. Benefits of AM methods include production of low radioactivity components as well as enabling new geometries and multi-material compositions. These simples to highly complex geometries may be impossible to produce using conventional techniques. In this talk, I will provide an overview of 3D printing techniques used for preparation of organic scintillator which may find future uses in HEP experiments. Results from high spatial resolution light-based 3D printing of scintillators as well as opportunities for new formulations and novel materials will be discussed.

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **84** Type: **Contribution Talk**

BREAD Gigahertz Pilot: A reflector-based search for the dark photon and the axion

Wednesday, 30 November 2022 13:55 (20 minutes)

BREAD is a broadband search for axions, axion-like particles, and other wave dark matter in the $1\ \mu\mathrm{eV}$ to $1\ \mathrm{eV}$ range using a reflector which can fit inside high-field solenoidal magnets. This talk will focus on the hardware developments for gigaBREAD, a room temperature, gigahertz frequency search for the dark photon and our first test of the BREAD reflector concept. We will discuss the design and characterization of the reflector and the coaxial horn antenna which couples to the reflector. We will outline the design of the data acquisition system and plans for operation and calibration of the detector during our upcoming run of the pilot experiment. Finally, we will review the sensitivity projections for the gigaBREAD pilot experiment and plans for future implementations of the BREAD reflector concept.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **85** Type: **Contribution Talk**

Usage of Machine Learning in CMS Level-1 Endcap Muon Trigger

Wednesday, 30 November 2022 11:55 (15 minutes)

The Level-1 trigger of the CMS experiment at the LHC uses custom hardware processors to select up to 100 kHz of interesting events out of a possible 40 MHz. Correct measurement of the transverse momentum of particles is crucial to correctly identify which events to keep. This task is particularly challenging in the endcaps of the CMS experiment due to the non-uniform magnetic field, reduced bending of particle trajectories, and the large amount of collision backgrounds in regions close to the beam line. These challenging conditions provide an ideal problem for machine learning (ML) based solutions. This talk discusses the development and performance of ML based transverse momentum assignment methods at the CMS Level-1 Endcap Muon Track Finder (EMTF) for Run 3 of the LHC as well as the plans for the foreseen Phase 2 upgrade of the EMTF system. A new addition for Run 3 is the neural network based transverse momentum assignment to muons originating from displaced vertices. The displaced NN will complement the boosted decision tree (BDT) based momentum assignment which is optimized for prompt muons that has been in use since 2016. The Phase 2 upgrade of the EMTF will instead use two NNs implemented into FPGAs to handle prompt and displaced muons separately. These new displaced muon triggers will enable new phase spaces for the CMS experiment to search for long-lived particles (LLPs) that decay into muons which are predicted by many beyond the Standard Model (BSM) scenarios.

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Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **86** Type: **Contribution Talk**

Measuring the Migdal Effect

Thursday, 1 December 2022 09:10 (20 minutes)

Searches for sub-GeV dark matter direct detection have been dominated by dark matter electron scattering. However, an inelastic scattering process known as the "Migdal effect", in which an atomic electron is ionized during a nuclear recoil, has been shown to greatly enhance the sensitivity of nuclear recoil experiments to sub-GeV dark matter. In this talk an experimental strategy to calibrate the Migdal effect in silicon and noble element detectors is shown, based on derivations of the Migdal angular spectrum for neutron scattering. Moreover we discuss the importance of these calibration measurements in the next generation of direct detection experiments.

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **87** Type: **Contribution Talk**

Q-Pix: Charge Readout Design and Prototyping

Thursday, 1 December 2022 11:35 (20 minutes)

The Q-Pix concept (arXiv: 1809.10213) is a continuously integrating low-power charge-sensitive amplifier (CSA) viewed by a Schmitt trigger. When the trigger threshold is met, the comparator initiates a 'reset' transition and returns the CSA circuitry to a stable baseline. This is the elementary Charge-Integrate / Reset (CIR) circuit. The instance of reset time is captured in a 32-bit clock value register, buffers the cycle and then begins again. What is exploited in this new architecture is the time difference between one clock capture and the next sequential capture, called the Reset Time Difference (RTD). The RTD measures the time to integrate a predefined integrated quantum of charge (Q). Waveforms are reconstructed without differentiation and an event is characterized by the sequence of RTDs. This technique easily distinguishes the background RTDs due to 39Ar decays (which also provide an automatic absolute charge calibration) and signal RTD sequences due to ionizing tracks. Q-Pix offers the ability to extract all track information providing very detailed track profiles and also utilizes a dynamically established network for DAQ for exceptional resilience against single point failures. This talk will present the current status of the charge readout design and simulation results, implementation of early prototypes, and future planned tests.

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **88** Type: **Contribution Talk**

Novel VUV Light Detection in a Pixelated Liquid Argon Time Projection Chambers

Wednesday, 30 November 2022 13:35 (20 minutes)

Projective readout technologies currently used in Liquid Argon Time Projection Chambers come with a set of challenges from the construction of the wire planes themselves to the continuous readout of the system required to accomplish the physics goals of proton decay searches and supernova neutrino sensitivity. Additionally, the reconstruction techniques required for these projective readouts become complex and difficult for complex neutrino interaction topologies. As such, research into reading out LArTPC's using true 3D pixel based schemes has recently garnered a lot of interest. This new charge readout poses a problem for detection of the scintillation light. In the wire based readout, the wires are transparent to the photons and thus photon detectors (PMT's and SiPM's) coated in wavelength shifting materials (TPB and PEN) can be deployed. However, pixel planes are opaque to the light and thus other methods of detection may be required. A number of novel ideas could be pursued to allow the pixel design to be an integrated tracking/photo-detector. One such notion is the exploration of coating the dielectric surface with a type of photo-conductor which would respond to the VUV light incident on the surface. When struck by a VUV photon, the photoconductor would have electrons elevated into the conduction band and move in the electric field toward a pixel button. We will present some early results and initial R&D being done into the realization of such an integrated tracking/photo-detector for pixel based LArTPCs using the Q-Pix readout scheme, simulation studies which show what is to be gained by such a readout scheme, and ongoing testing currently underway.

Primary author: ASAADI, Jonathan (University of Texas at Arlington)

Presenter: ASAADI, Jonathan (University of Texas at Arlington)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **89** Type: **Contribution Talk**

Measurement of electron in-liquid amplification in pure argon

Thursday, 1 December 2022 08:30 (20 minutes)

As a leading detector technology at the intensity frontier, liquid noble element detectors simultaneously measure the emission of ionization charge (electrons) and prompt scintillation light produced by ionizing particles passing through the noble element. Since the signals are relatively small, lots of efforts are being made to amplify the charge signals by electronic amplifiers after the electron charges are collected in the single-phase detector, which requires stringent electronics noise control, or to multiply electrons before their collection in the dual-phase detector, which introduces technical challenges in detector design and operation. To amplify the charge signals before electrons are collected in liquid phase will lower the energy threshold and improve the signal-to-noise ratio of the liquid noble element detectors, while simplifying the design, and operation of a detector. This technology has been demonstrated feasible in pure liquid xenon by several groups and in this talk, the preliminary results from the measurement of electron in-liquid amplification in pure argon will be presented, together with a future plan to optimize the measurement.

Primary author: MU, Wei (Fermilab)

Presenter: MU, Wei (Fermilab)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **90** Type: **Contribution Talk**

Novel multi-channel skipper-CCD packages for the OSCURA experiment

Wednesday, 30 November 2022 09:10 (20 minutes)

The next generation of experiments for rare-event searches based on skipper Charge Coupled Devices (skipper-CCDs) will bring new challenges for the packaging and read-out of the detectors. Scaling the active mass and simultaneously reducing the experimental backgrounds in two orders of magnitude will require a novel high-density Silicon-based package, that must be massively produced and stored. In this work, we present the design, first production, and testing of a 16-channel Silicon package, along with the outlook for the next steps towards producing 1500 wafers that will add up to a 10 kg skipper-CCD detector.

Primary author: BOTTI, Ana Martina (FNAL)

Presenter: BOTTI, Ana Martina (FNAL)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **91** Type: **Contribution Talk**

Developments of ITkPixV1.1 module Quality Control tools

Tuesday, 29 November 2022 12:10 (20 minutes)

The current ATLAS Inner Detector will be replaced with a new all-silicon Inner Tracker (ITk) to cope with the high-density environment during High Luminosity LHC (HL-LHC). The innermost part of the ITk will comprise a state-of-the-art pixel detector. The individual modules of the Inner Tracker pixel detector incorporate silicon sensors using diverse technologies, with the sensors readout using the new ITkPix ASIC.

The pixel project has mostly completed the prototyping phase and is moving toward the pre-production and production periods. The electrical performances that each module needs to meet to be used in the detector have been documented, and the quality control (QC) testing procedures and tools used to verify them are being developed. Since modules will be assembled and tested in many different institutes across the world, developing universal tools for electrical QC will help ensure uniformly high quality of all modules. In this poster, some of these procedures and tools will be presented.

Primary authors: PIANORI, Elisabetta (Lawrence Berkeley National Lab); ZHAO, Haoran (University of Washington); THOMPSON, Emily; CHAN, Jay; BAI, Kehang; MENG, Lingxin; MARJANOVIC, Marija; HSU, Shih-Chieh Hsu (University of Washington); HEIM, Timon (Lawrence Berkeley National Lab)

Presenter: ZHAO, Haoran (University of Washington)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **92** Type: **Contribution Talk**

PSD_CHIP_V2: An Improved Highly Programmable SiPM Readout ASIC For Neutron Imaging

Thursday, 1 December 2022 11:15 (20 minutes)

PSD_CHIP_V2 is a prototype ASIC that incorporates several features for fast neutron and gamma detection including pulse shape discrimination (PSD) capability, fast time resolution, on-chip integration of total energy, flexibility using programmable registers, low power usage, and scalability. Designed specifically for readout of SensL SiPMs, which have two coupled outputs - a capacitively coupled fast output (FOUT) and a resistively coupled standard output (SOUT) - PSD_CHIP_V2 performs a novel, real-time, analog PSD method. While intended to be used for a double-scatter neutron imager, this chip can be integrated into the front-end of multi-channel, SiPM-readout, neutron-imaging systems with generic topologies. Furthermore, this ASIC features a high level of on-chip programmability to facilitate its use with various scintillators in a final, integrated, neutron imager setup. Design overview, combined with preliminary testing results of PSD_CHIP_V2, will be presented. Bench tests of the PSD scheme using digitized data from a SiPM will also be presented.

Primary author: GODFREY, Benjamin (UC Davis)

Presenter: GODFREY, Benjamin (UC Davis)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **93** Type: **Contribution Talk**

The ETROC project: Precision Timing ASIC Development for LGAD-based CMS Endcap Timing Layer (ETL) upgrade

Thursday, 1 December 2022 11:35 (20 minutes)

The Endcap Timing ReadOut Chip (ETROC) is designed to process LGAD signals with time resolution down to about 40-50ps per hit, in order to reach 30-35ps per track with two detector layers. The most critical element of the ETROC is the analog front-end, namely the preamplifier and the discriminator and the TDC. The challenge here is to reach this level of time resolution while keeping the power consumption below ~3mW per pixel. In addition, the precision delivery of the clock signal to all pixels is also important, its contribution should be kept below 10ps. Due to the challenges described above, the development of the ETROC ASIC is divided into three prototyping phases: ETROC0 (single channel), ETROC1 (4x4 array) and ETROC2 (full size 16x16 with full functionality), with ETROC3 intended to be the final design. In this talk, the development strategy and the performance of ETROC0 and ETROC1 including lessons learned will be presented first, followed by the full size full functionality ETROC2 design (submitted in Oct 2022), with comments on future prospects and challenges for precision position and timing detector R&D.

Primary author: LIU, Ted (Fermilab)

Presenter: LIU, Ted (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **94** Type: **Contribution Talk**

New developments in large area MCP-PMTs

Thursday, 1 December 2022 10:35 (20 minutes)

Large Area Picosecond Photo-Detectors (LAPPDs) produced by Incom Inc. are the world's largest commercially-available planar-geometry photodetectors based on microchannel plates (ALD- GCA-MCPs). It features a chevron pair of "next generation" large area MCPs produced by applying resistive and emissive Atomic Layer Deposition (ALD) coatings to borosilicate glass capillary array (GCA) substrates encapsulated in a borosilicate glass or a ceramic hermetic package. These are available with 10 or 20 µm pore diameters.
A VUV-grade fused silica entry window of the detector is coated with a high sensitivity semitransparent bi-alkali photocathode with roughly 20 cm X 20 cm detection area.
Signals are read out via a capacitively coupled resistive anode. The "baseline" devices have demonstrated electron gains of 107, low dark noise rates (<1000 Hz/cm2), single photoelectron (PE) timing resolution less than 50 picoseconds RMS (electronics-limited), and single photoelectron spatial resolution under 1mm RMS (also electronics-limited), high (25% - 30%) QE uniform bi-alkali photocathodes.
Measurements with LAPPDs operating in strong magnetic fields have been performed. Stable high gain LAPPD operation was demonstrated at magnetic field strength of up to 1.4 T.
First prototypes of a smaller format, 10 cm X 10 cm High Rate Picosecond Photo-Detector (HRPPD) have been manufactured. In addition to all of the LAPPD attractive features, HRPPD has a fully active area with no window support spacers (structural supports). It is equipped with new 10 µm pore MCPs and a new anode design to provide sub-mm position resolution. In comparison with LAPPDs, HRPPD prototypes demonstrated similar gain and dark rates but higher spatial resolution.
LAPPDs and HRPPDs are good candidates for neutrino experiments, HEP experiments, neutrinoless double-beta decay experiments, medical and nuclear non-proliferation applications.Currently, LAPPDs have recently or will be tested at Fermilab, ANNIE, BNL, INFN, DESY, CERN and sold to several countries in the EU and domestically in the USA.

We report on the recent progress in the production and development of the LAPPDs and HRPPDs. Ongoing efforts on development of wide temperature range MCPs and red-enhanced photocathodes, extending sensor lifetime and enlarging sensor active area will also be discussed.

Primary author: LYASHENKO, Alexey

Presenter: LYASHENKO, Alexey

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **95** Type: **Contribution Talk**

Status of the installation and commissioning of the SBND detector at Fermilab

The Short-Baseline Near Detector (SBND) will be one of three Liquid Argon Time Projection Chamber (LArTPC) neutrino detectors positioned along the axis of the Booster Neutrino Beam (BNB) at Fermilab, as part of the Short-Baseline Neutrino (SBN) Program. The detector has been recently is completed and is anticipated to begin operation in 2023. SBND will record over a million neutrino interactions per year. Thanks to its unique combination of measurement resolution and statistics, SBND will carry out a rich program of neutrino interaction measurements and novel searches for physics beyond the Standard Model (BSM). It will enable the potential of the overall SBN sterile neutrino program by performing a precise characterization of the unoscillated event rate, and constraining BNB flux and neutrino-argon cross-section systematic uncertainties. In this talk, the current status and the plan for detector installation and commissioning are discussed.

Primary authors: Dr BLAKE, Andrew (University of Lancaster); Dr CASTILLO FERNANDEZ, Raquel (University of Texas at Arlington); Dr JONES, Rhiannon (University of Sheffield); Dr PANDEY, Vishvas (Fermilab)

Presenters: Dr BLAKE, Andrew (University of Lancaster); Dr CASTILLO FERNANDEZ, Raquel (University of Texas at Arlington); Dr JONES, Rhiannon (University of Sheffield); Dr PANDEY, Vishvas (Fermilab)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **96** Type: **Contribution Talk**

The SBND photon detectors system

Wednesday, 30 November 2022 13:55 (20 minutes)

SBND is the near detector of the Short Baseline Neutrino program at Fermilab. Its near location (110 m) to the neutrino source and relatively large mass (112 ton active volume) will allow studying neutrino interactions on argon with unprecedented precision.
This talk focuses on the SBND Photon Detection System. It represents a major R&D opportunity for the LArTPC technology. Its design is a hybrid concept combining a primary system of 120 photomultiplier tubes, and a secondary system of 192 XARAPUCA devices, all of them located behind the anode plane. Furthermore, covering the cathode plane with highly reflective panels coated with a wavelength shifting compound recovers part of the light emitted towards the cathode, where no optical detectors exist. This new design provides high light-yield and more uniform detection efficiency, an excellent time resolution and an independent position reconstruction (including the drift coordinate) using only the scintillation light.

Primary authors: BLAKE, Andrew (University of Lancaster); CASTILLO FERNANDEZ, Raquel (University of Texas at Arlington); JONES, Rhiannon (University of Sheffield); PANDEY, Vishvas (Fermilab)

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **97** Type: **Contribution Talk**

Nonlinear On-Chip Waveform Processing for Detector ASICs

Tuesday, 29 November 2022 11:50 (15 minutes)

Modern high energy and nuclear physics experiments generate massive (and steadily increasing) amounts of real-time data, much of which cannot be acquired and processed online and is thus discarded using a variety of hardware triggering schemes. This situation is not optimal since the triggering logic is based on established signal models and may discard unexpected signals (some of which may have led to new scientific discoveries). As a result, there is a growing trend towards trigger-less or "streaming" data acquisition (DAQ) schemes in which the hardware triggers are replaced by online feature extraction and machine learning (ML) algorithms. Hardware-level feature extraction from detected signals (also known as waveform processing) is an essential component of such streaming DAQ architectures since it allows real-time data rates to be greatly reduced while preserving the signal's information content. However, implementing these algorithms in hardware is challenging due to the limited power and area budget of the front-end ASICs used for signal conditioning and digitization of the detected signals.

Extracting high-level features from waveforms is a data fitting problem that can be solved by numerically minimizing a suitable cost function, which often includes a regularization term to ensure numerical stability. However, general-purpose nonlinear function minimization methods, such as gradient descent algorithms or artificial neural networks (ANNs), are too computationally expensive for integration within multi-channel front-end ASICs. On the other hand, traditional linear filtering methods such as deconvolution are not suitable for robust feature extraction in the presence of noise. This talk will describe non-linear recursive digital filtering (NRF) as a computationally efficient yet high performance alternative to established methods for real-time on-chip waveform processing. NRF reduces computational complexity by exploiting prior knowledge of signal shapes (e.g., pulses generated by high energy photons) to generate non-linear inverse functions can then be used to obtain features from a small number of successive samples. In addition, it enables signal shapes estimated from earlier samples to be recursively subtracted from the current set of samples, thus minimizing the effects of near-simultaneous signal arrivals (also known as pulse pile up) on spectroscopy at high count rates. The talk will also describe hardware-efficient implementations of NRF based on transversal filter structures that are analogous to those used to implement traditional finite impulse response (FIR) digital filters. The performance of these non-linear filters will be evaluated on waveforms generated by state-of-the-art multi-channel front-end ASICs.

Primary authors: MANDAL, Soumyajit (Brookhaven National Laboratory); DEPTUCH, Grzegorz (BNL); Dr MAJ, Piotr (BNL)

Presenter: MANDAL, Soumyajit (Brookhaven National Laboratory)

Session Classification: WG6: TDAQ and AI/ML

Track Classification: WG6: TDAQ and AI/ML

Contribution ID: **98** Type: **Contribution Talk**

Recent Progresses of Inorganic Scintillators for Future High Energy Physics Experiments

Tuesday, 29 November 2022 17:40 (20 minutes)

Following the priority research directions documented in the 2019 DOE Basic Research Needs Study on Instrumentation [1] for future HEP calorimetry novel inorganic scintillators are under development at the Caltech Crystal Lab. They are radiation hard LYSO:Ce crystals and LuAG:Ce ceramics, ultrafast BaF2:Y crystals and Lu2O3:Y ceramics, and cost-effective heavy scintillating crystals and glasses [2]. These novel inorganic scintillators are expected to provide the best energy resolution and detection efficiency for photons and electrons in future HEP experiments at the energy and intensity frontiers. We report recent progresses of novel inorganic scintillators and their potential applications for an ultra-compact and radiation hard ECAL at the HL-LHC and the proposed FCC-hh, an ultrafast calorimeter and a precision TOF detector, and a homogeneous hadron calorimeter for dual readout calorimetry for the proposed lepton Higgs factory, such as the ILC or FCC-ee.

References

[1] Basic Research Needs Study on HEP Detector Research and Development, 2019, https://science.osti.gov/hep/Community-Resources/Reports

[2] arXiv: 2203.06731 [physics.ins-det], https://doi.org/10.48550/arXiv.2203.06731;
arXiv: 2203.06788 [physics.ins-det], https://doi.org/10.48550/arXiv.2203.06788.

Primary author: ZHU, Ren-Yuan (Staff@caltech.edu)

Presenter: ZHU, Ren-Yuan (Staff@caltech.edu)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **99** Type: **Contribution Talk**

Deep learning for improved directional sensitivity to low-energy nuclear recoils in gas TPCs

Wednesday, 30 November 2022 17:20 (20 minutes)

Recoil-imaging gas TPCs with MPGD charge readout are promising detector candidates for directional dark matter searches beneath the neutrino fog. In a future directional dark matter detector, head/tail recognition efficiency is expected to be one of the most important performance metrics for using directionality to reject solar neutrino backgrounds and establish the galactic origin of dark matter. In this talk, we detail ongoing event-level head/tail studies using a 40 cm^3 micro-TPC with double GEM amplification and pixel ASIC readout, filled with a 70:30 mixture of $\mathrm{He{:}CO_2}$ at atmospheric pressure. We compare head/tail assignment performance on He recoils–both in simulation and in measurement–using traditional Bragg-curve-based approaches, as well as a deep learning approach that assigns head/tail using 3D convolutional neural networks (3DCNNs). In our preliminary studies at a double GEM gain of $\mathcal{O}(1000)$, we found deep learning to substantially improve head/tail recognition for He recoils down to $\mathcal{O}(10\ \mathrm{keV})$. We will also discuss our ongoing work and experimental challenges encountered in extending this work to much higher detector gain. In that regime, the detector has high efficiency to single primary electrons, which should eventually result in maximal directional sensitivity for keV-scale nuclear recoils.

Primary author: SCHUELER, Jeffrey (University of Hawaii)

Presenter: SCHUELER, Jeffrey (University of Hawaii)

Session Classification: Early Career Plenary

Track Classification: WG5: MPGDs

Contribution ID: **100** Type: **Contribution Talk**

Cs3Sb and Ag-O-Cs as Diode Detectors for Low Energy Photon and Particle Detection

Wednesday, 30 November 2022 13:55 (20 minutes)

Diode detectors for photons and photon energy use Si, Ge and many others. For very low energy photons, Si(Ge) pair energy Ep=3.6 eV(2.98eV) are too large for many applications. Semiconductor materials used for vacuum photocathodes have much lower Ep: Cs3Sb (S-11)~2eV pair energy; Cs-Ag-O (S-1) averaged pair energy/work function Ep=0.7 eV, and studies have shown that in small patches that the pair energy/work function is a remarkable Ep = 0.4 eV. We study atomic layer assembly techniques [ALD, MBE, low-temp pulsed-CVD] to make precisely structured Ag-Cs-O to achieve the lowest pair energy, and Cs3Sb for sensors with low energy threshold operating at room temperatures. Cs3Sb bandgap Eg =1.6 eV, larger than the Eg =1.1. eV of Si, yet a lower Ep=2 eV. That large Eg inhibits thermal energy from promoting carriers above the Fermi level, thereby operating with minimal or no cooling for detecting low energy photons.Atomic layer assembly techniques can be used to protect the cesiated materials from air and water vapor with films that are effectively transparent to radiation – single layer graphene is a standard deposited material; 1 layer excludes He. Graphene has been deposited on Cs3Sb photocathodes for protection from air and degradation.

Primary author: WINN, David (Fairfield University)

Presenter: WINN, David (Fairfield University)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **101** Type: **Contribution Talk**

Capacitive Monitoring of Xenon Concentration in a Xenon-Doped Argon Detector

Tuesday, 29 November 2022 12:10 (20 minutes)

Xenon and argon are widely used target media for low cross-section experiments including neutrino physics and dark matter searches. Xenon-doping of dual phase argon time projection chambers (TPCs) at the O(1%) level may enable these technologies to reach unprecedented sensitivity limits. However, the large temperature discrepancy between the argon and xenon boiling points can produce instabilities in a xenon-doped argon detector such as unwanted xenon distillation. Due to the challenging nature of maintaining mixture stability in xenon-doped liquid argon, it is desirable to develop sensors which can precisely measure changes in xenon concentration. We have built a custom capacitor that utilizes the difference in xenon and argon atomic polarizability to measure the xenon concentration in liquid argon with a precision of 0.1%. This talk will discuss the application of this capacitor to monitor the xenon concentration in a dual phase argon detector doped with xenon at 2.35% by molar fraction.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory (LLNL) under Contract DE-AC52-07NA27344 and was supported by the LLNL-LDRD Program under Project No. 20-SI-003. It is also supported by the U.S. Department of Energy (DOE) Office of Science, Office of High Energy Physics under Work Proposal Number SCW1676 awarded to LLNL. J. Kingston is supported by the DOE/NNSA under Award Number DE-NA0000979 and DE-NA0003996 through the Nuclear Science and Security Consortium.

Primary author: Mr KINGSTON, James (University of California, Davis)

Presenter: Mr KINGSTON, James (University of California, Davis)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **102** Type: **Contribution Talk**

Micro-Machined Vacuum Single Photon Photodetector with sub-ns time resolution, 100's MHz rates and high dynamic range

Thursday, 1 December 2022 11:15 (20 minutes)

At present a single pixel or camera plane capable of detecting single photons with high dynamic range, time resolution approaching 10ps, and frame rates above 100's MHz are unavailable. MicroChannel Plate (MCP) based imaging tubes or PMT have superior time resolution compared with PMT, and performance in magnetic fields due to secondary electrons with laterally confined paths to the anode. On the other hand, an MCP-PMT or Image Tube has rate, dynamic range and linearity deficits as it is inherently a resistance-dominated component, as compared for example with a dynode stack with independently powered dynodes. The quiescent current drawn from the HV for an MCP-PMT typically must be ~x100 higher than the signal current for linear behavior and dynamic range. The RC time constant, like a PMT with a purely resistive base, lowers rate and linearity performance. At high rates, the Ohmic heating of the resistive microchannel walls can cause thermal emission image blur. Similarly, consideration of an array of Single Photon Avalanche Diode (SPADs in SiPM) have a similar drawback as being inherently resistive; after an avalanche a SPAD has an RC dead time even with active recharging. No SiPM operates at rates exceeding a ~10 MHz even on single photons, and dense arrays of SPADS have noise from crosstalk when adjacent SPADs fire. A PMT with individual dynode HV draws very little power. We demonstrate combining PMT and Imaging MCP technology by channelizing the dynodes. MEMS (micro-electromechanical system) techniques and 3D printed glass form a thin sheet array of secondary emission channels similar to those of an MCP (microchannel plate) but with an aspect ratio length/diameter of only 1-5 (10-25 μm diameters) which serves as a single dynode stage, rather than as an MCP with a resistive wall. The glass walls and the top side are coated with conducting secondary emission (SE) oxide metal films similar to those used for PMT dynodes -stable and survive the electron bombardment in PMT. The bottom of each sheet dynode is insulated with spin-on glass or printed glass with a dielectric strength of ~10V/μm, to a thickness of ~10-30 μm. Voltages ~100-150V are applied between adjacent staked sheets, with stepped side tabs protruding to connect to dynode voltages. The sheets of micromachined dynodes are aligned so that confined helical channels are formed from the top to the bottom like a traditional MCP but without a significant resistive load. A 10 dynode stack is ~3 mm thick, similar to a traditional MCP.

Primary author: WINN, David (Fairfield University)

Presenter: WINN, David (Fairfield University)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **103** Type: **Contribution Talk**

3D reconstruction of low-energy electron recoils in gas Time Projection Chambers with MPGD charge readouts

Wednesday, 30 November 2022 12:15 (20 minutes)

Directional 3D reconstruction of low-energy electron recoils is widely applicable, for example to neutrino detection, characterization of the Migdal effect, and X-ray polarimetry. Electron recoils have low charge densities and non-trivial topologies, requiring highly segmented and sensitive MPGD charge readouts. The two leading order effects on the angular resolution of electron recoils in gas are the multiple scattering of the recoiling electron and the effective point resolution with which the secondary electrons can be detected. The PDG review on the Passage of Particles through matter provides an angular resolution formula for multiple scattering through small angles; however, we find that this formula does not accurately describe electron recoils in gas. With some modification, we obtain a similar formula that is better suited for this application. In addition, we incorporate treatment for the effective point resolution of the detector. The result is a framework that not only predicts the angular resolution of electron recoils in gas TPCs but determines how much of the recoil track should be fit to optimize the angular resolution. We demonstrate good agreement with simulations and first results with experimental data from the BEAST TPCs — miniature TPCs with highly-segmented pixel ASIC charge readout.

Primary author: GHREAR, Majd

Presenter: GHREAR, Majd

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **104** Type: **Contribution Talk**

The CRAB-0 Demonstrator Detector for Camera-Based Track Imaging in Xenon Gas

Thursday, 1 December 2022 10:55 (20 minutes)

The experimental effort to detect neutrinoless double beta decay has shown numerous R&D advancements in the past several years. One of the R&D lines being explored in high pressure gas xenon detectors, such as those used by the NEXT experiment, is the utilization of a fast optical camera in order to digitize the tracking information. Another R&D line is tagging of the daughter Barium ion, from the decay of Xenon136. Combining barium tagging with topological imaging via high speed cameras and VUV image intensifiers would enable a novel direction in the search for neutrinoless double beta decay within future NEXT detectors. In this talk we will present the first data taken with the high pressure gas xenon Camera Readout and Barium Tagging (CRAB-0) prototype constructed and operated at UT Arlington, and prospects of the larger NEXT-CRAB demonstrator at Argonne National Laboratory.

Primary author: PARMAKSIZ, ilker (University of Texas at Arlington)

Presenter: PARMAKSIZ, ilker (University of Texas at Arlington)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **105** Type: **Contribution Talk**

Removing optical and radiological contaminants from Water-based Liquid Scintillator

Thursday, 1 December 2022 09:30 (20 minutes)

The development of Water-based Liquid Scintillator (WbLS) for use in future particle physics experiments requires that a practical method be found for removing optical and radiological contaminants while not destroying the micelle-encapsulated LS. In addition, loading of some isotopes (e.g. Gd, Li, Te) may be desirable in order to expand the science scope of such detectors into solar physics and neutrinoless double beta decay. Thus, any the required process may also have to not remove some dissolved ions – meaning an atom-specific selective system is needed. In this talk I will describe the progress that has been made to develop just such a practical process using nanofiltration technology. This system will be tested at the BNL 1-ton and 30-ton demonstrators over the next two years.

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **106** Type: **Contribution Talk**

A Gaseous Argon-Based Near Detector for DUNE

Wednesday, 30 November 2022 11:35 (20 minutes)

The main goals of the Deep Underground Neutrino Experiment (DUNE) are to measure CP violation in the lepton sector, make precise measurements of neutrino oscillation parameters, observe supernova burst neutrinos, and detect rare processes such as proton decay. To fulfill these goals, DUNE will use a highly capable suite of near detectors. Among the components of the DUNE Near Detector complex is a magnetized high-pressure gaseous-argon TPC (HPgTPC) surrounded by a calorimeter, designed to provide fine-grained tracking. Due to its low detection threshold, HPgTPC will be able to constrain one of the least-understood sources of uncertainties in the oscillation analysis: nuclear effects in neutrino-nucleus interactions. This talk will provide an overview of the on-going R&D efforts for HPgTPC including the Fermilab R&D program focused on placing a test stand in the Fermilab test beam and an R&D effort dedicated to investigating a GEM readout.

Primary author: Dr MOHAYAI, Tanaz (Fermilab)

Presenter: Dr MOHAYAI, Tanaz (Fermilab)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **107** Type: **Contribution Talk**

The PISA concept: Photon Induced Scintillation Amplifier, an innovative high-gain photosensor for rare event detection

Wednesday, 30 November 2022 13:35 (20 minutes)

Research at the frontier of particle physics often requires the search for phenomena of extremely low probability of occurrence, the so called "rare events". Under this category falls the search for the hypothetical particles potentially composing the mysterious dark matter (DM) of the Universe, like e.g. the Weakly Interacting Massive Particles (WIMPs) or the axions. Being low energy events with faint probability of occurrence, they are buried under much higher levels of background events from environmental radiation. The task is challenging, relying heavily upon reducing background levels to extremely low rates. DM experiments are among the highest priorities in contemporary modern particle physics roadmaps and are typically carried out by large international collaborations. It could be that a breakthrough discovery in one or more of these searches may happen during the next decade. Such a discovery would have ground-breaking consequences for our knowledge of the foundations of particle physics and the nature of the Dark Universe.
There are currently a number of on-going efforts worldwide to directly detect DM in terrestrial particle detectors employing dual-phase gas/liquid xenon or argon. Xenon has in the last few years come to the forefront of the field as a powerful detection medium, with the best scalability prospects for the next generation of multi-ton scale experiments, e.g. DARWIN and MAX [e.g. 1,2], due to its high liquid density and moderate price.
However, the current generation of noble liquid DM detectors is limited by the radioactivity from the detector materials, mostly from the specially radio-clean photomultiplier tubes (PMTs), contributing to the background at ~ 80% level. Additionally, and despite of being the reference photosensors, PMTs have less than full active photocathode area, ~70%. Nevertheless, regarding the characteristically low rate and high background of these experiments, to effectively discriminate de recoiling events from the background it is crucial to have the highest possible photosensor gain and sensitiveness to single photon detection, being these the main reasons to use PMTs.
Large area avalanche photodiodes (LAAPDs), e.g. used by the EXO 200 experiment [3], have small gain (few hundreds, to be compared to the 10^6 of PMTs), small area (few cm^2, to be compared to the few tens of cm^2 of PMTs), insensitiveness to low scintillation levels and high cost per unit of area, limiting their application. In addition, SiPMs although presenting gains around 10^6, have too small active areas to be an alternative. On the other hand, large area hybrid vacuum PMTs are under development to be used as alternative to standard PMTs. Nevertheless, the problems related with vacuum sealing and with the applied high voltages are limiting factors. In addition, the large dimensions that are sought for competitiveness, limit the spatial resolution that could be obtained for the event interaction position.
However, the challenging goals of future multi-ton experiments motivate the development of new photon-detector concepts; these should not only be more affordable than PMTs, but must also allow for a significant improvement in detection sensitivity and background rejection.
We propose a simple concept, the Photon Induced Scintillation Amplifier (PISA), for photoelectron signal amplification in Gas Photomultipliers (GPMs) [4]. Instead of a multi-element stack of micropattern electron multipliers, reading out the charge avalanche produced by the photoelectrons inside the holes of the micropattern electron multipliers, in the PISA a true photon-multiplier is conceived: it is the secondary scintillation produced in the charge avalanches that take place inside the holes of the micropattern electron multiplier that will be read out by suitable photosensors, like SiPMs.
We have shown that a very large number of photons are produced in micropattern electron multipliers enabling the use of just one single multiplier [5]. One electron may produce about 10^5 and 10^4 photons in the THGEM avalanches in xenon and argon, respectively. A Micro-Hole and Strip Plate, etched on Kapton for radiopurity sake, can be used instead of the GEM or THGEM cas-

cade, since the former presents higher photon output. A large photon output in the final charge avalanche ensures the capability for single-photon sensitivity.
This will be a breakthrough also in terms of radiopurity, as the kapton foils, the SIPMs, the GPM fused silica window and the metal case can be obtained with reduced radioactivity levels and, also important is the feasibility to the deployment of remote "hot" electronics, since the large gains achieved in the SiPMs allow for signal transmission over large distances without significant degradation. In addition, the GPM will be cost effective in comparison with the vacuum PMTs and will allow for area coverage above 80% [4]. This higher coverage is important to maximize the photon detection efficiency, as the photoelectron collection efficiency in the gas can be made similar to that of the PMTs (~80%) but, on the other hand, the quantum efficiency of CsI is ~25% (in vacuum) at 175 nm (the CERN RD-26 nominal value), lower than the somewhat above 30% for the photocathode presently used in the PMTs of DM TPCs. The SiPMs can be distributed in a 2D array with a pitch suitable for the needed position resolution.
In this presentation we will show in detail the PISA concept, and experimental results meanwhile obtained for a first prototype, equipped with a GEM or a MHSP, are presented in terms of total number of scintillation photons produced in the charge avalanches, number of photons per avalanche electron and the optical gain, i.e. the number of photoelectrons produced in the photosensor per primary electron that originates a charge avalanche. These parameters will be presented for several scintillating gases/gas mixtures (e.g. based on Ne, CF4, CH4, N2, CO2) of interest for GPM operation, either at room temperature or for cryogenic operation.

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[2] DN McKinsey, J. Phys. Conference Series 718 (2016) UNSP 042039.
[3] JB Albert et al., Phys. Rev. C 92 (2015) 015503.
[4] L Arazi et al., JINST 12 (2017) P10020.
[5] CMB Monteiro et al., Phys. Lett. B 714 (2012) 18.

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **108** Type: **Contribution Talk**

Study of the Properties of Quantum Dot InAs/GaAs Scintillators for Future 4D Trackers

Tuesday, 29 November 2022 17:20 (20 minutes)

Future collider experiments will require particle tracking performance beyond the reach of existing technologies. A novel type of scintillation material based on InAs quantum dots (QD) embedded within GaAs has been developed in pursuit of satisfying the demands of next generation 4D trackers. The epitaxially grown structure utilizes QDs as luminescence centers with radiative timescales on the order of ~0.5 nanoseconds. This fast scintillation response, along with high light yield and potential for picosecond-scale timing resolution in particle detection have all been established for this heterostructured semiconductor. While the refraction index of GaAs (n=3.5) tends toward total internal reflection and waveguiding (WG), efficient collection of scintillation photons is achieved through monolithic photodetector (PD) integration. Crystals up to 25 μm thick have been grown using molecular beam epitaxy and include a metamorphic buffer layer to prevent strain-related defects between the scintillation and photodetection regions. A scanning laser-excited 2D photoluminescence map of a scintillator with the integrated PD has been produced. The attenuation length was measured at 1-2.5 cm^{-1}, limited by self-absorption and surface scattering. Measurements with 5.5 MeV α-particles from ^{241}Am source in unit gain mode have shown the collection of ~10,000 photoelectrons/MeV of the deposited energy and the energy resolution of ~17% FWHM. In addition, our preliminary measurements with 122 keV gamma photons from ^{57}Co are presented. We also report results of the irradiation studies of the scintillator performed with the 1.5 MeV H^{+} beam and the proton fluxes up to 10^{14} cm^{-2}.

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Presenter: MAHAJAN, Tushar Deepak

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **109** Type: **Contribution Talk**

Particle Identification using GEM based TRD/T

Tuesday, 29 November 2022 15:10 (20 minutes)

The phenomena of transition radiation has been used successfully in several High Energy experiments to discriminate particles with different values of γ= E/mc^2 . Traditionally multiwire proportional chambers (MWPC) , longitudinal drift chamber (DC) or straw tubes are being used for Transition Radiation Detector (TRD) which themselves suffer from low rate. Replacing these older charge amplification devices in TRD with Micro Pattern Gaseous detectors (MPGD) like Gas Electron Multiplier (GEM) will not only allow the operation of TRD in both high multiplicity and high luminosity environment but will also aid in high precision tracking. In this talk development and initial results of GEM based TRD will be presented along with future plans associated with this technology.

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Presenter: TARAFDAR, Sourav (Vanderbilt University)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **110** Type: **Contribution Talk**

Controlling the Stability of Xenon-Doped Argon Mixtures

Tuesday, 29 November 2022 11:50 (20 minutes)

The scintillation, ionization, and electroluminescence properties of liquid argon are substantially modified by the addition of small quantities of xenon in a way that benefits many experiments. The resulting target medium retains the low cost and light nuclear mass of argon needed for large neutrino CE⊠NS and dark matter experiments. Maintaining a stable mixture suitable for particle detection requires a cryogenic system designed with specific attention to the large difference in vapor pressures of the components and the xenon solubility limit. We present experiments within a specially designed liter-scale system containing up to 2.35% xenon mole fraction, which is projected to significantly modify the gas-phase electroluminescence spectrum. We describe the exploration of different modes of operation that strongly affect the mixture stability and the implications of this for the design of xenon-doped argon systems.

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **111** Type: **Contribution Talk**

Ion Back Flow and Energy Resolution study for Quadruple GEM detector

Tuesday, 29 November 2022 13:30 (20 minutes)

Gas Electron Multipliers are recently being used in Time Projection Chamber in ALICE and upcoming sPHENIX experiments. The backwards-drifting Ions , known as Ion Back Flow (IBF) in GEM detectors are undesirable for TPC operation because they distort the uniform electric field in the detector gas volume and hence introducing larger uncertainty in tracking charged particles. For particle identification purpose excellent energy resolution is one of the most important requirement. Both the IBF and energy resolution depends on operating voltage of GEM detectors. The studies done by our group involve optimizing the operating voltage for quadruple GEM detector using GEMs of 140 μm pitch to provide low IBF while maintaining good energy resolution along with selecting gas mixture having low space charge density.

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Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **112** Type: **Contribution Talk**

Neutron Imaging Detectors using Ultra-Thin Converter Layers

Thursday, 1 December 2022 08:50 (20 minutes)

We present a novel methodology for application to neutron imaging detectors equipped with boron layers. State of the art boron coated neutron detectors are equipped with 10B films deposited on substrate plates with combined thickness larger than the range of the fission fragments emitted upon a neutron capture reaction. Since these fission fragments are emitted back-to-back, one of them (at least) is always lost into the converter foil with the 10B material. Our novel methodology uses an ultra-thin converter foil, which allows for both fission fragments to reach its surface and be detected in coincidence by two gaseous detector, placed on the sides of the converter foil. By combining the information extracted from tracks produced in the gas by the two fission fragments, it is possible to achieve superior position reconstruction, for shorter exposures, and to provide intrinsic gamma-ray suppression. Through GEANT4 simulations, we verified that the spatial resolution obtained by centre of gravity charge readout methods can be significantly improved [1]: our results show that, by using 0.5 µm thick B4C layers deposited on a 0.9 µm Mylar substrate, the spatial resolution can be improved by a factor of 8, compared to conventional detectors with thick 10B detection layers.
We will present the novel methodology and, along with the requirements and advances in the production of ultra-thin converter foils, share the results obtained so far and the prospects for future neutron imaging applications.

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Presenter: AMARO, Fernando (LIBPhys - Universidade de Coimbra)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **113** Type: **Contribution Talk**

The R&D of the MCP based PMTs for High Energy Physics Detectors

Thursday, 1 December 2022 11:35 (20 minutes)

Researchers at IHEP have conceived two types of MCP-PMTs for photon detection in particle physics. One is the 20-inch Large MCP-PMT (LPMT) with small MCP units in the large area PMTs for neutrino detection. This LPMT has already been mass-produced in more than 15K pieces in the JUNO experiment and has also been evaluated by the PMT group in LHAASO and HyperK. The other is the 2-inch Fast MCP-PMT (FPMT) with the fast timing resolution for particle identification in the collider detector. The FPMT prototypes have been produced with 50 ps time resolution and also with the 8X8 readout anode for the position resolution. This talk will introduce the two types of MCP-PMT and their performance tested in the lab.

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **114** Type: **Contribution Talk**

R\&D studies forward a SiPM-based readout for the dRICH detector at the EPIC experiment

Tuesday, 29 November 2022 16:00 (20 minutes)

Silicon photomultipliers (SiPM) are the baseline option as the photodetector technology for the dual-radiator Ring-Imaging Cherenkov (dRICH) detector at the future Electron-Ion Collider (EIC) in the Electron-Proton/Ion Collider experiment (EPIC). A SiPM-based readout offers important advantages being cheap devices, highly efficient and insensitive to high magnetic field (~ 1 T at the expected location in the experiment). On the other hand, SiPM are well known as not radiation tolerant, showing an increase of the DCR with the radiation dose. The radiation environment is however expected to be moderately hostile (< 10^{11} 1-MeVn_{eq}/cm^2 after several years running at maximum luminosity) with respect to other foreseen SIPM applications in particular at the LHC. The current R\&D program aims thererofre to test if single photon-counting capabilities and timing resolution can be retained despite the radiation damage accumulated during operations.

Several options are available to maintain the DCR to an acceptable rate (below ~100 kHz/mm^2), namely by reducing the SiPM operating temperature, using the timing information with high-precision TDC electronics, selection cuts based on bunch crossing information, and by recovering the radiation damage with high-temperature annealing cycles.

Results on studies performed on a large sample of commercial (Hamamatsu, SensL) and prototype (FBK) SiPM sensors will be presented. The devices have undergone two distinct irradiation campaigns using a 140 MeV proton beam: 1) an increasing NIEL dose up to 10^{11} 1-MeV n_{eq}/cm^2 has been delivered to different sensor subsets that have then undergone high-temperature annealing cycles to recover the radiation damage. and 2) repeated irradiation - annealing cycles on the same sensors using each time a small radiation dose (10^9 1-MeV n_{eq}/cm^2) mimicking the foreseen mode of operations and to test the reproducibility of the procedure.

The characterization results - measurements have been performed in a climatic chamber - were obtained with a complete readout system based on the first 32-channel prototypes of the ALCOR ASIC chip, the candidate ASIC for the dRICH application. Recent results achieved with the irradiated sensors at a test beam using a dRICH prototype will also be presented. Next R\&D steps will be also briefly discussed, including development of annealing in-situ methodologies, irradiation with neutrons, test of time resolution of the irradiated sensors.

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **115** Type: **Contribution Talk**

The R&D of the New Glass scintillator with high density and high light yield

Thursday, 1 December 2022 08:50 (20 minutes)

Scintillation materials can convert high-energy rays into visible light. Generally, solid scintillator can be divided into crystal scintillator, plastic scintillator, glass scintillator and ceramic scintillator. Compared with crystal scintillators, the glass scintillator has many advantages, such as a simple preparation process, low cost, and continuously adjustable components. Therefore, glass scintillator has long been conceived for application in nuclear detection such as hadron calorimeters, the HCAL of CEPC. In 2021 scientists at the Institute of High Energy Physics (IHEP) set up the Large Area Glass Scintillator Collaboration (GS group) to study the new glass scintillator with high density and high light yield. Currently, a series of high-density and high-light yield scintillation glasses have been successfully developed. The maximum density of the glass can exceed 6.9 g/cm3. And the maximum light yield can reach up 3400 ph/MeV. Moreover, Ce3+-doped borosilicate glass can balance the targets of high density and high light yield. In addition, the glasses can achieve neutron/gamma dual detection due to the presence of Li, B, and Gd element

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **116** Type: **Contribution Talk**

Results of a prototype TES detector for the Ricochet experiment

Thursday, 1 December 2022 11:15 (20 minutes)

Coherent elastic neutrino-nucleus scattering (CEνNS) offers a valuable approach in searching for physics beyond the Standard Model. The Ricochet neutrino experiment aims to perform a precision measurement of the CEνNS spectrum at the ILL nuclear reactor with cryogenic solid-state detectors. The experiment will employ an array of 36 detectors, each with a mass of around 30 g and a target energy threshold of 50 eV. Nine of these detectors, the Q-Array, will use Transition Edge Sensors (TESs) coupled to gram-scale targets to observe particle interactions. In this talk, I will present the initial performance of a Q-Array-style detector architecture consisting of a 1-gram Si target coupled to a single TES.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **117** Type: **Contribution Talk**

A TOPAS Simulation of Low-Dose High-Resolution Low-Z-Medium Whole-Body TOF-PET

Tuesday, 29 November 2022 17:00 (20 minutes)

We have used the TOPAS Geant4-based package to write a parametric simulation of the pattern recognition and image reconstruction of a whole-body TOF-PET camera employing a liquid scintillator with low atomic number (Z) as the active medium rather than conventional high-Z crystals, and with large-area MCP-based photodetectors for determination of Time-of-Flight. For 511 keV gamma rays Compton scattering dominates the photo-electric effect by a factor of 10^4, resulting in a chain of successive scatterings with decreasing energy. Each scatter in the detector medium produces a recoil Compton electron that deposits ionization energy along its track.

The kinematic constraints of Compton scattering and the recorded energies and positions in the chain of scatters are used to time-order the scattering events, which are typically separated by at least several centimeters. The first interaction of each gamma ray in the detector medium is chosen from the most probable ordering. A Line-of-Response (LOR) is then constructed between the first interaction points of the two gamma rays. The LOR is parameterized by a transverse Gaussian resolution determined by the detector medium and the optical system viewing the medium, and a longitudinal resolution determined by the time-of-flight (TOF) measured by large-area fast photodetectors.

The TOPAS package was used to simulate a detector consisting of a 30 cm thick, 200-cm long, cylinder surrounding a 45 cm diameter bore. The active medium is assumed to be linear alkylbenzine (LAB),doped with a (yet-to-be-determined) photoswitchable fluorescent dye, capable of many cycles of excitation to fluorescence after being activated by the ionization of the Compton electrons.

Two phantoms were simulated using ^{18}F as the radioactive tracer: the Derenzo geometric phantom, and the human brain of the XCAT voxelized whole-body phantom with an added 2 cm diameter tumor. We present statistics on signal reconstruction efficiencies, misidentifications and signal-to-noise. We show reconstructed images with current nominal activities, and with the activities reduced by factors of 10^2, 10^3, and 10^4.

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **118** Type: **Contribution Talk**

Proposal to Develop an Economical Low-Power Sub-psec Resolution ASIC

Thursday, 1 December 2022 11:55 (20 minutes)

We propose to develop a pathfinder multichannel chip using a modern CMOS process to demonstrate large channel count and scalable multi-buffered readout with sub-psec timing resolution. The development will address the important challenges of calibration, stability and power density that will need to be overcome to create a robust detector system for particle physics experiments in HEP and NP using precise timing for identification of particle flavor and family.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **119** Type: **Contribution Talk**

Phonon-mediated kinetic inductance detectors for low mass dark matter searches

Thursday, 1 December 2022 11:55 (20 minutes)

As the search for dark matter moves toward the sub-GeV mass region and detecting energy depositions too small to create electron-hole pairs, phonon detection will play an increasingly important role. Phonon detection using transition-edge sensors (TESs), a thermal detector, has achieved baseline phonon resolutions as low as 2.65(2) eV in gram-scale targets and is on a trajectory to reach sub-eV thresholds. Kinetic inductance detectors (KIDs) are a pair-breaking alternative also well-positioned to reach sub-eV thresholds and having potential long-term advantages in scalability. We currently estimate the baseline energy resolution for our KID-based detectors to be 20 eV, with large systematic uncertainty. We first will report on progress toward performing an LED-based absolute energy calibration to reduce this uncertainty. We then show a clear path forward to a 20x improvement on the resolution via new KID materials and readout with a quantum-limited low-noise amplifier. Once an eV-scale resolution is demonstrated, we would deploy the detector at the Northwestern Experimental Underground Site for a low-background dark matter search. In a parallel effort, we also demonstrate the massive multiplexability of KIDs, facilitating position reconstruction. We show how such a detector can improve on current methods of discriminating nuclear recoils from electron recoils to more easily reach the neutrino fog in the 0.5-5 GeV/c^2 mass range.

Primary author: WEN, Osmond (Caltech)

Co-authors: BUMBLE, Bruce (JPL); RAMANATHAN, Karthik (California Institute of Technology); BASU THAKUR, Ritoban (Caltech); GOLWALA, Sunil (California Institute of Technology); ARALIS, Taylor (Caltech); CHANG, Yen-Yung (Caltech)

Presenter: WEN, Osmond (Caltech)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **121** Type: **Contribution Talk**

An overview of the MPGD Development for the EIC's ePIC Detector

Tuesday, 29 November 2022 14:50 (20 minutes)

The future Electron-Ion Collider (EIC) at Brookhaven National Laboratory (BNL) will collide polarized electrons with polarized proton/ions. The electron Proton and Ion Collider (ePIC) detector is being designed as the day one EIC detector. The EIC physics program requires precision tracking and PID capabilities that extend over a large kinematic acceptance. Micro-Pattern Gaseous Detectors (MPGDs) are able to provide space point measurements that will aid in both tracking and PID. The eRD108 group has been charged with developing both planar and cylindrical MPGDs for ePIC which address several challenges that would need to be overcome for a successful physics program. These MPGDs will span large angular acceptance and will see tracks entering over a large angular range, in addition to tracks bending due to the ePIC's magnetic field, leading to a degradation of the space point resolution. Furthermore, one needs to deal with potential hit ambiguities and maintain good pattern recognition to ensure the signal hits can be distinguished from background/ghost hits. Finally, depending on where the detectors are located, their material budget could have a significant effect on the tracking performance. An overview of R&D activities by eRD108 to address the above mentioned challenges will be presented here.

Primary author: POSIK, Matt (Temple University)

Presenter: POSIK, Matt (Temple University)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **122** Type: **Contribution Talk**

Secondary Emission Calorimetry

Thursday, 1 December 2022 08:30 (20 minutes)

Calorimetry in high-radiation environments is particularly challenging. Examples
are forward regions of lepton and hadron collider-detectors. A viable choice is to construct a sampling calorimeter with radiation-hard active media. We have developed a radiation-hard, fast, robust and cost effective technique: secondary emission calorimetry(SE cal). Secondary emission from metal oxide films on pure metal are proven to survive GRads of dose, as in PMT dynodes and accelerator beam monitors. We constructed and beam-tested prototype secondary emission sensors. In a secondary emission detector module, secondary emission electrons are generated from a SE-cathode and amplified in subsequent dynodes - similarly to photoelectrons - when hadron or electromagnetic shower particles penetrate the SE module. SE occurs in 10 ps or less and scales as dE/dx, being ~200x larger at low energy than at minimum ionizing, is sensitive to n collisions with the SE surfaces, and very sensitive to nuclear breakup ions, with consequences for good compensation. Here we report on the principles of secondary emission calorimetry, results from beam tests, and comparison with the Monte Carlo simulations.

Primary author: WINN, David (Fairfield University)

Presenter: WINN, David (Fairfield University)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **123** Type: **Contribution Talk**

Scintillating Bubble Chambers for Rare Event Searches

Wednesday, 30 November 2022 10:55 (20 minutes)

The Scintillating Bubble Chamber (SBC) collaboration will combine the well-established liquid argon and bubble chamber technologies to search for GeV-scale dark matter and the coherent elastic neutrino-nucleus scattering from MeV reactor neutrinos. SBC detectors benefit from the excellent electron-recoil insensitivity inherent in bubble chambers with the addition of energy reconstruction provided from the scintillation signal. The targeted nuclear recoil threshold is 100 eV, made possible by the high level of superheat attainable in noble liquids while remaining electron-recoil insensitive. Two functionally-identical, 10 kg detectors are being built. SBC-LAr10, under construction at Fermilab, will be used for engineering and calibration studies and a potential measurement of the coherent elastic neutrino-nucleus scattering on argon. A low-background version, SBC-SNOLAB, for the dark matter search will be operated at SNOLAB. Details of the design and status of the SBC-LAr10 and SBC-SNOLAB detectors will be presented.

Primary author: BROERMAN, Benjamin (Queen's University)

Presenter: BROERMAN, Benjamin (Queen's University)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **124** Type: **Contribution Talk**

Results on LAPPD 38 single photoelectron detection and measurements of charge cloud radius

Wednesday, 30 November 2022 14:35 (20 minutes)

In this talk I will present my most recent results of single photoelectron detection with an Incom Inc. LAPPD (LAPPD 38). The single photoelectron signal is used to determine the characteristic dependence of gain on MCP and photocathode voltages. It is also used to calibrate the LAPPD in units of number of photoelectrons for Cherenkov light detection.
I will also discuss my incipient work on measurements of charge cloud radius in the context of tests of possible MCP gain variation due to MCP pore sharing by electrons at the amplification stage.

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Presenter: MALACE, Simona (Jefferson Lab)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **125** Type: **Contribution Talk**

Development of a barium tagging sensor for NEXT neutrinoless double beta decay searches

Thursday, 1 December 2022 11:15 (20 minutes)

Demonstration of a highly efficient single ion barium tagging sensor could reduce backgrounds in searches for neutrinoless double beta decay ($0\nu\beta\beta$) to negligible levels in ton to multi-ton scale experiments. The NEXT collaboration is pursuing a phased program to search for $0\nu\beta\beta$ using high pressure xenon gas time projection chambers. The implementation of single ion barium tagging sensors is a possible new technology to enhance the sensitivity of xenon gas detectors. In this talk, I will present recent developments based on single molecule fluorescence imaging (SMFI) using a novel high pressure gas microscope and custom-engineered organic fluorophores for dry functionality and an in-situ barium ion beam for sensor testing. This prototype sensor serves as a first of its kind for integration into a future barium tagging high pressure xenon gas TPC experiment.

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Presenter: NAVARRO, Karen (University of Texas at Arlington)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **126** Type: **Contribution Talk**

Non-VUV luminescence of liquid and gaseous argon

Thursday, 1 December 2022 09:10 (20 minutes)

Modern particle detectors based on liquid and gaseous argon are designed to detect scintillation light in vacuum-ultraviolet (VUV) regime. It is known however, that luminescence at longer wavelengths takes place, in visible part of the spectrum and up to the near-infrared (NIR).

Studies of argon scintillation in various spectral ranges are being performed at Fermilab, specifically focused on scintillation processes in low temperature argon gas. The latter is less studied than liquid phase, but relevant for various experimental situations in the current and planned argon TPCs, for example ground-based prototypes, where light emission from the interactions in the gas ullage volume may be significant.

A recent experiment involves an Am-241 alpha-source and three photosensors with sensitivity in different spectral ranges. Data analysis results confirm significant fraction of argon luminescence in visible part of the spectrum and possibly in NIR

New data on the argon scintillation dynamics will help theoretical understanding of the underlying processes and their modeling, which might lead to advancements in the design of argon TPCs, with improved light collection and possibly particle identification.

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Presenter: Dr KISH, Alexander (Fermi National Accelerator Laboratory)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **127** Type: **Contribution Talk**

Experience and results of the ATLAS ITK pre-production staves at Brookhaven National Laboratory

Wednesday, 30 November 2022 11:35 (20 minutes)

The ATLAS experiment is currently preparing for an upgrade of the inner tracking detector for High-Luminosity LHC. The new tracker, ITk, employs an all-silicon detector with outer Strip layers. The building block of the ITk Strip barrel is the stave which consists of a low-mass support structure hosting the common electrical, optical and cooling services as well as 28 silicon modules. Half of the ITk Barrel Strip Detector will be assembled at Brookhaven National Laboratory (BNL) between 2023 and 2026. In this contribution, we outline the challenging aspects of the stave pre-production phase at BNL. The electrical characterization of these staves, hosting the final design of both front-end electronics and ASICs, will be discussed in detail.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **128** Type: **Contribution Talk**

The CYGNO experiment, a directional optically readout detector for Dark Matter searches

Tuesday, 29 November 2022 11:50 (20 minutes)

We are going to discuss the CYGNO/INITIUM experiment, a recent Dark Matter (DM) project focused on developing a new and innovative approach for directional DM searches: a high precision, optically readout, 3D tracking gaseous Time Projection Chamber. The searches will focus on the detection of low mass (0.5-50 GeV) WIMPS and, eventually, solar neutrino spectroscopy. For its detection medium, this project uses a mixture of $He:CF_4$ at 1 atm, a low-density gas sensitive to both spin-dependent and independent interactions.

In the CYGNO approach, the charge amplification stage is composed of a stack of three Gas Electron Multipliers, and the readout is carried out through the combined use of a scientific CMOS camera and PMTs which record the light produced during the electron avalanche. By merging the information of the two-dimensional projection (X-Y) obtained with a sCMOS camera and the track's longitudinal tilt (Z) reconstructed using the PMT signal, it is possible to perform a 3D reconstruction of the ionising events. In addition, the camera's high granularity provides a detailed reconstruction of the energy deposition over a path length which enables topology, directional and head-to-tail recognition down to $O(1)$ keV nuclear recoil energies.

In synergy with this, the INITIUM project, an ERC Consolidator project, aims at developing negative ion drift within the CYGNO optical approach.

We will present the latest overground results obtained with our 50 L, 50 cm drift prototype, LIME, concerning the response linearity, energy resolution, data - Monte Carlo comparison, and expected background rejection capabilities. We will also discuss the installation and operation of LIME underground, and the first steps towards the validation of the design of a 0.4 m^3 detector which will ultimately serve as demonstrator of the technology, performance, and scalability of the project for the experiment's phase 1 detector, a $O(30)$ m^3 TPC already competitive with other DM search experiments in the low WIMP mass region.

David J. G. Marques* on behalf of the CYGNO collaboration

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **129** Type: **Contribution Talk**

Low-threshold Phonon-Mediated Hybrid Detectors with Background Discrimination

Wednesday, 30 November 2022 14:35 (20 minutes)

Two important limitations hinder searches for low-mass dark matter and the reactor neutrino coherent scattering: Backgrounds and the threshold. SuperCDMS experiment is addressing both challenges by using two complementary and different technologies. Using simultaneous ionization and phonon measurement, SuperCDMS gains even-by-event background discrimination and addresses the backgorund challenge and using internal high voltage phonon amplification and the unprecedented threshold thereof, it addresses the threshold challenge.
Our new hybrid phonon-only design provides an alternative that can address both challenges in a single monolithic detector. During the previous CPAD meeting, We presented the performance of a prototype hybrid detector down to ~1 keV nuclear recoil threshold. Here we will present an update on our progress in reaching thresholds well below the existing technologies with background discrimination and our plans to reach single-electron resolution detectors with background discrimination.

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Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **130** Type: **Contribution Talk**

Assessing the performance of metalenses to enhance the light collection of silicon photomultipliers

Wednesday, 30 November 2022 08:30 (20 minutes)

A metalens is an emerging type of flat optical metamaterial that presents several advantages over a traditional lens, such as reduced cost and reduced bulkiness. We developed a set of software tools and fabrication procedures for the rapid development and characterization of new metalens designs. A large field-of-view centimeter-scale metalens was fabricated, and its performance compared with GEANT4-based predictions. We explored the potential in using this metalens to gain an increase in SiPM light collection in a variety of detector geometries.

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Presenter: Dr STANFORD, Chris (Fermilab)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **131** Type: **Contribution Talk**

Automated Circuit Skeleton for All-Digital Implementation of Configuration-Testability-Readout Functionalities in Front-End ASICs

Thursday, 1 December 2022 12:15 (20 minutes)

There are three basic elements in every semiconductor radiation detector: the sensor, the readout chip front-end, and readout chip back-end. To achieve the best possible performance, each of these components must interoperate with each other as well as be optimized within its structure. While sensors and front-end components are often tailored to a specific application, and are relying on the analog domain processing, it may be tempting to develop a versatile but nevertheless sufficiently flexible back-end, that could be almost automatically grown form the code containing its parametrized recipe. The purpose of the back-end is to perform handling and storing of the configuration data, assuring testability, processing output data from the front-end before sending it to the acquisition system and sending the results off chip. Reaching the readiness of the parameterized code, which when executed results in unpacking the physical structure of the entire back-end contributes to reducing the workload of both the ASIC designer and the test engineer, thanks to the ability to reuse already developed solution. It also minimizes the risks of failure. We have developed such a generic and optimized framework, in which the readout part is based on the EDWARD architecture [1], along with a method for its implementation using CAD tools for synthesis and automatic P&R. We present this implementation flow here and hope that with this approach we can soon expand the portfolio of detectors being developed at BNL.

References

[1] D.S. Gorni et al 2022 JINST 17 C04027.

Primary authors: GORNI, Dominik (Brookhaven National Laboratory); CARINI, Gabriella; DEPTUCH, Grzegorz (BNL); MANDAL, Soumyajit (Brookhaven National Laboratory); MIRYALA, Sandeep; PINAROLI, Giovanni (Brookhaven National Laboratory); SIDDONS, Peter (BNL NSLS); RUMAIZ, Abdul (BNL NSLS)

Presenter: GORNI, Dominik (Brookhaven National Laboratory)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **133** Type: **Contribution Talk**

Cosmology with Line-Intensity Mapping using On-Chip Spectrometers and SPT-SLIM

Wednesday, 30 November 2022 14:55 (20 minutes)

Line-intensity mapping (LIM) at millimeter wavelengths is a powerful emerging probe of the large-scale structure of the Universe, but achieving meaningful constraints on cosmological parameters with LIM requires focal planes with orders of magnitudes more detectors than existing instruments. SPT-SLIM is an upcoming experiment to demonstrate LIM observations of CO at $0.5 < z < 2.0$ using on-chip spectrometers with kinetic inductance detectors (KIDs), a new technology that enables scaling to the much larger arrays of detectors needed to probe cosmology. I will present the overall experimental design and specific goals of SPT-SLIM, as well as several innovations in readout electronics and detectors that it will test in the field when it deploys to the South Pole Telescope in 2023. In addition, I will highlight the long-term science goals enabled by on-chip spectrometers and millimeter-wavelength LIM, including the potential to constrain dark energy, neutrino masses, and primordial non-gaussianity.

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Presenter: ANDERSON, Adam (Fermi National Accelerator Laboratory)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **134** Type: **Contribution Talk**

Novel Light-Field Imaging Device with Enhanced Light Collection for Cold Atom Clouds

Wednesday, 30 November 2022 08:50 (20 minutes)

Long baseline atom interferometry offers new opportunities to expand the search for ultra-light dark matter, mid-band gravitational waves, and very weakly-coupled fifth forces. In this context, we developed a novel light-field imaging system that captures multiple views of an atom cloud with a single shot while also maximizing light collection. This enables a single-shot, 3D tomographic reconstruction of cold atom clouds, enhancing the physics capabilities of current and future quantum experiments using cold atom clouds. Simulation results demonstrate that this system is capable of single-shot tomography of atom clouds of size O(1mm) with O(100μm) features, reconstructing the 3D distribution of atoms and features not accessible from any single view angle in isolation. We also demonstrate this system with a 3D-printed prototype. The prototype is used to take images of O(1mm) sized objects, and 3D reconstruction algorithms running on a single-shot image successfully reconstruct target features. The prototype also shows that the system can be built with 3D printing technology and hence can be deployed quickly and cost-effectively in experiments with needs for enhanced light collection or 3D reconstruction.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **135** Type: **Contribution Talk**

A tracker for PIONEER

Wednesday, 30 November 2022 11:55 (20 minutes)

A next-generation rare pion decay experiment, PIONEER at the Paul Scherrer Institute, is strongly motivated by several inconsistencies between Standard Model (SM) predictions and data pointing towards the potential violation of lepton flavor universality. It aims to measure the difference between decay of pion into electron and muon with a precision of 1 part in 10^4 to study lepton flavor universality and the rare process of pion beta decay, with 3 to 10-fold improvement in sensitivity, to test CKM unitarity, which is very important in light of the recently emerged tensions. In addition, various exotic rare decays involving sterile neutrinos and axions will be searched with unprecedented sensitivity. The aimed precision requires excellent reconstruction of decay particles which the collaboration aims to achieve with a detector consisting of a segmented Low Gain Avalanche Detector (LGAD) based Active Target (ATAR), a Liquid Xenon Calorimeter of 25 radiation length and a tracker. We present GEANT study of an optimized micro-RWell tracker surrounding the ATAR to achieve the required precision.

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Presenter: DATTA, Jaydeep (Stony Brook University)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **136** Type: **Contribution Talk**

Design Concept of Imaging Barrel Electromagnetic Calorimeter for the Electron-Ion Collider

Wednesday, 30 November 2022 08:50 (20 minutes)

The Electron-Ion Collider (EIC) will be an experimental facility to explore the gluons in nucleons and nuclei, shedding light on their structure and the interactions within. Physics goals, detector requirements, and technologies at the EIC are outlined and discussed in the EIC community White Paper and Yellow Report. In particular, for the barrel electromagnetic calorimetry, the electron energy and shower profile measurements play a crucial role in the separation of electrons from background pions in deep inelastic scattering processes. Moreover, the calorimeter must measure the energy and position of photons, identify single photons originating from deeply virtual compton scattering process, and photon pairs from π^0 decays. Based on detector requirements, we propose a design of the imaging barrel electromagnetic calorimeter. It is a hybrid design utilizing imaging calorimetry based on monolithic silicon sensors (AstroPix) and scintillating fibers embedded in Pb. We have studied the proposed calorimeter in detail through realistic simulations to test it against the requirements for the physics case described in the EIC community Yellow Report. In this talk, I will present the expected calorimeter performance based on simulations with 3 T magnetic field and the outlook of the upcoming R\&D program related to the imaging calorimetry will be also presented.

This work is supported by Laboratory Directed Research and Development (LDRD) funding, "Tomography at an Electron-Ion Collider: Unraveling the Origin of Mass and Spin" and "Towards Prototyping the Design of a Generic Imaging Barrel Electromagnetic Calorimeter" from Argonne National Laboratory, provided by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC02-06CH11357.

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Presenter: KIM, Jihee (Argonne National Laboratory)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **137** Type: **Contribution Talk**

Proton endcap ElectroMagnetic Calorimeter Design and Simulations

Wednesday, 30 November 2022 09:10 (20 minutes)

The proton endcap ElectroMagnetic Calorimeter (pECal) at EIC is essential for measuring jets in the hadron-going direction, identifying the π^0 decay photons, and e/π separations. The pECal requires to have a good energy resolution and fine granularity. It is planned to be a sampling calorimeter. The current design of pECal is a W-powder/ScFiber (W/ScFi) detector initially developed at UCLA. The W/ScFi detector design has unique features that match the requirements of the ePIC scientific program very well. I will discuss considerations for the W/ScFi pECal design and compare it with other possible alternatives. I will discuss the current pECal design and preliminary performance results for GEANT4 simulations.

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Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **138** Type: **Contribution Talk**

Highly-charged Ion Atomic Clock and Ultra-light Dark Matter

Wednesday, 30 November 2022 09:10 (20 minutes)

The QSNET consortium is building a network of next-generation atomic and molecular clocks that will achieve unprecedented sensitivity to variations of the fine structure constant, α, and the electron-to- proton mass ratio, μ. Variations in α can arise in a wide range of theories that extend the standard model, and constrain a wide range of models of ultra-light dark matter. An outline of the experimental and theoretical goals will be presented, and progress will be reported in constructing a highly charged Californium ion clock.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **139** Type: **Contribution Talk**

AC-LGAD detectors for Spatial and Timing Measurements at the Electron-Ion Collider

Tuesday, 29 November 2022 17:00 (20 minutes)

The Electron Ion Collider (EIC), the next Nuclear Physics flagship facility, will be constructed at Brookhaven National Laboratory over the next decade. The EPIC detector will be the first experiment at the EIC dedicated to detailed studies of the structure of nucleons and nuclei in electron-proton and electron-ion collisions.

The ambitious physics program of the EIC requires hermetic particle identification spanning a wide momentum range. In EPIC, a dedicated time of flight (TOF) detector system will cover the lower end of the expected momentum spectrum, while simultaneously providing high resolution position information to aid in track reconstruction. Detectors in the far-forward direction, such as Roman Pot detectors, have similar requirements in spatial and temporal resolution for the detection of scattered protons at very small angles.

The AC-coupled low gain avalanche detector (AC-LGADs) is the currently preferred technology for both the TOF and Roman Pot detectors in EPIC. They have demonstrated precise spatial resolution as low as 10um while providing a TOF precision of 20-30ps for single MIPs. Various studies on sensor design and characterization, frontend readout ASIC R&D as well as system design and integration are underway within the EPIC collaboration.

In this talk, we will present the layout, specifications, R&D status and plans to develop the full system design for EPIC.

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Presenter: HARTBRICH, Oskar (Oak Ridge National Lab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **140** Type: **Contribution Talk**

GeSiSn nano-structures for HEP and QIS detectors

Thursday, 1 December 2022 11:35 (20 minutes)

Several applications in High Energy Physics and Quantum Information require extending the spectral sensitivity of photon detectors at wavelengths in the IR spectral range beyond what is achievable with Si or Ge but maintaining high sensitivity. III-Vs semiconductors, PbSe/PbTe and InGaAs/AlGaAs have been dominating the scene, but they cannot be monolithically integrated on Si platform. We report here on novel material system based on GeSiSn which provides the extended spectral range up to 5 um and that may boosts single photon sensitivity. Alloying GeSi with Sn relultes in a transition from indirect to direct band-gap in the semiconductor . This opens new possibilities for developing detectors working within IR spectral range, i.e. between NIR and LWIR. Moreover, this material is attractive for applications due to its easy integration with Si-platform. In order to shift band-gap towards longer wavelengths, higher concentration of Sn is required. However, due to significant lattice mismatch between Ge and Sn of 14%, this task is difficult. Solution to this issue is growing GeSiSn nanostructures such as quantum dots and wells where reaching sensitivity to longer wavelength is achieved at lower concentration of Sn because of the confinement energy contribution. We discuss structure design and growth strategy that will allow us to achieve devices working between 2 and 6 µm.

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Presenters: Dr ZAJAC, Joanna (Brookhaven National Laboratory); CULTRERA, luca (BNL)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **141** Type: **Contribution Talk**

Spark Monitoring System for sPHENIX TPC GEMs

Tuesday, 29 November 2022 14:10 (20 minutes)

The sPHENIX experiment at RHIC requires a high resolution tracking detector in order to distinguish different states of the Upsilon meson to study the evolution of quark gluon plasma (QGP). A Time Projection Chamber (TPC) will serve as a main tracking detector for this measurement. The sPHENIX TPC uses a stack of Gas Electron Multipliers (GEMs) as a gain stage in a reduced ion back-flow configuration. In non-ideal conditions, the high voltage across a GEM stack can create sparks which can cause physical damage and result in dead time as the detector settles. In order to limit the occurrence of sparks in the TPC GEMs it is important to monitor for sparks. In this talk we will present a method for detecting sparks so that GEM voltages can quickly be adjusted in order to prevent further sparking. Further, the development of monitoring electronics which will take in the spark signal and produce a signal that can be digitized at 10 MHz, will be discussed.

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Presenter: DRIEBEEK, Julian (Stony Brook University)

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **142** Type: **Contribution Talk**

Optimizing MKIDs for Future Millimeter Wavelength Cosmological Surveys

Thursday, 1 December 2022 12:15 (20 minutes)

Future mm-wave cosmological surveys need mega-detector focal planes to confirm or rule out defining theories for the missing cornerstones of modern cosmology. Microwave kinetic inductance detectors (MKIDs) can straightforwardly scale to large-format detector arrays, including photometer arrays and on-chip filter-bank spectrometers. This talk will present a suite of optimization efforts toward the next-generation MKIDs-based detector arrays. I will report the separation and tuning of detector noise components that resulted in photon noise-limited detectors. The optical efficiency, detector quality factor, and spectrometer resolution depend on dielectric loss. I will discuss our low-loss dielectrics and their loss tangent measurements from centimeter to millimeter wavelengths. Reliable galvanic contact between the niobium capacitor and aluminum inductor in our detector is a third challenge that we overcome by capping the niobium with a niobium nitride layer before depositing aluminum. These efforts have led to photon-noise-limited photometers with high optical efficiency and paved the way for our next-generation spectrometers.

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Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **143** Type: **Contribution Talk**

Charge sharing in pixelated semiconductor sensors

Wednesday, 30 November 2022 14:35 (20 minutes)

The charge sharing between neighboring pixels in pixelated sensors
can be used to measure particle or x-ray coordinates with accuracy better than the pixel pitch.
The accurate model of the charge distribution shape is essential to achieve ultimate coordinate accuracy.
The charge sharing is caused by charge carriers diffusion on the path from the generation point to pixels.
This paper is focused on the diffusion of the initially compact charge cloud in the field free region.
The diffusion equation solutions are obtained using
separation of variable and Fourier synthesis method for different initial conditions and
resulting charge distributions are integrated over pixel areas.
The look up table containing pre-calculated values for pixel charge fractions is proposed to speed up numerical calculations.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **144** Type: **Contribution Talk**

Radiation damage investigation of epitaxial p-type silicon using Schottky and pn-junction diodes

Wednesday, 30 November 2022 11:55 (20 minutes)

This project, which is part of RD50, focuses on the investigation of trap energy levels introduced by radiation damage in epitaxial p-type silicon. Using 6-inch wafers of various boron doping concentrations (1e13, 1e14, 1e15, 1e16, and 1e17 cm^{-3}) with a 50 µm epitaxial layer, multiple iterations of test structures consisting of Schottky and pn-junction diodes of different sizes and flavours are being fabricated at RAL and Carleton University.

In this talk, details on the diode fabrication and electrical measurements of the structures will be given. IV and CV scans of fabricated test structures have been performed and cross-checked between institutes, the results of which will be presented. Furthermore, another focus of this talk will be in the characterisation of trap parameters obtained from Deep-Level Transient Spectroscopy (DLTS) and supplemented by Thermal Admittance Spectroscopy (TAS). Spectra for unirradiated and irradiated diode samples will be shown and their details collected from Arrhenius analyses will be listed.

Finally, the on-going activities for the next round of wafer processing and proposed plans for measurements and irradiation in the coming months, will be reviewed.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **145** Type: **Contribution Talk**

LArPix and LightPix: highly-scalable, cryogenic readout electronics

Thursday, 1 December 2022 11:55 (20 minutes)

3D ionization information facilitates unambiguous mm-scale fine-tracking in high occupancy liquid argon time-projection chamber (LArTPC) environments. LArPix-v2 incorporates low-power 64-channel custom ASICs with a mixed-signal large-format printed circuit board for an unambiguous 3D charge-readout anode. With robust I/O and control architecture, a 10-by-10 array of ASICs instrument a 6,400-pixel PCB-based anode. The system is compatible with standard large-scale commercial electronics production techniques, enabling low-cost quick-turn production. Here I present a system design overview alongside LArPix-v2 ASIC and pixel anode tile benchmark performance evaluation. This system will be deployed in upcoming ProtoDUNE-ND LArTPC physics operation.

The development of scalable cryogenic-compatible electronics capable of reading out very large numbers of silicon photomultipliers (SiPMs) would enhance current and future neutrino and dark matter experiments. The prototype LightPix system is an attempt to meet this need, and is based on slight adaptation of the LArPix system that has been proven in liquid argon time-projection chambers at the 100,000-channel scale. The first-generation LightPix ASIC reuses most of the LArPix design, adding a low-power TDC with sub-nanosecond resolution. Additionally, LightPix-v1 features multi-channel coincidence triggering modes to suppress excess data from SiPM dark noise. Here we present an initial performance evaluation of the LightPix-v1 ASIC.

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **146** Type: **Contribution Talk**

Sub-electron skipper-CCD readout with multi-channel cryogenic low-noise readout ASICs

Thursday, 1 December 2022 09:30 (20 minutes)

The MIDNA series of application specific integrated circuits (ASICs) are cryogenic skipper-CCD readout chips fabricated in a 65 nm LP CMOS process and intended for the OSCURA dark matter detection project. Each MIDNA ASIC integrates four front-end channels designed to interface with four of the 4000 skipper-CCDs that make a 28 gigapixel dark matter detection camera. Each channel is less than 0.2 mm² and achieves an equivalent noise charge of 1 e⁻_{rms} at 20 µs integration time in simulation. Taking advantage of the non-destructive readout capabilities of skipper-CCDs, the first chip, MIDNA 1, has demonstrated a CCD image readout with 0.2 e⁻_{rms} noise by averaging samples of each pixel. The averaging can be performed digitally, by sampling the output of the chip, or it can be performed in the analog domain by using the analog pile-up readout scheme, thus reducing the number of analog-to-digital conversions required per pixel. Both chips enable the scaling required by OSCURA by integrating readout channels containing a pre-amplifier, a DC restorer, and a dual-slope integrator. The channel has four gain settings to maximize dynamic range for a variety of CCD charge gains. The minimum integration time is 1 µs. The power consumption is 6.5 mW per channel plus 5.5 mW for auxiliary circuitry. The linear dynamic range is 3000 e⁻ in nominal gain. The temperature range is 84-120 Kelvin as required by the skipper CCD, and the input referred noise is less than 6 nV/√Hz at 10 kHz. The second iteration of the chip, MIDNA 2, additionally integrates a voltage reference, bias generation, and reference buffering on chip, which reduces channel to channel crosstalk.

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Presenter: BRAGA, Davide (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **147** Type: **Contribution Talk**

Development and testing of AC-LGAD sensors for future 4D-trackers

Tuesday, 29 November 2022 17:20 (20 minutes)

Precise timing information will play a critical role in the performance of future tracking detectors and currently poses a profound challenge to their development. Tracking detectors capable of achieving 5-25 ps timing resolution and 5-30 μm position resolution are needed for many proposed future colliders. The new technology of AC-coupled LGADs has been demonstrated as a good candidate for such a detector. Detailed characterization of sensors fabricated by the BNL and HPK have been carried out at the Fermilab Test Beam Facility to study these sensors performances with unparalleled level of details. We present a world's first demonstration of silicon sensors in a test beam that simultaneously achieve better than 5−10 μm position and 30 ps time resolution. We also report studies of large-area AC-LGAD sensors, which serve as prototypes for future 4D-tracker applications.

Primary authors: TRICOLI, Alessandro (Brookhaven National Lab); APRESYAN, Artur (Fermilab); MADRID, Christopher; PEÑA, Cristián (Fermilab); D'AMEN, Gabriele (Brookhaven National Laboratory (US)); GIACOMINI, Gabriele (BNL); HELLER, Ryan; XIE, Si (Fermilab); BROOKS, William (Universidad Técnica Federico Santa María); YE, Zhenyu (University of Illinois at Chicago)

Presenter: APRESYAN, Artur (Fermilab)

Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **148** Type: **Contribution Talk**

Chip Development Toward 12 bit 10 GSPS Cryogenic ADC for Multiplexed Quantum Readout

Thursday, 1 December 2022 09:50 (20 minutes)

The ROADS (Readout of Analog Data Simultaneously) effort at Fermilab is a collaboration with Microsoft Quantum. The goal is to advance the state-of-the-art in cryogenic electronics for quantum computing applications, especially in highly scaled systems. The design objectives center around the development of a high-speed, high-linearity analog-to-digital converter (ADC) as part of a fully digital solution for frequency multiplexed readout. The ADC is targeted for 10 GSPS, 12 bit performance operating at 4 Kelvin based on an interleaved Successive Approximation Register (SAR) architecture. To date, the effort has taped out two chips using the GF 22 nm Fully Depleted Silicon-on-Insulator (FD-SOI) process. The first was the Mis-Match Test Chip which included test structures for a SAR ADC: a 6-bit capacitive digital-to-analog converter (DAC), bootstrapped switches, and source-follower readout. The chip has been tested and proven to be functional at cryogenic temperatures with good binary-scaled control, effective sampling from the bootstrapped switches, and acceptable readout performance. The second tape out was the Michigan chip, which is a development pathfinder prototype for the high-speed ADC and low-jitter PLL. Michigan included four SAR ADC channels with analog input buffering, a type II charge pump LC phase-locked loop (PLL), various clock generation circuits, and digital data handling with integrated memory. The fully programmable PLL runs at 10.24 GHz. The next chip, Glebe, will include further refinements of the designs. Full speed ADC slices will be interleaved to achieve 10 GSPS, and a double-sampling PLL that employs a cryo-VCO with common mode resonance technique is being developed. Specific performance metrics and figures of merit can be presented at the workshop.

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Session Classification: WG1: Solid State Detectors and ASICs

Track Classification: WG1: Solid State Detectors and ASICs

Contribution ID: **149** Type: **Contribution Talk**

Effects of Ionisation Electron Diffusion on Calibrations in LArTPCs

Thursday, 1 December 2022 09:30 (20 minutes)

To maximise the physics reach of time projection chambers, it is vital that we have accurate knowledge of the transport properties of the ionisation electrons that drift through such detectors. One such property, ionisation electron diffusion, has typically been considered during detector design, with little attention given to its effects on high-level physics. This talk will provide a brief overview of the diffusion measurements that have been made to date, and will present a GEANT4 based study that shows diffusion can bias current calibration techniques at the ~5% level.

Primary author: LISTER, Adam (University of Wisconsin - Madison)

Presenter: LISTER, Adam (University of Wisconsin - Madison)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **151** Type: **Contribution Talk**

The TRANSLATE (simulation models the TRANSport in Liquid Argon of near-Thermal Electrons) simulation package and the LArCADe Project

Wednesday, 30 November 2022 09:10 (20 minutes)

Liquid argon (LAr) is widely used as a detector medium to image particle interactions from the keV to GeV scale in searches for rare processes and measurements of neutrino interactions. Furthermore, a vibrant R&D community is active in developing scalable LAr detectors with lower thresholds and fine granularity. One such effort, LArCADe, intends to explore the feasibility of charge amplification in liquid argon to enable measurements of low-threshold processes such as CEνNS. As experiments grow in scale and complexity and R&D efforts advance, the development of tools to investigate important microphysics effects impacting LAr detectors becomes necessary. We present a new time-domain Monte Carlo simulation of electron transport in liquid argon. The simulation models the TRANSport in Liquid Argon of near-Thermal Electrons (TRANSLATE) with the aim of providing a multi-purpose software package for the study and optimization of detector environments, with a particular focus on ongoing and next generation liquid argon neutrino experiments utilizing the time projection chamber technology. TRANSLATE builds on previous simulation tools, with an emphasis on the simulation of charge amplification and ionization electron transport in non-uniform electric fields. The simulation is validated by benchmarking its performance with swarm parameters from data collected in experimental setups operating in gas and liquid. This presentation will cover the TRANSLATE simulation and the status of the LArCADe R&D project.

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Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **152** Type: **Contribution Talk**

Extending the Reach of Dielectric Haloscopes

Wednesday, 30 November 2022 14:35 (20 minutes)

Dark photons and axions can be converted to photons at the interface between dielectrics with different indices of refraction. Dielectric haloscopes take advantage of this by using stacks of dielectric layers with alternating indices of refraction to boost the photon generation rate from the dark sector [1]. Recent proof-of-concept results from the LAMPOST experiment at MIT [2] and the MuDHI experiment at NYU Abu Dhabi [3] have used such haloscopes to set new limits on dark photon dark matter at the 1eV scale. The BREAD experiment at Fermilab is based on a similar principle. A large ($10m^2$) focusing mirror acts as a highly broadband dark-matter-to-photon converter in the meV to eV range [4]. In order for the next generation of dielectric haloscopes to be competitive with BREAD, they will have to be upscaled or upgraded. For the next iteration of LAMPOST, we are exploring new concepts for improving both the dielectric structure and the superconducting photon detector to increase sensitivity and bandwidth.

While the superconducting cavity haloscopes used at lower frequencies (GHz) can be tuned to scan over a large frequency range, the dielectric stack of LAMPOST cannot be adjusted after fabrication. Thus, in order for layered dielectric haloscopes to have significant reach, many dielectric stacks of different dimensions will be needed. As an alternative, we are investigating dielectric powders as dark matter absorbers. The high surface area to volume ratio of a powder provides a high density of dielectric interfaces for photon production. A large-area single-photon detector collecting signal from a powder of highly transparent material like sapphire or NaCl could have three orders of magnitude more reach (bandwidth times sensitivity) than the LAMPOST prototype.

[1] Millar et al, JCAP 01 (2017)
[2] Chiles et al, Phys. Rev. Lett. 128 (2022)
[3] Manenti et al, Phys. Rev. D. 105 (2022)
[4] Liu et al, Phys. Rev. Lett. 128 (2022)

Primary author: KOPPELL, Stewart (Massachusetts Institute of Technology)

Co-authors: Mr PAUL, Dip Joti (Massachusetts Institute of Technology); Mr COLANGELO, Marco (Massachusetts Institute of Technology); Prof. BERGGREN, Karl (Massachusetts Institute of Technology)

Presenter: KOPPELL, Stewart (Massachusetts Institute of Technology)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **153** Type: **Contribution Talk**

2D pixelated LAPPDs for Ring Imaging Cherenkov Detectors in High Energy and Nuclear Physics Experiments

Wednesday, 30 November 2022 15:15 (20 minutes)

Large Area Picosecond Photodetectors (LAPPDs) are micro-channel based photosensors featuring hundreds of square centimeters of sensitive area in a single package and timing resolution on the order of 50 ps for a single photon detection. However, until recently LAPPDs did not exist in finely pixelated 2D readout configurations that in addition to the high-resolution timing would also provide the high spatial resolution required for Ring Imaging CHerenkov (RICH) detectors.

One of the more modern LAPPD models, the so-called Gen II LAPPD, provides the opportunity to overcome the lack of pixellation in a relatively straightforward way. The readout plane of Gen II LAPPD is external to the sealed detector itself. It is a conventional inexpensive capacitively coupled printed circuit board (PCB) that can be laid out in a custom application-specific way for 1D or 2D sensitive area pixellation. This allows for a much shorter readout-plane prototyping cycle and provides unprecedented flexibility in choosing an appropriate segmentation that then could be optimized for any detector needs in terms of pad size, orientation, and shape. We fully exploit this feature by designing and testing a variety of readout PCBs with conventional square pixels and interleaved anode designs. Data acquired in the lab with the LAPPD tile 97 provided by Incom will be shown using a laser system to probe the response of several interleaved and standard pixelated patterns. Results from beam tests at Fermilab Test Beam Facility will be presented as well, including world's first Cherenkov ring measurement with this type of a photosensor. 2D spatial resolutions well below 1 mm will be demonstrated for several pad configurations.

Very recently, a DC-coupled LAPPD model (High Resolution Picosecond Photodetector, HRPPD) with internal 3.2mm pixellation became available. Efforts towards building a mechanical and electrical interface for these photosensors, and plans of their characterization in the lab and under beam conditions will be discussed.

Primary author: KISELEV, Alexander (BNL)

Presenter: KISELEV, Alexander (BNL)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **154** Type: **Poster Presentation**

A measurement and modeling of the complex impedance of the Transition Edge Sensor for the Ricochet experiment

Wednesday, 30 November 2022 15:15 (20 minutes)

Coherent elastic neutrino-nucleon scattering (CEvNS) offers a new avenue in searching for physics beyond the Standard Model. The Ricochet neutrino experiment aims to detect CEvNS at the Institut Laue–Langevin (ILL) nuclear reactor. One of the two cryogenic detector arrays employs a modular TES (Transition Edge Sensor) based readout strategy. This poster will introduce the latest measurement and modeling of the complex impedance of TES modules at the Argonne National Laboratory and silicon-based detectors operated at University of Massachusetts Amherst.

Primary author: Mr CHEN, Ran (Northwestern University)

Co-authors: SCHMIDT, Benjamin (Northwestern University); Mr VEIHMEYER, Charlie (University of Massachusetts Amherst); CHANG, Clarence (Argonne National Laboratory); PINCKNEY, Doug (University of Massachusetts Amherst); FIGUEROA-FELICIANO, Enectali (Northwestern University); WANG, Gensheng (Argonne National Laboratory); Ms BRATRUD, Grace (Northwestern University); ZHANG, Jianjie (Argonne National Laboratory); Mr KENNARD, Kyle (Northwestern University); Ms MATEO, Lidabel (Northwestern University); CHAPLINSKY, Luke (Member@umass.edu); LISOVENKO, Marharyta (Argonne National Laboratory); HERTEL, Scott (University of Massachusetts Amherst); Dr NOVATI, Valentina (Northwestern University); YEFREMENKO, Volodymyr (Argonne National Laboratory); HONG, Ziqing (University of Toronto)

Presenter: Mr CHEN, Ran (Northwestern University)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **155** Type: **Contribution Talk**

Towards a 10 kg Skipper-CCD detector: the multiplexing analog electronics for the OSCURA experiment

Wednesday, 30 November 2022 09:50 (20 minutes)

We present a multiplexed analog readout electronics system for Skipper-CCDs. The system allows for sub-electron noise-level operation while maintaining a minimal number of acquisition channels. In addition, it requires low-disk storage and low-bandwidth data transfer with zero added multiplexing time during the simultaneous operation of thousands of channels. We describe the implementation and results of this system in a new instrument composed of a large number of sensors operated with a two-stage analog multiplexed readout scheme. The instrument, which can hold up to 256 Skipper-CCDs, is a part of the R&D effort of the OSCURA experiment.

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Presenter: CHAVEZ, CLAUDIO (Fermilab)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **156** Type: **Contribution Talk**

Recent developments for fast readout of Skipper-CCD sensors for particle physics and optical applications

Wednesday, 30 November 2022 09:30 (20 minutes)

Non-destructive readout capability of the Skipper Charge Coupled Device (CCD) has been proven to be a powerful technique to reduce the noise limitation of conventional silicon devices even to levels that allow single-photon or single-electron counting. The noise reduction is achieved by spending extra time taking several measurements of the same pixel charge. The technique requires minimal modification in its design in the output stage, so other good advantages of the CCDs such as the extremely low leakage current, large pixel size, and transfer efficiency are conserves. These features have motivated its use as a particle detector for experiments for faint signals such as the direct detection of galactic light dark matter, reactor neutrinos, etc. However, its ultimate performance and its use for other applications like astronomy and quantum imaging are still limited by the long readout time due to the successive measurements of each pixel. In recent years, Fermilab has persuaded the development of strategies to fasten the readout time of the Skipper sensors for the construction of new astronomical and quantum imaging instruments. In this talk, I will present the new experimental results with a faster readout obtained with new sensors together with a novel readout technique called Smart Skipper that allows selective readout based on the desired signal-to-noise ratio for each pixel. As part of the talk, I will also present the main experimental goals motivating these developments.

Primary author: FERNANDEZ MORONI, Guillermo

Presenter: FERNANDEZ MORONI, Guillermo

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **157** Type: **Contribution Talk**

Waveform Digitizing Electronics for Reading out Next Generation Detectors

Tuesday, 29 November 2022 11:30 (20 minutes)

Recent advances in photonic and radiation sensors and detectors has allowed high quality and high
timing resolution measurements of phenomena related to high energy physics, nuclear physics and
astro- particle physics experiments. Examples of such sensors include silicon photomultipliers (SiPM),
multi-channel plate photomultiplier tubes (MCP-PMTs), large area picosecond photo multipliers (LAPPDs) and low gain avalanche photodiodes (LGADs). What most of these sensors have in common is electrical outputs in the form of a pulse with medium to fast rise times (0.2-2ns) and rather short pulse duration (0.2-4ns FWHM). The pulse amplitude, source driver impedance, physical density and cross talk characteristics of these detectors normally vary and can create challenging environments for optimum readout electronics. One method to get the most performance out of such sensors is to use waveform digitizing electronics to capture the electronic pulse output and then post-process them locally or remotely to extract desired features such as time of arrival or the amount of charge at accuracies that are interesting for the experiments. At Nalu Scientific, LLC we have designed such digitizer microchips, hardware, firmware and software to readout a variety of these sensors. We will discuss a number of the microchips and related circuits and present results on performance that we have measured so far and possibilities for improvement.

Primary author: MOSTAFANEZHAD, Isar (Nalu Scientific, LLC)

Presenter: MOSTAFANEZHAD, Isar (Nalu Scientific, LLC)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **158** Type: **Contribution Talk**

Superconducting Nanowire Single Photon Detectors

Tuesday, 29 November 2022 13:30 (20 minutes)

Superconducting Nanowire Single Photon Detectors (SNSPDs) are world-leading detectors for time-resolved single photon counting from the UV to the infrared. We will survey the latest progress in the field of SNSPDs, and discuss recent progress as a community in reducing the energy threshold (as low as 70 meV), increasing the active area (to the 1 mm 2 scale and beyond), and reducing the dark counts (below 10 -5 counts per second). We will discuss the prospects to infuse SNSPDs into future experiments to search for dark matter and probe fundamental physics.

Primary authors: BEYER, A. D (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); SHAW, M . D (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); KORZH, B. (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); WOLLMAN, E. E. (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); LUSKIN, J (University of Maryland, College Park, MD 20742)

Presenter: SHAW, M . D (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **159** Type: **Contribution Talk**

Secular disequilibrium in materials: implications on background estimates for rare event detectors

Wednesday, 30 November 2022 14:15 (20 minutes)

The characterization and minimization of backgrounds from primordial radionuclides and their long-lived progeny is critical to accurately simulate background and achieve sufficient signal-to-noise for a detection in rare-event physics detectors, like direct detection of dark matter and neutrinoless double beta decay investigations. Current inductively coupled plasma mass spectrometry assay capabilities can achieve 232 Th and 238 U determinations down to the nanoBq/kg level while radiometric counting methods are typically several orders of magnitude less sensitive for the decay chain progeny for which they are most sensitive. When direct determination of the entire decay series is indiscernible due to insufficient sensitivity, many experiments assume secular equilibrium. However, physical and chemical processes in material manufacturing can significantly fractionate the decay series to be out of secular equilibrium. This can lead to inaccurate background predictions and mischaracterized detector sensitivities.

This work reports an extensive literature study regarding the current understanding of secular equilibrium in materials used for low-background detectors. We will discuss future research that will investigate how physical and chemical processes perturb secular equilibrium and whether these processes can be utilized to better understand and/or develop ultra-pure materials for future generation experiments.

Primary authors: ARNQUIST, Isaac; HOBBS, Kirby (Pacific Northwest National Laboratory); LAURA DI VACRI, Maria; SCHLIEDER, Tyler

Presenter: HOBBS, Kirby (Pacific Northwest National Laboratory)

Session Classification: Cross Cutting Topics

Track Classification: WG8: Cross Cutting Topics

Contribution ID: **160** Type: **Contribution Talk**

The LFHCAL forward hadronic calorimeter for the EPIC detector at the EIC

Wednesday, 30 November 2022 09:30 (20 minutes)

The Electron Ion Collider (EIC) is the next Nuclear Physics flagship experiment to be constructed at Brookhaven National Lab over the next decade. The EPIC detector will be the first experiment at the EIC dedicated to detailed studies of nuclear structure in electron-proton and electron-ion collisions.

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The ambitious physics program of the EIC requires a high performance hadronic calorimetry syste

LFHCAL is designed as a plastic scintillator-steel sandwich calorimeter read out by silicon pho

To reduce R\&D cost and risks, we are investigating producing the required plastic scintillator

This talk will present the current status as well as ongoing and future R\&D of the LFHCAL for
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Primary authors: NOVITZKY, Norbert (ORNL); NOVITZKY, Norbert (University of Tsukuba)

Presenters: NOVITZKY, Norbert (ORNL); NOVITZKY, Norbert (University of Tsukuba)

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **161** Type: **Contribution Talk**

Nucleation efficiency of a liquid xenon bubble chamber

Wednesday, 30 November 2022 11:15 (20 minutes)

Bubble chambers using liquid xenon (and liquid argon) have been operated (resp. planned) by the Scintillating Bubble Chamber (SBC) collaboration to search for GeV-scale dark matter and CEvNS from nuclear reactors. This requires a robust calibration program of the nucleation efficiency of low-energy nuclear recoils in these target media. Such experiments were performed with a liquid xenon test chamber, gathering data in varying operating conditions and from different neutron sources. The obtained bubble formation efficiency in liquid xenon as a function of recoil energy and thermodynamic state is presented. Parametric Monte Carlo studies were also carried out to validate the model paradigm.

Primary author: DURNFORD, Daniel

Presenter: DURNFORD, Daniel

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **162** Type: **Contribution Talk**

Stave-Oriented Photon Detector Readout with Event Waveform Recording

Tuesday, 29 November 2022 16:20 (20 minutes)

Silicon photomultipliers (SiPMs) are suitable for scintillation light detectors used in multiple rare searches experiments. The SiPMs are distributed on a hierarchical structure of mini-tiles, multiple readout channels tiles, integrated on staves, and arranged in a form of a barrel of detectors with large area of SiPM, looking inside the volume filled with noble liquid. In addition to cryogenic operation, another challenge for developing the readout using ASICs can be meeting the requirements of ultra-pure, effectively free of natural radioactivity environment. These two requirements translate to very strict constraints. In terms of quantity and type of material that may contain radio-contaminants, power dissipation, design of the readout to adapt to the limits, whereas it must be very reliable in operation over a decade or longer.
To optimize the SiPM readout electronics, we have been addressing multiple conceptual challenges. The proposed system concept is based on the very low rate of photo electron events due to all causes (incl. SiPM dark counts and calibration by external radioactive sources) no exceeding about a few thousands of eevents pers. In contrast to transmitting all samples at a typical rate of 2 MS/s (aka "data streaming"), only portions of waveforms, snippets, resulting from any and all photoelectron SiPM signals are transmitted for data processing and analysis. Snippets contain sufficient number of samples (e.g., 32) surrounding the event waveform to characterize the baseline and the noise. No "raw" event data are lost in this process. The second aspect of this concept is optimal distribution of functionality between readout integrated circuits, providing analog signal processing, conversion to digital form and data transmission to external DAQ. The related barrel structure with SiPM tiles and, staves as well as the allocation of these circuits on the stave are optimized. Additional studies include the feasibility of the mechanical structure with cabling, signal transmission, ground and power distribution, and communication within the staves themselves, as well as connections to the world outside the cryostat by the feedthroughs. Our concept, which is tentatively named as Waveform Snippet and Stave Oriented readout (WSSO) provides all the signals generated by SiPMs with a record for all events, at a significantly lower data rate. It leads to reductions in the number of low dispersion cables and their connections by an order of magnitude or more, and as a result, to a reduction in the amount of background contributing material, combined with a simplification of the feedthrough design, and lower cost. This concept developed for the nEXO Photon Readout Electronics (PRE) sub-system can be used more broadly always providing system complexity reduction and data bandwidth optimization.

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **163** Type: **Contribution Talk**

Recent results from the pixel-based accelerated aging of Large Area Picosecond Photodetectors (LAPPD)

Wednesday, 30 November 2022 14:15 (20 minutes)

Here we describe the physics behind the pixel based accelerated aging method of the microchannel plate-photomultiplier tubes (MCP-PMTs) developed at the University of Texas at Arlington. In this fast lifetime testing method, a highly localized region of the MCP-PMT is exposed to photons at a high repetition rate. The pixel-based testing method was inspired by our previous research that has shown that the radiation effects of a pixel-based exposure are highly localized with minimal damage beyond the exposed area. We utilize the pixel based accelerated lifetime testing to investigate the aging behavior of a 20 cm × 20 cm Large Area Picosecond Photodetector (LAPPD) by INCOM Inc which also has the largest active area among the commercially available planar photodetectors. The reasonably high gain of the LAPPD even at high event rates allow us to extract large current densities and thus, measure the onset of the performance degradation in reasonable time frames. In this work, we will discuss the initial results from an ongoing lifetime testing of the LAPPD. We will show the pre-test performance of the LAPPD MCP-PMT along with its performance as a function of extracted charge per unit area.
1This work was supported by DOE Grant DE-SC0011686

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Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **164** Type: **Contribution Talk**

The FoCal detector at the ALICE experiment

Thursday, 1 December 2022 09:10 (20 minutes)

The FoCal detector at the ALICE experiment at the CERN LHC is designed for studying a wide range of physics observables to probe non-linear QCD dynamics in an unexplored kinematic region. FoCal is a high-granularity calorimeter covering the pseudorapidity interval $3.4 < \eta < 5.8$, and is scheduled to start operations in Run 4. The FoCal detector design has been optimized for studying prompt photons. The separation between isolated photons and pi0 relies on the high-granularity electromagnetic detector (FoCal-E) consisting of layers of Si-pads and Si-pixels interleaved with tungsten absorbers. A hadronic calorimeter (FoCal-H) completes the detector, providing photon isolation and jet measurements. In this talk, we will present the most recent results from R&D studies and test beams conducted at CERN in summer and fall 2022.

Primary author: ISIDORI, tommaso

Presenter: ISIDORI, tommaso

Session Classification: WG2: Calorimetry

Track Classification: WG2: Calorimetry

Contribution ID: **165** Type: **Contribution Talk**

Delayed Electron Emission in DarkSide-50

Thursday, 1 December 2022 08:50 (20 minutes)

Dual-phase noble gas Time Projection Chambers (TPCs) suffer from spurious electron background events in the lowest detectable energy region. This background has also been reported in liquid xenon TPCs, and some of the causes are discussed in the literature. Understanding its origin is of paramount importance, as this background sets the analysis threshold and affects the most sensitive part of the region of interest for low mass dark matter searches. We present preliminary results of a study of the spurious electron events observed in the liquid argon TPC in the DarkSide-50 experiment. Our analysis indicates a significant fraction of spurious electron events are related to impurities in the TPC. While a full understanding of spurious electron emissions will require dedicated R&D, possible mechanisms and mitigation strategies are discussed, in light of what we know from observations in DarkSide-50. Differences from spurious electron emission in liquid xenon TPCs are also discussed.

Primary author: BERZIN, Elizabeth

Presenter: BERZIN, Elizabeth

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **166** Type: **Contribution Talk**

Excess backgrounds in dark matter searches and superconducting photon detectors

Tuesday, 29 November 2022 14:50 (20 minutes)

Multiple mechanisms allow energy accumulation in materials and delayed releases. Interactions between excitations, defects, or other configurations carrying excess energy can lead to correlated energy releases and phenomena like self-organization in systems with energy flow. Exact modeling of these phenomena is often impossible because of insufficient knowledge of interactions. Comparison and analogies between excess low-energy backgrounds in solid-state detectors, mechanisms of inelastic deformations of crystals, and relaxation processes in glasses allow essential predictions for detectors and insight into the physics of glasses.
We observed energy accumulation and releases as delayed luminescence in NaI(Tl) and demonstrated predicted suppression of delayed luminescence by exposure to red light. Expected correlated emission of photons and dependence of the delayed luminescence on environmental factors are still to be verified.
The most intriguing prediction is a correlation between dark counts of superconducting IR photon detectors and the introduction of non-equilibrium low-energy sub-gap excitations in superconductors and substrates. We suggest an experimental program with SNSPD to decrease the energy threshold for IR-microwave photon counting and check for the role of energy accumulation and releases in excess noise and decoherence production in superconducting quantum sensors.
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-841572.

Primary author: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Presenter: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **167** Type: **Contribution Talk**

What surfaces in noble liquid dark matter detectors "Fifty shades of the dark"

Wednesday, 30 November 2022 09:30 (20 minutes)

We have a history of dark matter searches with noble liquids dual-phase detectors with an increasing track of observed condensed matter effects and contradictions that are yet unresolved. By attempting to establish correspondence with results and trends observed in low-temperature helium physics, we come up with a hypothesizes that the accumulation of unextracted electrons on the liquid-gas interphase can lead to Wigner crystallization and immobilization of surface-bound electrons, and to instabilities of the charged liquid surface in a strong electric field. One should expect interactions of surface waves with surface charges, and we observed evidence of such interactions. Electrons and ion accumulation can lead to uncontrollable changes in the observed spectrum of low-energy events by generating surface-charge extraction events and by alternating and suppressing the extraction of electrons produced by events below the liquid surface. We also expect the participation of impurities in the extraction of electrons into the gas and discuss underlining atomic physics effects and trends known from helium physics. Thus, we are suggesting possible resolutions for ambiguities and corrections to currently accepted models of detector operation which can have strong effects on the interpretation of results of current experiments and on the design of future small and multi-ton detectors.
This work was performed under the auspices of the U.S. Department of Energy

by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL-ABS-841570.

Primary author: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Presenter: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **168** Type: **Contribution Talk**

Following real-time biochemistry in live cell

Thursday, 1 December 2022 12:15 (20 minutes)

New live-cell chemical imaging techniques became feasible due to the progress in superconducting quantum detectors. One can decompose IR radiation coming from the region of the single cell dimensions over 1000 or more spectral channels and timestamp IR photons arriving to the detector array with about 10 ps time resolution. This opens ways to use IR luminescence spectroscopy, which can be minimally invasive, does not produce phototoxicity, does not require external tagging markers, and can provide more information about cell processes than techniques based on Raman scattering of visible light. One can measure IR light-induced luminescence and self-luminescence of the samples. Special design tricks
can minimize thermal radiation from outside of the sensing volume to entering the detection system, and induced luminescence is compatible with cryopreservation, where the thermal radiation background is absent.
Through technique will require a table-top cryogenic enclosure for a cold monochromator, detectors, and small samples which can stay warm, it will be compatible with other optical techniques used for live cell
studies. The system can be used to study possible therapeutic effects of low-intensity modulated RF, microwave, and IR signals and to look for quantum entanglement and squeezing of biophotons which is more likely to observe in IR than in ultra-low visible and UV photon emission from live cells.
Currently, SNSPD technology allows the detection of photons up to 15 um wavelengths, and we expect further technological progress and an increase of the energy sensitivity toward the detection of single quanta in sub-mm (THZ) region due to important application in space astronomy, particle physics,
quantum communications, and quantum computing.
This work was performed under the auspices of the U.S. Department of Energy
by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Primary author: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Presenter: PEREVERZEV, Sergey (Lawrence Livermore National Laboratory)

Session Classification: WG7: Photon Detectors (incl. CCDs)

Track Classification: WG7: Photon Detectors (incl. CCDs)

Contribution ID: **171** Type: **Contribution Talk**

Camera Readout and Barium Tagging (CRAB) for Neutrinoless Double Beta Decay

Wednesday, 30 November 2022 17:00 (20 minutes)

Finding evidence of neutrinoless double beta decay would reveal the Majorana nature of the neutrino and give insight into the origins of the matter-antimatter asymmetry in the universe, the smallness of neutrino mass, and the symmetry structure of the Standard Model. The NEXT collaboration is developing a sequence of high pressure xenon gas time projection chambers with the aim of creating a ton-scale and beyond-ton-scale, very low background neutrinoless double beta decay search. In this talk, I will highlight the strengths of this program and will present new technological developments in the NEXT collaboration that will enable high pressure Xenon TPC technologies to become essentially background free at the largest scales, opening the door to beyond-ton-scale experiments that could probe the normal ordering of neutrino masses.

Primary author: Dr ROGERS, Leslie (ANL)

Presenter: Dr ROGERS, Leslie (ANL)

Session Classification: Early Career Plenary

Track Classification: WG3: Noble Element Detectors

Contribution ID: **172** Type: **Contribution Talk**

LAr Doping R&D for Low Energy Sensitive LArTPCs

Thursday, 1 December 2022 09:50 (20 minutes)

The low energy program of next generation LArTPCs is currently expected to span a range of energies as low as 10s of MeV. LArTPC capabilities below 10 MeV could enable DUNE sensitivity to solar neutrinos and neutrino-less double-beta decay in addition to enhanced sensitivity to the supernova neutrino signals. We summarize the challenges of enhancing LArTPC sensitivities near 1 MeV and propose photosensitive dopants to address said challenges. We will also detail the studies we are undertaking in a 10-cm cubic LArTPC at Fermilab in pursuit of a systematic characterization of the MeV-scale capabilities of doped LArTPCs.

Primary author: PSIHAS, Fernanda (Fermi National Accelerator Laboratory)

Presenter: PSIHAS, Fernanda (Fermi National Accelerator Laboratory)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **173** Type: **Contribution Talk**

Calibrating the scintillation and ionization responses of xenon recoils for high-energy dark matter searches

Wednesday, 30 November 2022 12:15 (20 minutes)

Liquid xenon-based direct detection dark matter experiments have recently expanded their searches to include high-energy nuclear recoil events as motivated by effective field theory dark matter and inelastic dark matter interaction models, but few xenon recoil calibrations above 100 keV are currently available. In this presentation, we will describe the experimental setup and results from our recent work measuring the scintillation and ionization yields of xenon recoils up to 426 keV. The experiment uses 14.1 MeV neutrons to scatter off xenon in a compact liquid xenon time projection chamber and produce quasi-monoenergetic xenon recoils between 39 keV and 426 keV. The xenon recoil responses and their electric field-dependence for recoil energies were measured up to 306 keV; due to the low event statistics and the relatively mild field dependence, the yield values at higher energies are reported as the average of xenon responses for electric fields between 0.2-2.0 kV/cm. This result will enable xenon-based dark matter experiments to significantly increase their high energy dark matter sensitivities by including energy regions that were previously inaccessible due to lack of calibrations.
This work was performed under the auspices of the U.S. Department of Energy by
Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Primary author: PERSHING, Teal (LLNP)

Presenter: PERSHING, Teal (LLNP)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **175** Type: **Contribution Talk**

Signal over fiber and power over fiber transmission: a new concept for the PDS in DUNE VD

Tuesday, 29 November 2022 14:30 (20 minutes)

(on behalf of DUNE PhotonDetector Consortium)
The Deep Underground Neutrino Experiment (DUNE) is currently investigating a new prototype design for its second Far Detector module. The new concept proposes a Vertical Drift (VD) LArTPC, with a cathode at mid-height in the detector and anodes made of printed circuit boards (PCB), located at the top and bottom of the detector volume. The photon detection system (PDS) will make use of large size X-Arapuca tiles distributed over the cathode, as well behind the file cage. This layout does not allow to accommodate the PDS behind the anode plane, as in traditional LArTPCs, due to the opacity to light of the PCB plane structure. The new concept of operating on the high voltage cathode plane requires PDS cathode-mounted modules to be electrically isolated from the external readout electronics. To meet this challenging constraint, photosensors and front-end electronics will be powered and rad-out using novel power over fiber and signal over fiber technologies respectively, thus providing the desired electrical isolation (and also noise immunity).

Primary author: TOTANI, D (UC SantaBarbara)

Presenter: TOTANI, D (UC SantaBarbara)

Session Classification: WG3: Noble Element Detectors

Track Classification: WG3: Noble Element Detectors

Contribution ID: **176** Type: **Contribution Talk**

Superconducting Nanowire Single Photon Detectors for sub-GeV Dark Matter Searches

Tuesday, 29 November 2022 14:30 (20 minutes)

Superconducting Nanowire Single Photon Detectors (SNSPDs) have rapidly emerged as a leading detector type for time-correlated single photon counting from the UV to the near-infrared. Due to their unique combination of low energy thresholds and low intrinsic dark count rates, SNSPDs have become attractive as sensors in novel experiments that seek to probe the poorly explored sub-GeV dark matter (DM) parameter space. One novel detection scheme sensitive to electron recoils from interacting MeV-scale DM uses n-type GaAs as a scintillating target and large-area SNSPDs as sensors to read out scintillation photons. We will highlight recent optical excitation experiments on milligram-scale targets read out with state-of-the-art 1 mm2 SNSPD arrays. We will also discuss pathways to scale this system to larger target volumes, and, in particular, how this is driving the development of cm2-scale active area SNSPDs.

Primary authors: LUSKIN, J (University of Maryland, College Park, MD 20742); BEYER, A. D (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); KORZH, B. (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); WANG, Christina (Caltech); PEÑA, Cristián (Fermilab); WOLLMAN, E. E. (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); SHAW, M . D (Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109-8099); SPIROPULU, Maria (Caltech)

Presenter: LUSKIN, J (University of Maryland, College Park, MD 20742)

Session Classification: WG4: Quantum and Superconducting Detectors

Track Classification: WG4: Quantum and Superconducting Detectors

Contribution ID: **177** Type: **Contribution Talk**

TPOT: Micromegas detectors to reconstruct distortions in the TPC for the sPHENIX experiment

Tuesday, 29 November 2022 14:30 (20 minutes)

The sPHENIX detector is under assembly at the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory. It will be commissioned for data taking in 2023. It will focus on measuring jets as well as open and hidden heavy flavor production in heavy ion collisions to study the properties of the Quark Gluon Plasma.
A robust and efficient calibration of the constituting detectors is required to achieve sPHENIX physics program. In particular, the distortions of the electron drift in the sPHENIX TPC (the main tracking device of the experiment) due to magnetic field and space charge effects, must be accurately measured and corrected. The TPC Outer Tracker (TPOT) is a Micromegas detector that will be installed outside of the TPC and will greatly facilitate measuring the electron drift distortions in the TPC, in addition to the other existing solutions in sPHENIX. In particular it will allow to make the maximum use of tracks to reconstruct beam-induced space charge distortions and monitor the electron drift velocity. The subsystem consists of 16 Micromegas detectors grouped two-by-two to provide an additional space point on the outside of the TPC in a limited fraction of its acceptance.
This talk will cover the technology used for the Micromegas detectors, the design and the production at CEA Saclay as well as the current status of the detector assembly and installation at BNL.

Primary authors: FRANCISCO, Audrey (CEA-Saclay); PEREIRA DA COSTA, Hugo (Los Alamos National Laboratory); VANDENBROUCKE, Maxence (CEA Saclay); AUNE, S

Presenters: FRANCISCO, Audrey (CEA-Saclay); PEREIRA DA COSTA, Hugo (Los Alamos National Laboratory); VANDENBROUCKE, Maxence (CEA Saclay); AUNE, S

Session Classification: WG5: MPGDs

Track Classification: WG5: MPGDs

Contribution ID: **178** Type: **not specified**

Cross Cutting Summary

Friday, 2 December 2022 11:25 (15 minutes)

Presenter: MERKEL, Petra (Fermilab)

Session Classification: Closing Plenary

Contribution ID: **179** Type: **not specified**

Perspective from the DOE

Thursday, 1 December 2022 13:35 (10 minutes)

Presenter: Dr MARSISKE, Helmut

Session Classification: Townhall

Contribution ID: **180** Type: **not specified**

Perspective from NSF

Thursday, 1 December 2022 13:45 (10 minutes)

Presenter: DE, Kaushik (Univ. of Texas at Arlington)

Session Classification: Townhall

Contribution ID: **181** Type: **not specified**

2022 DPF Instrumentation Award

Thursday, 1 December 2022 14:40 (15 minutes)

Presenter: YU, Bo (BNL)

Session Classification: Awards Plenary

Contribution ID: **182** Type: **not specified**

2022 DPF Early Career Instrumentation Award

Thursday, 1 December 2022 14:55 (15 minutes)

Presenter: WINKLEHNER, Daniel (MIT)

Session Classification: Awards Plenary

Contribution ID: **183** Type: **not specified**

DPF Instrumentation Award Introduction

Thursday, 1 December 2022 14:35 (5 minutes)

Presenters: WHITE, Andrew; HEEGER, Karsten (Yale University); MERKEL, Petra (Fermilab)

Session Classification: Awards Plenary

Contribution ID: **184** Type: **not specified**

CPAD GIRA Award Introduction

Thursday, 1 December 2022 15:10 (5 minutes)

Presenters: POCAR, Andrea (U. of Massachusetts, Amherst); HEEGER, Karsten (Yale University); MERKEL, Petra (Fermilab)

Session Classification: Awards Plenary

Contribution ID: **185** Type: **not specified**

2022 GIRA Award: Development of a Negative Ion Gas TPC to Observe the Migdal Effect

Thursday, 1 December 2022 15:15 (15 minutes)

Presenter: TILLY, Elizabeth (University of New Mexico)

Session Classification: Awards Plenary

Contribution ID: **186** Type: **not specified**

2022 GIRA Award: Skipper CCDs for Dark Matter Measurements with Cosmic Surveys

Thursday, 1 December 2022 15:30 (15 minutes)

Presenter: MARRUFO, Edgar (University of Chicago)

Session Classification: Awards Plenary

Contribution ID: **187** Type: **not specified**

2022 GIRA Award Runner Up: Development of a CMOS Charge Sensing Pixel Array for the Selena Neutrino Experiment

Thursday, 1 December 2022 15:45 (15 minutes)

Presenter: NI, Xiaochen (University of Washington)

Session Classification: Awards Plenary

Contribution ID: **188** Type: **not specified**

2022 GIRA Award Runner Up: Radio-frequency Quantum Upconverters for dc-VHF Quantum Metrology

Thursday, 1 December 2022 16:00 (15 minutes)

Presenter: VAN ASSENDELFT, Elizabeth (Stanford University)

Session Classification: Awards Plenary

Contribution ID: **189** Type: **not specified**

Summary from R&D Consortia Round Table

Friday, 2 December 2022 08:30 (15 minutes)

Presenter: ARTUSO, Marina (member@syr.edu;employee@syr.edu;faculty@syr.edu)

Session Classification: Closing Plenary

Contribution ID: **190** Type: **not specified**

Summary from EIC-HEP Synergies Round Table

Friday, 2 December 2022 08:45 (15 minutes)

Presenter: DEHMELT, Klaus (Stony Brook University)

Session Classification: Closing Plenary

Contribution ID: **191** Type: **not specified**

Summary from Electronics Workforce Round Table

Friday, 2 December 2022 09:00 (15 minutes)

Presenters: CARINI, Gabriella; DEPTUCH, Grzegorz (BNL)

Session Classification: Closing Plenary

Contribution ID: **192** Type: **not specified**

google doc to collect ideas

Thursday, 1 December 2022 16:40 (20 minutes)

Presenter: ARTUSO, Marina (member@syr.edu;employee@syr.edu;faculty@syr.edu)

Session Classification: Round Table #1

Contribution ID: **193** Type: **not specified**

google doc to collect ideas

Thursday, 1 December 2022 16:40 (20 minutes)

Presenter: DEHMELT, Klaus (Stony Brook University)

Session Classification: Round Table #2

Contribution ID: **194** Type: **not specified**

google doc to collect ideas

Thursday, 1 December 2022 16:40 (20 minutes)

Presenter: CARINI, Gabriella

Session Classification: Round Table #3