NuSec Annual Technical Workshop 2023

Report of Contributions

https://indico.cern.ch/e/nusec2023

Contribution ID: **76** Type: **Poster Presentation**

New method of thermal neutrons imaging using a fast optical camera

Monday, 9 October 2023 13:30 (15 minutes)

We present a novel and condensed imaging technique for thermal neutrons utilizing a fast event mode optical camera (Timepix3) combined with a 6Li:LYSO scintillator. Previous studies have demonstrated the high spatial-resolution imaging capabilities of 6LiF:ZnS scintillators compared to traditional neutron imaging [1]. However, the proposed 6Li:LYSO scintillator exhibits a significantly faster decay time (˜35 ns) due to its unique composition, in contrast to the microseconds decay time of 6LiF:ZnS scintillators required for gamma discrimination. Building upon successful statistical analysis-based thermal neutron reconstruction [2], our research encompasses three main components.

The research is separated into three parts:
1. Measurement using the setup.
2. Simulating ways to reduce gamma accompanied with neutron sources.
3. Experimental result analysis and comparison to the simulation.

Firstly, the experimental setup focuses on the interaction products (alpha and tritium) of the thermal neutron with 6Li to produce localized flashes of light in the LYSO crystal scintillator. These photons were guided through an optical path to be captured by a micro-channel plate intensifier connected to a fast optical camera, TPX3CAM, as shown below.

Secondly, we explore ways to reduce the gamma rays arriving at the LYSO scintillator using the TOPAS simulation package. LYSO exhibits peak absolute quantum efficiency at ˜200 keV, coinciding with the peak of the AmBe gamma spectrum [3]. Simulation results show that the attenuation of gamma rays using 5 cm of lead allows us to mitigate their impact, at the cost of reducing the total efficiency of the neutrons moderation and the 6Li reaction.

Thirdly, we analyse the acquired data. A centre-of-mass reconstruction algorithm is applied to the data recorded from the Timepix3. Each reconstructed neutron event consists of sub-clusters, representing groups of photons generated by the photon multiplier from a single photon input. Background sources, including gamma rays from the source, Lutetium radiation, and DAC noise, are considered during data analysis. Figure 2 shows an example of an event, each blue dot is a photon. It has 4 photon groups that are all within 40 ns time window of each other and is not shaped as a line, then this event could be determined as the result of a neutron hit.

Our findings demonstrate the potential of this optical neutron imaging technique, enabling remote and long-distance detection with a variable field of view. By employing a faster decaying scintillator, the clustering time window is reduced from milliseconds to nanoseconds, significantly decreasing the "exposure" time required for thermal neutron detection applications such as imaging and nuclear security scans.

References:
[1] Losko, A. S., et al. "New perspectives for neutron imaging through advanced event-mode data acquisition." Scientific reports 11.1 (2021): 1-11.
[2] Gao, T, et al. "Novel imaging technique for thermal neutrons using a fast optical camera." Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment (2022): 167604.
[3] Allahverdy, A, et al. "Gamma Spectrometry in the Presence of Fast Neutrons." Frontiers in Biomedical Technologies 6.1 (2019): 22-27.

Primary author: GAO, Tian-Qi (University of Manchester)

Presenter: GAO, Tian-Qi (University of Manchester)

Session Classification: Lunch and Poster Session

Contribution ID: **77** Type: **Oral Presentation**

Enhancing Nuclear Security: Leveraging Non-Negative Matrix Factorization for High Sensitivity Threat Detection with Small Volume Gamma Detectors

Monday, 9 October 2023 14:45 (20 minutes)

The threat from nuclear terrorism represents a complex challenge for global governments. Although current systems for detecting threats from illicit materials exist, each have inherent limitations. It is crucial that a system can detect material being transported with malicious intent which is likely to cause health risks and require extensive clean-up operations. One monitoring approach comprises the use of a network(s) of distributed detectors to detect anomalous events. To keep costs low, these networks may be made up primarily or entirely of small volume, handheld, scintillator-based detectors. Utilising algorithms capable of raising the alarm when detecting a threat, but with a low false alarm rate, is vital. For these small-volume and portable systems this can be a challenging task as signal to noise ratios are low. One currently applied method for the detection of radioactive sources uses principal component analysis (PCA) to characterise complex background environments. An implementation of this approach is described by Shokhirev et al. (Shokhirev et al., 2012). From the components found using PCA, incoming spectra can be reconstructed, maximizing the Poisson distributed likelihood. Another approach that additionally creates components from which to reconstruct incoming spectra is non-negative matrix factorization (NMF). NMF has the advantage of being a more physical treatment of the background than PCA as there are no negative components. Both of these source detection methods have been implemented using an existing set of background data from portable scintillator detectors deployed around London. The performance was tested using threats injected into the dataset, generated using GEANT4 and empirically measured detector response parameters. A comparison of the performances of the PCA and NMF-based approaches has been completed and visualised via their receiver operating characteristic curves (ROC curves). Utilising NMF components achieves high sensitivity to threats with a high precision, providing a promising method for nuclear security with small volume gamma detectors.

Primary authors: Mr FEARN, Sam (University of Bristol); Mr CONNOLLY, Euan (University of Bristol); Dr MARTIN, Peter (University of Bristol)

Presenter: Mr FEARN, Sam (University of Bristol)

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **78** Type: **Oral Presentation**

Organic semiconductor radiation detectors for alpha and neutron detection

Monday, 9 October 2023 10:20 (20 minutes)

In recent decades organic electronics have entered mainstream use in consumer electronics found in households around the world. I will present radiation sensors based on organic semiconductor technology, and in particular applications related to detection of hadronic radiation. This includes α, fast and thermal neutron radiation.

Primary author: HORNER, Aled (Queen Mary, University of London)

Presenter: HORNER, Aled (Queen Mary, University of London)

Session Classification: Session 1: New Detector Concepts

Contribution ID: **79** Type: **Oral Presentation**

A Raspberry Pi based multi-channel data acquisition system

Monday, 9 October 2023 12:10 (20 minutes)

We present a summary of a commercial off the shelf data acquisition project to demonstrate the ability to use a Raspberry Pi as a data acquisition system for a multi channel readout of sensors. The system realised was capable of reading out with a 150ns sampling rate and had a 16 channel capability (expandable to 32 channels) with a touch screen interface. This could be used for radiation detection, or coupled with other types of sensor.

Primary author: VOZDECKY, Lubos (University of London (GB))

Co-author: BEVAN, Adrian (Queen Mary University of London (GB))

Presenter: VOZDECKY, Lubos (University of London (GB))

Session Classification: Session 2 Detector Systems

Contribution ID: **80** Type: **Oral Presentation**

Organic Field Effect Transistors as radiation detectors

Monday, 9 October 2023 10:40 (20 minutes)

Organic semiconductor radiation detectors based on diode-like structures are well established. Here I present preliminary results on the potential for Organic Field Effect Transistors (OFET) as radiation detectors, where the nature of the OFET means that the signal is intrinsically amplified by the device.

Primary author: AMJAD, Zahaab (Queen Mary University of London)

Presenter: AMJAD, Zahaab (Queen Mary University of London)

Session Classification: Session 1: New Detector Concepts

Contribution ID: **81** Type: **Poster Presentation**

Passive Radiological Inspection of Shipping Containers using a UAV-Mounted Scintillator Detector

Monday, 9 October 2023 13:15 (15 minutes)

Radiation detectors mounted on unmanned aerial vehicles (UAVs) can be utilised to screen freight passing through a seaport for radioactive material that could be used in radiological dispersal or improvised nuclear explosive devices. Payload and battery life restrictions limit the size of the sensor package that can be deployed on a UAV and as a result a low-cost system is likely to deploy small and lightweight detectors that produce count-starved spectra. To support existing screening infrastructure in place at seaports using drone-based detectors radioactive source identification from these limited spectra is necessary. An established technique for processing count-starved spectra to identify different radioactive isotopes and special nuclear materials uses the ratio of counts in different spectral bins, effectively comparing the shape of different spectra and thus being less susceptible to background. A challenge in the application of this method to screening shipping containers arises from the inherent shielding present; scattering in cargo materials changes the shape of the spectra. This work presents an investigation into the optimum spectral bins required for detecting concealed 137Cs, 60Co and special nuclear materials using the method of spectral comparison ratios. A shift in the optimum bins is seen with 2.5 cm of iron shielding for 137Cs and 60Co sources, while the shielding effect is expected to have less impact for special nuclear materials.

Primary author: CONNOLLY, Euan

Co-author: MARTIN, Peter (University of Bristol)

Presenter: CONNOLLY, Euan

Session Classification: Lunch and Poster Session

Contribution ID: **82** Type: **Oral Presentation**

Low Power, Compact, Dual Mode Detectors for Nuclear Security Applications

Monday, 9 October 2023 12:30 (20 minutes)

Detection of nuclear materials remains a matter of utmost importance due to potential security issues. Current detection techniques for neutrons and gammas involve using a combination of a 3He proportional counter, which allows for detection of thermal neutrons, along with a plastic scintillator, which allows for detection of gammas. This in itself creates issues as 3He is a rare and expensive material, with dwindling global supply, and as such a detector which does not rely on 3He is favourable.

Not only should a new detector meet these requirements, but it should also be low power, robust, and relatively small, which would allow the detector to be deployed in many field settings, allowing for wide and varied use that would be necessary to evaluate any potential nuclear material.

This is possible using dual mode detectors, a material that would allow for both neutrons and gammas to be detected. To accomplish this, pulse shape discrimination (PSD) algorithms would be used to analyse recorded data and determine whether a neutron or gamma was detected.

The scintillator materials selected for investigation were, CLLBC, an inorganic scintillator made of Cerium, Lanthanum, Lithium and BromoChloride. As well as EJ-276, an organic plastic scintillator. These materials will be paired with Silicon Photomultipliers (SiPM's), which were chosen to meet the requirements of being robust and having a low operating voltage, along with single photon sensitivity.

Initial tests have taken place with these materials and photomultiplier tubes (PMT's), which were chosen to begin with due to their greater stability when compared to SiPM's. Results taken using CLLBC have demonstrated a 5% energy resolution at 662KeV.

Once this preliminary stage has been completed, an SiPM will replace the PMT. Firstly, a GEANT4 simulation will be developed to yield idealised results, then PSD algorithms will be developed to effectively separate neutron and gamma spectra, with final testing then taking place to ascertain whether an analog or digital form will be best to meet the initial low power criteria.

Primary author: BENNETT, David (University of Glasgow)

Co-authors: Dr SEITZ, Bjoern (University of Glasgow); Dr THOMSON, Frank (University of Glasgow)

Presenter: BENNETT, David (University of Glasgow)

Session Classification: Session 2 Detector Systems

Contribution ID: **83** Type: **Poster Presentation**

The Simulation and Optimisation of Position-Sensitive LaBr3 Detectors for Compton Imaging

Monday, 9 October 2023 13:45 (15 minutes)

The Simulation and Optimisation of Position-Sensitive LaBr3 Detectors for Compton Imaging

By Emily Richardson and Dr Fraser Holloway
The University of Liverpool

Abstract: Scintillator-based Compton cameras are a practical choice for nuclear security applications; however, the energy resolution is comparatively poorer than semiconductor-based approaches and accurate determination of interaction position is challenging. This work aims to improve the position sensitivity and energy resolution of LaBr3-based scintillator detectors for use in nuclear security. In this investigation, various novel crystal geometries were designed, their performance characterised, and their geometry optimised. To assess the performance of the novel detectors, Monte Carlo simulations were conducted for multiple positions within a geometry using GEANT4. Pulse Shape Analysis (PSA) was then performed, in which simulated experimental responses were compared to a pre-simulated basis at known positions. In this comparison, the figure of merit was determined, where the minimum is considered the position of the γ-ray interaction.

It was found that using a novel crystal geometry provided additional information to the PSA, leading to an increased position sensitivity of the detector when compared to simpler crystal geometries. Whilst the use of these novel geometries results in a poorer intrinsic energy FWHM, by utilising the simulated efficiencies from GEANT4 and effective PSA, it was determined that the corrected energy FWHM could be significantly improved beyond conventional detectors. Finally, novel detector responses were used to perform two interaction PSA. It was found that both interactions could be successfully identified and located within the crystal.

Primary author: RICHARDSON, Emily

Co-author: Mr HOLLOWAY, Fraser

Presenter: RICHARDSON, Emily

Session Classification: Lunch and Poster Session

Contribution ID: **85** Type: **Oral Presentation**

Water-based quantum dots liquid scintillator for radiation detection

Monday, 9 October 2023 09:40 (20 minutes)

Liquid scintillators consist of scintillating organic flours in organic solvents, and they have been used in radiation detection for many years. However, there are a number of advantages to using water as a solvent, and R&D of water-based liquid scintillators is becoming popular. Here, we have developed an alternative approach. We use quantum dots, or nano-crystals, as scintillating flours and suspend in water solvent. This water-based quantum dots liquid scintillator is tested with cosmic rays to measure scintillation efficiency and decay time. Other optical properties are also measured. We confirmed that this new material can be a potential radiation detector in particular a new neutrino detector.

Primary authors: COLE, James (King's College London); Dr KATORI, Teppei (King's College London)

Presenter: Dr KATORI, Teppei (King's College London)

Session Classification: Session 1: New Detector Concepts

Contribution ID: **86** Type: **Oral Presentation**

Poisson-FOCuS on SIGMA data

Monday, 9 October 2023 14:25 (20 minutes)

The Poisson Functional Online Cumulative Sum (Poisson-FOCuS) method is a method for solving the likelihood ratio test of Poisson(λ) null against Poisson($\mu\lambda$) alternative where $\mu > 1$, i.e. searching for an increase in count. This can be thought of as equivalent to testing all possible anomaly start points $\tau \leq T$ at each timestep T, giving a computationally efficient way to analyse count anomalies that occur over intervals of time. We run the Poisson-FOCuS method on SIGMA data, with an additional adjustment to remove anomaly tail traces, and report the results.

Primary author: WARD, Kes

Presenter: WARD, Kes

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **87** Type: **Oral Presentation**

Neutron-Gamma Detectors for Borehole Formation Evaluation Applications

Monday, 9 October 2023 12:50 (20 minutes)

Conventional nuclear well-logging detectors employ a neutron source downhole in parallel with a detector tool to monitor interactions of radiation with the surrounding rocks. Chemical radioisotope source replacement is desirable to reduce the number of high activity AmBe and Cf-252 sources in circulation, and replace them with electrical pulsed sources. Deuterium-Tritium (D-T) sources offer the advantage of on/off operation, as well as pulsed operation, which presents opportunity for exploitation of timing characteristics. To measure the formation response, sources are commonly coupled with a series of He-3 tubes or inorganic scintillators. Here, a low-cost thermal neutron and gamma sensitive detector module for borehole applications is presented, comprised from in-house manufactured plastic scintillator coupled to BN:ZnS(Ag) converter foils. Initial designs proposed a detector with optically isolated fibre readout from single detector modules for higher levels of segmentation. Results from both simulated and empirical studies of fibre readout demonstrate unsatisfactory levels of neutron-gamma misclassification from pulse shape discrimination. With direct PMT readout, misclassification is reduced to 1.8% and a figure of merit of 1.85 ± 0.02 was achieved. This detector will form the constituent parts of a larger tool tested using the University of Sheffield's D-T generator as part of a mock rock testbed. Simulations have been performed to examine a hypothetical detector response to different formations, and boosted decision trees were applied to make predictions of hydrogen index.

Primary author: GREER, James

Presenter: GREER, James

Session Classification: Session 2 Detector Systems

Contribution ID: **88** Type: **Oral Presentation**

CsPbBr3 Nanocrystals based Plastic Scintillator for Ionizing Radiation Detection

Monday, 9 October 2023 10:00 (20 minutes)

Herein, we study a facile, toxic solvent-free surfactant-dependent mechanochemical synthesis of highly luminescent CsPbBr3 nanocrystals (NCs) and study their scintillation properties. A small amount of surfactant oleylamine (OAM) plays an important role in the two-step ball milling method to control the size and emission properties of the NCs. CsPbBr3 NCs capped with different amounts of surfactant were dispersed in toluene and mixed with polymethyl methacrylate (PMMA) polymer and cast into scintillator discs. We varied perovskite loading concentration in the nanocomposite and studied emission properties. The most intense PL emission was observed from the 2% perovskite-loaded disc, while the 10% loaded CsPbBr3/PMMA disc exhibited the highest radioluminescence (RL) emission from 50 kV X-rays. The strong radioluminescence yield may be attributed to the deep penetration of X-rays into the composite, combined with the large interaction cross-section of the high-Z atoms within the NCs. The nanocomposite disc shows an intense RL emission peak centered at 536 nm and a fast RL decay time of 29.4 ns. We have demonstrated the X-ray imaging performance of a 10% CsPbBr3 NC-loaded nanocomposite disc. The neutron response of the scintillator was further studied by using a commercial PMT and a neutron generator. Thus, low-cost nanocomposite scintillators have great potential for ionizing radiation detection and imaging.

Primary authors: GHOSH, Joydip (University of Surrey); Dr CREAN, Carol (University of Surrey); SELLIN, Paul

Presenter: GHOSH, Joydip (University of Surrey)

Session Classification: Session 1: New Detector Concepts

Contribution ID: **89** Type: **Oral Presentation**

Spectroscopic Anomaly Detection and Isotope Identification using Non-negative Matrix Factorization and Application to AWE SIGMA Data

Monday, 9 October 2023 15:05 (20 minutes)

In order to reliably detect and identify weak radiological/nuclear sources in real-world environments while maintaining low probabilities of false alarm, it is necessary to employ algorithms that are able to account for temporally and spatially varying backgrounds, exploit the full information content of acquired spectra, and provide interpretable detection metrics.

Over the last several years, Lawrence Berkeley National Laboratory has demonstrated the use of Non-negative Matrix Factorization (NMF) [1] as a framework for the analysis of spectroscopic radiation data [2]. Anomaly detection and isotope identification algorithms [3,4] based on the use of NMF have shown the ability to offer state-of-the-art detection performance. Recent innovations include online learning approaches that allow NMF models of the background to be updated using recently acquired data, and a method to automatically extract common spectral signatures from real-world anomalies.

In this presentation, we will discuss NMF-based algorithms for spectral anomaly detection and isotope identification, and their application to the analysis of data recorded during the AWE SIGMA pilots in the context of the NuSec/AWE SIGMA Data Challenge.

Focussing on data recorded with several statically placed 2x4x16"NaI(Tl) detectors, we will describe the radiological background and associated variability observed for each detector in the context of the NMF framework, and show a range of observed anomalies including medical and industrial sources, and weather-induced anomalies. Finally, we will provide a general perspective on the use of the data for algorithm development and evaluation, potential next steps, and ongoing activities associated with the development of NMF-based radiological detection algorithms.

References

[1] Lee, D., Seung, H. Learning the parts of objects by non-negative matrix factorization. Nature 401, 788–791 (1999). https://doi.org/10.1038/44565

[2] M. S. Bandstra, T. H. Y. Joshi, K. J. Bilton, A. Zoglauer and B. J. Quiter, "Modeling Aerial Gamma-Ray Backgrounds Using Non-negative Matrix Factorization," in IEEE Transactions on Nuclear Science, vol. 67, no. 5, pp. 777-790, May 2020, doi: 10.1109/TNS.2020.2978798.

[3] K. J. Bilton et al., "Non-negative Matrix Factorization of Gamma-Ray Spectra for Background Modeling, Detection, and Source Identification," in IEEE Transactions on Nuclear Science, vol. 66, no. 5, pp. 827-837, May 2019, doi: 10.1109/TNS.2019.2907267.

[4] J. Lee et al., "An Ensemble Approach to Computationally Efficient Radiological Anomaly Detection and Isotope Identification," in IEEE Transactions on Nuclear Science, vol. 69, no. 10, pp. 2168-2178, Oct. 2022, doi: 10.1109/TNS.2022.3198906.

Primary authors: FAALAND, Stefan (Lawrence Berkeley National Laboratory); Dr BANDSTRA, Mark (Lawrence Berkeley National Laboratory); Dr COOPER, Reynold (Lawrence Berkeley National Laboratory); JONES, Andrew (Lawrence Berkeley National Laboratory); Dr SALATHE, Marco (Lawrence Berkeley National Laboratory); Dr QUITER, Brian (Lawrence Berkeley National Laboratory)

Presenter: FAALAND, Stefan (Lawrence Berkeley National Laboratory)

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **90** Type: **Poster Presentation**

Development and Evaluation of a Low-Cost Preamplifier/Shaping Amplifier System For Boron-Coated-Straw Neutron Detectors

Monday, 9 October 2023 13:45 (15 minutes)

The applications of neutron monitors extend to many critical fields such as leak detection in nuclear power plants, cosmic ray detection for space-weather monitoring, and homeland security in preventing the unauthorised transport of nuclear materials. The industry standard neutron monitor technologies are based on helium-3 but due to the volatile price and scarcity of this rare isotope, the production of these detectors, and scaling of projects involving them, is unsustainable and expensive. It is therefore valuable to explore and develop alternative technologies. Commercially available signal processing systems are costly and lack versatility, so this project aims to facilitate the scaling of neutron monitor networks by providing a platform for low-cost electronic systems for their operation. The project involves the final stages of development of a preamplifier and shaping amplifier system created for use with a PTI-110 boron-coated-straw neutron monitor and the verification and evaluation of its functionality with the use of a californium-252 neutron source. A second version of the preamplifier and shaping amplifier was created for use with high count rates (>1000cps) which incorporates a novel slew-rate-limited shaping architecture allowing few components to be required. The adverse effects of capacitor leakage and operational amplifier bias current are explored, and solutions are found to negate them. Testing showed the preamplifier and shaping amplifier has a desirable response curve whereby the amplitude of the output voltage pulse is directly proportional to the magnitude of the input charge. Furthermore, the system produces a desirably shaped pulse approximating a gaussian curve. A pulse height spectrum that is consistent with other similar detectors was obtained by exposing the detector to a neutron source. The shaping-time and gain of the system are widely variable by altering values of passive components. The project provides a low cost (£10), customisable platform for proportional counter tube operation with suggestions for alternative configurations and further optimisation.

Primary author: Mr ERDODI, Krisztian (Lancaster University)

Presenter: Mr ERDODI, Krisztian (Lancaster University)

Session Classification: Lunch and Poster Session

Contribution ID: **91** Type: **Oral Presentation**

Investigation of an end-to-end neural architecture for image-based source term estimation

Monday, 9 October 2023 11:50 (20 minutes)

In various critical applications, the accurate estimation of physical parameters is a necessity for ensuring public safety and effective decision-making. One such critical application where these considerations come into play is source term estimation (STE) in the context of hazardous material releases. The urgency for rapid and precise STE is accentuated by the growing risks of hazardous material releases due to accidents, acts of terrorism, or natural disasters. Quick identification of key release parameters such as the source location, timing, and environmental variables like wind speeds is essential for safeguarding public health and orchestrating effective emergency measures. Atmospheric Dispersion Simulation (ADS) models, including Gaussian models, have traditionally been employed for this purpose. While these models are efficient and simple, they require several input variables, some of which are often unknown and must be inferred from sensor data. Although many STE methodologies rely on ground-based sensors or sparse sensor networks, these are not always feasible, especially in remote or inaccessible locations. In this work, we explore an alternative approach that leverages the increasing availability of multi/hyperspectral satellite imagery for STE. Artificial neural networks (ANNs) have emerged as a promising approach to enhance STE. ANNs offer unparalleled capabilities in capturing the intricate, nonlinear dynamics inherent to the problem. Coupled with the advent of high-performance computing and GPU acceleration, ANNs have achieved rapid convergence and real-time applicability, making them a go-to solution for STE in time-sensitive and critical scenarios. However, existing ANN-based approaches for STE are designed to estimate a subset of the source term parameters such as the release rate the release rate and release time, or the source 2D coordinates, while the other parameters are assumed known. In this work, we introduce a two-stage ANN pipeline designed for estimating source term parameters from time-series hyperspectral satellite images. The first stage of the pipeline focuses on calculating the hazardous material release rate over time, subsequently generating a 3D concentration map derived from the time-series hyperspectral satellite images. The second stage utilizes the 3D concentration map to estimate the 2D source location, the release time, along with the easterly and northerly wind speeds. The effectiveness of the proposed approach is thoroughly validated using a simulated dataset.

Primary authors: Dr ABDULAZIZ, Abdullah (Heriot-Watt University); Prof. DAVIES, Mike E. (University of Edinburgh); Prof. MCLAUGHLIN, Steven (Heriot-Watt University); Dr ALTMANN, Yoann (Heriot-Watt University)

Presenter: Dr ABDULAZIZ, Abdullah (Heriot-Watt University)

Session Classification: Session 2 Detector Systems

Contribution ID: **92** Type: **Poster Presentation**

An Investigation Into the Susceptibility of Memory Cards to Neutron Damage

Monday, 9 October 2023 14:00 (1 minute)

The safeguarding of nuclear materials and facilities is a global challenge. There are different methods to maintain nuclear safeguarding, with a primary method being the use of cameras. Therefore it is fair to consider the vulnerabilities of the elements of this method of safeguarding. One of these vulnerabilities may be neutron damage to memory cards. This project aims to investigate whether a causal relationship exists between neutron damage and failure in memory cards. This investigation was carried out practically and experimentally, using the Lancaster University Californium-252 neutron source, which emits neutrons of between 1x10-10 –1MeV, to irradiate microSD cards of three different storage sizes, 32 GB, 64 GB, and 128 GB, in batches of five. A read/write function check program was written using C++ and uploaded to an Arduino Uno that ran the program through a microSD breakout circuit. This project also aimed to assist in the calculation of the activity of the Lancaster University 252Cf neutron source through the neutron activation of copper foils. This project has helped provide insight into the service life of memory cards in nuclear environments, contribute to the advancement of nuclear safeguarding and security, and influence the need for further research in this area, for example, the effect of higher energy neutrons on memory cards.

Primary authors: SRIDHAR, Raghuram; Prof. CROFT, Stephen (Lancaster University)

Presenters: SRIDHAR, Raghuram; Prof. CROFT, Stephen (Lancaster University)

Session Classification: Lunch and Poster Session

Contribution ID: **93** Type: **Oral Presentation**

Regional analysis of neutron/gamma figure-of-merit in scintillator volumes using a multi-anode photomultiplier tube

Monday, 9 October 2023 11:30 (20 minutes)

Accurate neutron detection can be important for nuclear forensics, safeguards, and nuclear security applications. Organic scintillation detectors are used widely due to their resilience, rapid timing characteristics, and their dual sensitivity to both gamma and fast neutron events. Pulse-shape discrimination (PSD) is often used to separate gamma and neutron events as part of the analysis of data obtained with these systems, but challenges can arise at lower energies approaching 500 keV where the gamma and fast neutron plumes tend to overlap. The associated figure-of-merit (FoM) quantifies the separation possible by dividing the distance between the neutron and gamma event plumes by the sum of their respective widths but this parameter is prone to artificial augmentation via energy cut-offs, which can exclude the low-energy overlap zone somewhat selectively, inherently reducing the overall detection efficiency. Moreover, FoM is only representative of the specific field within which it was measured: for example, high-energy fields such as that derived from americium-beryllium sources often yield a degree of separation that is superior to that achievable with californium-252, highlighting that the neutron/gamma discrimination performance may not be directly transferable to realistic neutron fields encountered in nuclear safeguarding or SNM monitoring scenarios. This study reports on a novel approach to the assessment and improvement of FoM via simultaneous location and analysis of event pulses within a continuous scintillator by employing a 16 × 16 multi-anode photomultiplier tube (MAPMT). Real-time measurement of centre-of-interaction coordinates showing anisotropy in full-volume event data is demonstrated that enables a regional quantification of FoM across a scintillator volume. This allows for the selection or rejection of events based on pulse quality metrics, eliminating the need for arbitrary and rigid energy thresholds. On this basis it is anticipated that FoM might instead be optimised in-field according to situational needs, allowing more accurate measurements across the full spectrum capabilities of the detector and amplifying the efficacy of established nuclear safeguarding and SNM forensic monitoring methods.

Primary author: COLLINS-PRICE, Patrick (Lancaster University)

Presenter: COLLINS-PRICE, Patrick (Lancaster University)

Session Classification: Session 2 Detector Systems

Contribution ID: **94** Type: **Poster Presentation**

Applying Matrix Factorisation methods to improve specificity of fast anomaly detection algorithms

Monday, 9 October 2023 13:45 (15 minutes)

NNL entered two teams into the SIGMA data challenge, one internal team and one in collaboration with K.Ward at the University of Lancaster. The internal team utilises the work of K.Ward and his Poisson-FoCuS algorithm, a fast online detection method to identify anomalies. As implemented in the SIGMA data challenge the method provides information on anomalies at a temporal scale but does not currently possess the specificity to attribute the anomaly to specific energy ranges. The NNL internal team used the fast identification of the Poisson-Focus algorithm to narrow the temporal ranges of interest for further analysis. Time periods containing anomalies are identified and selected from the main body of data and subjected to more computationally expensive techniques, including the matrix factorisation methods Sparse Principal Component Analysis (SPCA) and Non-negative Matrix Factorisation (NMF). This type of multivariate analysis is important to identify the nature of the anomalies in order to determine whether action is required. Findings from this multivariate approach could be used to improve the specificity of the Poisson-FoCuS algorithm when applied to the SIGMA data.

Primary author: MCGARRY, Luke (NNL)

Co-author: PYKE, Caroline (NNL)

Presenters: MCGARRY, Luke (NNL); PYKE, Caroline (NNL)

Session Classification: Lunch and Poster Session

Contribution ID: **95** Type: **Oral Presentation**

SIGMA Data Challenge Journey So Far

Monday, 9 October 2023 14:15 (10 minutes)

Brief overview of the SIGMA data challenge, where it came from, who is involved and where it was intended to go.

Primary author: Dr MARTIN, Philip (AWE)

Presenter: Dr MARTIN, Philip (AWE)

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **96** Type: **Oral Presentation**

AWE in-house algorithm development

Monday, 9 October 2023 15:25 (20 minutes)

Overview of the GROUSE algorithm work done to date by AWE on the SIGMA Data Challenge data.

Primary author: Dr MARTIN, Philip (AWE)

Presenter: Dr MARTIN, Philip (AWE)

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **97** Type: **Oral Presentation**

Introduction and Welcome

Monday, 9 October 2023 09:30 (10 minutes)

A brief welcome to the NuSec Technical Workshop

Primary author: SELLIN, Paul

Presenter: SELLIN, Paul

Session Classification: Session 1: New Detector Concepts

Contribution ID: **98** Type: **Oral Presentation**

Sigma Discussion and Closing Remarks

Monday, 9 October 2023 15:45 (15 minutes)

Q&A from the Sigma Session, followed by Workshop conclusion

Primary author: SELLIN, Paul

Presenter: SELLIN, Paul

Session Classification: Session 3: Sigma Data Challenge

Contribution ID: **100** Type: **Poster Presentation**

Background measurements at Hartlepool Nuclear Power Station to assess the viability of on-site-antineutrino detection

Monday, 9 October 2023 14:00 (15 minutes)

In the field of nuclear security, safeguard and non-proliferation antineutrino flux profiles have the potential to be used as a verification tool to ensure operations at a nuclear facility are being accurately reported. Due to this potential, there is an interest in performing antineutrino measurements on an operating reactor site, such as the Hartlepool Advanced Gas Reactor. To help assess the viability of obtaining antineutrino flux measurements from the operating reactor the background neutron and gamma radiation measurements were performed at various locations within and outside of the Radiation Controlled Area at Hartlepool Nuclear Power Station. The results of the analyzed measurements are used to provide accurate background data to be used in modelling and to determine a potential site for an antineutrino detector to perform near-field antineutrino measurements

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