Nuclear Security Detection Workshop

Report of Contributions

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

Contribution ID: **3** Type: **Oral Presentation**

Exploring opportunities for future on-line tritiated water detection by in-situ ATR FTIR: real time isotopic analysis of water

Monday, 15 April 2019 11:15 (15 minutes)

Accurate quantification of tritium at low levels in water streams is both a regulatory and environmental necessity for the nuclear industry. The most widely used current method is liquid scintillation counting (LSC), which measures the beta-radiation emitted from tritium decay and can therefore be used to indirectly quantify the concentration of tritium. This is a relatively laborious off-line technique requiring separate sampling, preparation and analysis steps. An on-line or in-line monitoring system which directly measured the tritiated water concentration would likely have a variety of benefits, being both cheaper to operate and possibly affording instantaneous access to results.

The technology to achieve such a system already exists in the form of in-situ infrared spectroscopy equipment designed to follow the kinetics of chemical reactions in real-time (ReactIR). The infrared absorbances of H2O, deuterated water (HDO) and tritiated water (HTO) are distinct enough to quantify separately, and therefore a program of work to investigate the feasibility of this approach has been carried out. Using HDO as a proxy for HTO, off-the-shelf ReactIR equipment and software has been employed to create and methodically test a system for obtaining real-time data on the deuterium atom concentration in water samples.

The development and subsequent validation of the method showed that it was indeed possible to quantify deuterium content in this way, with a standard deviation for repeated determinations of 42.6 ppm deuterium (δD of 273.53 ‰) and a limit of detection (LOD) of 137 ppm D (1212.00 ‰), with the method proving to be linear up to ca. 10000 ppm D and beyond. In addition, the method demonstrated robustness to changes in pH, ionic strength and ambient atmosphere. A further development of the method using protic ethanol to chemically amplify the signal afforded a much improved standard deviation of 247 ppb D (1.60 ‰) and an LOD of 5.30 ‰. See Table 1 for a comparison with currently available techniques.

References:
(1) Sessions, A. L. J. Sep. Sci. 2006, 29 (12), 1946–1961.
(2) Skrzypek, G.; Ford, D. Environ. Sci. Technol. 2014, 48 (5), 2827–2834.
(3) Lis, G.; Wassenaar, L. I.; Hendry, M. J. Anal. Chem. 2008, 80 (1), 287–293.
(4) Litvak, I.; Anker, Y.; Cohen, H. RSC Adv. 2018, 8 (50), 28472–28479.

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Presenter: PROVIS-EVANS, Cei (University of Bath)

Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Track Classification: Other topics

Contribution ID: **4** Type: **Submitted Poster**

Solution processable organic bulk heterojunction diodes as direct radiation detectors

Monday, 15 April 2019 18:10 (20 minutes)

We report steady state 5.49 MeV alpha particle detection results using organic semiconductor diodes fabricated using a blend of poly(3-hexylthiophene) and phenyl-c61-butyric acid methyl ester, under modest bias conditions (up to ±20 V). Alpha particle device sensitivities between 10ˆ4 and 10ˆ7 nC mGyˆ-1 cmˆ-3 are achieved (depending on individual device and drive conditions). The alpha particle charge detection efficiencies are compared to transient and steady state photoconduction charge detection efficiencies for the same devices. Trapped electrons within the organic blend induce significant current gain in forward biased devices, both in photoconduction and in alpha detection. Results indicate that the photoconductive charge generation efficiency is a viable proxy for the alpha particle device sensitivity or detection efficiency, given the approximately linear experimental relationship between them. Hecht equation fitting of the collected charge-electric field results obtained returns mobility-lifetime values of order 10ˆ-7 cmˆ2 Vˆ-1, consistent with Time of Flight results for the same devices. The results provide proof of principle that large area, solution processed, organic semiconductor based diodes can achieve high sensitivity alpha detection without requiring high bias drive conditions or the growth of single, large molecular crystals.

Primary authors: Mrs LIU, Xiaoqi (Queen Mary University of London); Dr KREOUZIS, Theo (Queen Mary University of London); Dr BEVAN, Adrian (Queen Mary University of London)

Presenter: Mrs LIU, Xiaoqi (Queen Mary University of London)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **5** Type: **Oral Presentation**

Neutron sensitivity of HEXITEC and capability in localisation of neutron radiation source

Tuesday, 16 April 2019 09:45 (15 minutes)

The compact energy resolved pixelated HEXITEC detector that uses CdTe (1mm thick) as the active detector material has been widely tested and characterised for its sensitivity to photon radiation but is yet to be tested under neutron radiation. In this project, the fast neutron and thermalised neutron sensitivity of the detector were tested by irradiation with 241AmBe radioisotope sources. With the bare detector, the primary detection of the incoming neutron from the 241AmBe source is via prompt gamma emitted from the neutron inelastic scattering due to Cd in the detector element. Adding 0.5mm thick B4C and Gd2O3 on top of the detector to act as a conversion layer; producing prompt gammas from the neutron capture of B and Gd elements. In addition, the HEXITEC detector was also used tested for neutron source localization using the RadiCAL technique.
The result shows that the HEXITEC detector has the capability in detecting the neutron radiation through the prompt gamma detection of the CdTe detector when coupled with the Gd2O3 filter conversion layer. The result is validated with the combination of Pb and B4C shielding to cut off the gamma spectrum and thermal neutrons, respectively. The introduction of the Gd2O3 neutron conversion layer causes two low energy lines at ˜50 and 55 keV to appear in the spectrum which are associated with prompt gamma emission from the Gd. The low energy features do not appear in the non-filter region. The result is also further validated with B4C filter, where the prompt gamma is outside the detector energy range. Higher energy Gd prompt gamma spectrum that within the detector range are yet to be found in the data. This is probably due to low efficiency from the 1 mm of CdTe detector material. Monte Carlo modelling will be required to investigate this further. However, the thin CdTe detector does not limited the detector capability in using the RadICAL technique. This preliminary study suggest that it is possible to further develop the CdTe detector for RadICAL applications in nuclear security where it is able to locate both gamma and neutron radiation.

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Co-authors: Dr MOSS, Robert (University College London); Prof. SPELLER, Robert (University College London)

Presenter: KHONG, Jia Chuan (University College London)

Session Classification: Session 5: Imaging and Detection 1 (Session Chair Richard Hewitt)

Track Classification: Detectors & Systems

Contribution ID: **6** Type: **Invited Talk**

DTRA Basic Research Support for Radiation Detection

Tuesday, 16 April 2019 09:15 (30 minutes)

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Primary author: PETERSON , David (DTRA)

Presenter: PETERSON , David (DTRA)

Session Classification: Session 5: Imaging and Detection 1 (Session Chair Richard Hewitt)

Track Classification: Other topics

Contribution ID: **7** Type: **Invited Talk**

Consortium for Nonproliferation Enabling Capabilities (CNEC): Mission and Accomplishments

Monday, 15 April 2019 12:00 (30 minutes)

.The Consortium of Nonproliferation Enabling Capabilities (CNEC) is an alliance of 10 US universities and 4 US national laboratories led by North Carolina State University. The consortium is sponsored by the US National Nuclear Security Administration (NNSA) Office of Defense Nuclear Nonproliferation Research and Development (DNN R&D, a.k.a. NNSA NA-22) as one part of NA-22's Integrated University Program (IUP). CNEC is currently in its fifth year of operation. The consortium's mission is to develop new capabilities and a pipeline of new professional researchers that will enable the US to meet future challenges to nuclear nonproliferation. Approximately 200 university professors, students, and post-docs have comprised CNEC's multidisciplinary team of academic researchers from 7 different fields, including Computer Science, Electrical & Computer Engineering, Mathematics, Nuclear Engineering, Physics, Political Science, and Statistics. John Mattingly will present an overview of CNEC's R&D initiatives and accomplishments and highlight some of the consortium's most impactful research projects.

John Mattingly has worked as an Associate Professor of Nuclear Engineering at North Carolina State University (NCSU) since 2011. At NCSU, John directs a team of graduate students and post-docs conducting research on applications of neutron and gamma radiation detection, imaging, and inverse analysis to nuclear nonproliferation, emergency response, and forensics. John serves as the CNEC Chief Scientist and Principal Investigator, where he directs and coordinates the efforts of professors and students at 10 US universities and scientists at 4 US national laboratories, all of whom are conducting new science and policy research and education to develop the next-generation of proliferation detection and deterrence capabilities.
Prior to joining the NCSU faculty, John worked at Sandia National Laboratories from 2003 to 2011 and Oak Ridge National Laboratory from 1997 to 2003. At Sandia, he was one of the lead developers of GADRAS, which is used by nuclear emergency responders in the US and other countries to identify radioactive materials. He also served as an on-call analyst for the US DOE Triage and US DHS Reachback emergency response systems, and he participated in international emergency response exercises in the UK and France. At Oak Ridge, John led the physics design of the Blend-Down Monitoring System, which was deployed to Russia to monitor the down-blending of Russian highly-enriched uranium (HEU) for the US-Russia HEU Purchase Agreement. He also led the team that performed active neutron interrogation measurements to confirm the inventory of nuclear weapons components at the US Y-12 National Security Complex, and he participated in the original NNSA NA-22 warhead measurements campaign at the US Pantex Plant in 1997. John has performed hundreds of active and passive neutron and gamma measurements of special nuclear materials at facilities in the US, UK, France, and Russia. He earned his Ph.D. in Nuclear Engineering from University of Tennessee in 1998.

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Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Track Classification: Other topics

Contribution ID: **8** Type: **Invited Talk**

Relying on robotics: towards remotely operated inspection and maintenance in high hazard scenarios

Monday, 15 April 2019 10:45 (30 minutes)

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Primary author: BUCKINGHAM, Rob (UKAEA, RACE Robotics Centre)

Presenter: BUCKINGHAM, Rob (UKAEA, RACE Robotics Centre)

Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Track Classification: Other topics

Contribution ID: **10** Type: **Invited Talk**

Imaging and locating radioactive isotopes for security

Tuesday, 16 April 2019 11:30 (30 minutes)

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Primary author: SPELLER, Robert (UCL)

Presenter: SPELLER, Robert (UCL)

Session Classification: Session 6: Imaging and Detection 2 (Session Chair Lee Thompson)

Track Classification: Detectors & Systems

Contribution ID: **11** Type: **Invited Talk**

Monitoring nuclear reactor neutrinos with WATCHMAN/AIT

Monday, 15 April 2019 16:00 (30 minutes)

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Primary author: THOMPSON, Lee (University of Sheffield)

Presenter: THOMPSON, Lee (University of Sheffield)

Session Classification: Session 3 Monitoring and Inspection (Session Chair Andrew Boston)

Track Classification: Core Monitoring & Cosmics

Contribution ID: **13** Type: **Submitted Poster**

Peak Identification in Low-Resolution γ-ray Spectra Using the Cosine Similarity Measure

Monday, 15 April 2019 18:10 (20 minutes)

Peak Identification in Low-Resolution γ-ray Spectra Using the Cosine Similarity Measure

M. Nakhostin and P. J. Sellin
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Automated identification of radioisotopes through γ-ray spectroscopy with low-cost γ-ray detectors such as NaI(Tl) is of great interest for applications such as nuclear security, nuclear emergency, and environmental radiation monitoring. This task is generally accomplished by using algorithms that search for γ-ray peaks in the spectra. However, the performance of the peak search algorithms can be seriously affected by the intrinsic statistical variations in the shape of γ-ray spectra collected over a short period of time. This paper reports on a novel approach for the identification of peaks in low statistics γ-ray spectra by using the cosine similarity measure [1, 2]. The cosine similarity measure is used to simultaneously serve two purposes: (i) smoothing the spectra to suppress the effect of statistical variations, and (ii) enhancing the intensity of peaks against the non-peak features of the spectra such as Compton continuum. The theoretical basis of the method is described and the results of test experiments with NaI(Tl) detectors of different sizes are shown. The method exhibits excellent performance of 95 % successful identification of 137Cs γ-ray peak in the laboratory measurements with a 2"×2" cylindrical NaI(Tl) detector when the total number of recorded events is as low as eighty. The performance of the method is also examined against the international performance standard ANSI N42.34 for 152Eu, 60Co and 137Cs [3]. The method easily meets the requirements of the ANSI standard by making more than 80 % successful identification of radioisotopes at dose rates of 0.5 μSv/h in less than 120 seconds. Simple implementation and computational economy are other advantages that make this algorithm well suited for implementation in handheld radioisotope identification devices.
[1] P.-N. Tan, M. Steinbach, V. Kumar, "Introduction to Data Mining," Addison-Wesley (2005).
[2] S. Cha, "Comprehensive survey on distance/similarity measures between probability density functions," Int. Journal of Mathematical Models and Methods in Applied Science, Vol. 1 (2007) 300.
[3] American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides, IEEE Std., Rev. ANSI N42.34-2006, 2007.

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Co-author: SELLIN, Paul (University of Surrey)

Presenter: Dr NAKHOSTIN, Mohammad (Department of Physics, University of Surrey)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **14** Type: **Submitted Poster**

Geometry and reflection effects on pulse shapes within plastic scintillators using Geant4

Monday, 15 April 2019 18:10 (20 minutes)

Portal monitors for use in nuclear security typically use large volume detectors such as plastic scintillator detectors fabricated from polyvinyl toluene (PVT). Recent advancements in plastic scintillators have produced new scintillator materials which respond to both neutron and gamma radiation. These materials show pulse shape discrimination (PSD) properties which can b used to distinguish between the fast neutron and gamma events. However it is observed that PSD performance generally degrades with increasing scintillator size. In this work we aim to understand the optical transport processes in PSD-sensitive plastic scintillator and how these are potentially important for future portal monitors. Geant4 is a Monte Carlo radiation transport toolkit which is often used to model energy deposition in detector systems. However it also has the ability to ray-trace and track optical photons and tally
their arrival time at a collecting surface. In addition the performance of the reflective coating and of the scintillator geometry can be altered to study different detector configurations. Optical photons generated in a scintillation event can be sampled from a distribution with multiple exponential decay constants allowing the dependency of PSD on material properties to be studied. This paper will demonstrate Geant4 modelling of optical photon arrival times for a variety of material properties and geometries of plastic scintillator. These phenomena directly effect the time profiles and shapes of the detected optical pulses. We will discuss the effect of optical photon transport on the PSD performance of plastic scintillator, and the underlying causes of reduced PSD performance in large volume scintillators.

Primary author: HUBBARD, Michael (University of Surrey)

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Presenter: HUBBARD, Michael (University of Surrey)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **15** Type: **Oral Presentation**

Studying the use of Thallium Bromide as a Gamma Ray Sensor

Tuesday, 16 April 2019 12:15 (15 minutes)

Studying the use of Thallium Bromide as a Gamma Ray Sensor

Olivia Voyce (1), Tim Veal (1), Dan Judson (1), Paul Nolan (1), Amlan Datta (2), Laura Harkness-Brennan (1)

(1) The University of Liverpool Physics Department, (2) CapeSym Inc.

Gamma ray spectroscopy is a common assay method used in the identification and characterisation of radioactive samples at nuclear sites as it can be used to extensively survey, identify and assess the magnitude of waste in contaminated areas of such facilities. Following on from the results of a NuSeC summer project research is being undertaken at the University of Liverpool , with collaboration from CapeSym inc. into the development of a ground breaking, novel detector fabricated from the compound semiconductor Thallium Bromide (TlBr). This material is expected to excel as a portable, room temperature detector owing to its wide band gap (2.68eV), large bulk resistivity (10ˆ10-10ˆ11Ωcm) and high detection efficiency. Composition from high atomic number elements (ZTl=81, ZBr=35) and large density of 7.56 g/cm3 equips TlBr sensors with enhanced sensitivity compared to existing competing materials such as CZT. The long term performance of these sensors however is inhibited by the degradation of the device through ionic polarization of the crystal and subsequent reaction of bromine with the electrode materials. To this end, studies are currently underway to assess and quantify the mechanism of this phenomenon, in addition to developing methods to inhibit the degradation. The expected outcome of this work is the development of a novel portable gamma ray sensor with significantly reduced counting times and improved isotope identification compared to existing technologies, this will be discussed in the presentation. Furthermore, the fabrication methods of TlBr detectors as well as current energy resolution results will be presented, in addition to a discussion of the limitations of manufacturing these detectors.

Primary author: VOYCE, Olivia (The University of Liverpool)

Presenter: VOYCE, Olivia (The University of Liverpool)

Session Classification: Session 6: Imaging and Detection 2 (Session Chair Lee Thompson)

Track Classification: Detector Materials

Contribution ID: **16** Type: **Pilot Project Poster**

Evidential Reasoning for Radiological Detection

Monday, 15 April 2019 18:10 (20 minutes)

Detecting radioactivity is inherently uncertain. In a typical passive detection scenario (e.g. scanning cargo coming off a ship), a large number of factors need to be taken into
account, all of which can be subject to varying levels of uncertainty. For example, sensor count rates can vary, cargo can contain benign sources of radiation (e.g. bananas or tiles) that could mask other proscribed materials, the shipping manifest might not be clear, etc. Ultimately, this uncertainty tends to be handled on a subjective basis. Individual operators take what are often ad-hoc decisions. This means that there can be a large degree of variation in terms of how operators handle detection events such as alarms. In this project we attempt to apply a statistical multi-faceted decision support technique called Evidential Reasoning (ER) to provide a more systematic means by which to address this uncertainty. ER represents a decision problem as a hierarchy of factors, ranging from the top overarching question, down to the low-level atomic factors. It enables an operator (or indeed a sensor depending on the context) to supply an opinion on each of the lowest-level sub-factors, and automatically amalgamates this information to provide a high-level outcome. Importantly, this outcome makes any doubt or uncertainty explicit and quantifiable.

Primary author: WALKINSHAW, Neil (University of Leicester)

Presenter: WALKINSHAW, Neil (University of Leicester)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **17** Type: **Pilot Project Poster**

Digital Silicon SPAD Photosensor

Monday, 15 April 2019 18:10 (20 minutes)

This project focuses on exploring one of the most advanced light sensors coupled to bright scintillator detectors, which are used for detecting ionizing radiation. This novel device, which has been initially developed by the University of Edinburgh for improving the sensitivity of positron emission tomography using a time-of-flight correction, can also enable a whole new generation of radiation detectors for nuclear security. This pioneering sensor combines light detection and electronic signal processing on the same Silicon material. The advantages offered by this technology enable a highly compact, robust and fully digital readout with sub-mm
position sensitivity and ultra-fast timing response. The financial support by the Nusec Pilot Projects has enabled a summer student to focus on evaluating this device coupled to various scintillator detectors and to transfer knowledge from the University of Edinburgh to the University of York and Kromek company who envision to explore and utilise this device further.

Primary authors: ERDOGAN, A.T. (University of Edinburgh); PITMAN-WEYMOUTH, D. (University of York); FRASER, E.D. (University of York); R.K., Henderson (University of Edinburgh); RADLEY, I. (Kromek Group PLC); JOSHI, P. (University of York); PASCHALIS, S (University of York)

Presenter: BROWN, Jamie (University of York)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **18** Type: **Submitted Poster**

Passive Radiation Imaging

We examine the feasibility of inferring the internal geometry of an object based on passive measurements of the radiation emitted by that object. The approach taken in this paper is one designed to produce the radiation source density as well as the attenuation of the materials making up the object, herein referred to as f and a respectively. We refer to this problem, of recovering a and f from radiation measurements, as radiation tomography. The work is motivated by the need to determine the internal structure of devices containing
radioactive material entirely from passive measurements for the inspection requirements associated with the enforcement of potential nuclear arms treaties.

Primary authors: RICHARDSON, P. (University of Manchester); HOLMAN, S. (University of Manchester)

Presenter: HOLMAN, S. (University of Manchester)

Session Classification: Temp

Track Classification: Other topics

Contribution ID: **19** Type: **Pilot Project Poster**

Colloid suspension of nanoparticles as basis for detection of particles, gamma and X-ray

Monday, 15 April 2019 18:10 (20 minutes)

A detecting element which consists of a dense colloid suspension of nanoparticles is sensitive to ionising radiation both particulate and electromagnetic; at room temperature. The detector output is measured directly as a voltage and does not require intermediate photon detection. A large detecting surface area increases the probability of interaction between radiation and detector. The nanoparticle material does not need to be a semi-conductor but when exposed to ionisation radiation behaves basically the same as solid-state semiconductor detectors; Silicon, Germanium, Cadmium telluride or Cadmium zinc telluride (CZT). Ionising radiation causes a release of electrons. The electrons promoted into the conduction band are localized in the bulk or near the surface of the nanoparticle; no dopant or electrode bias is required. The spatial resolution of the detector depends only on the interval between electrodes of simple measuring array. It is possible to construct this array with micron or sub-micron spacing using conventional electronic manufacturing techniques. The existing prototype has an electrode interval (≈ 1mm) which is approximately the same as inter-pixel pitch in a typical CZT detectors. Many colloid materials are available which makes it possible to develop and modify the device easily, for example Gadolinium coating for high neutron capture. The device offers a cheaper alternative to existing detectors.

Primary authors: REN, J. (Liverpool John Moore's University); CLAIDEN, P. (Sino-British College, Shanghai); LI, S.D. (Liverpool John Moore's University)

Presenter: CLAIDEN, P. (Sino-British College, Shanghai)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **20** Type: **Submitted Poster**

Simulating Organic Radiation Detectors

Monday, 15 April 2019 18:10 (20 minutes)

The use of organic semiconductors as radiation detectors is a new organic electronics research. A particularly valuable tool to aid development of such devices is an emerging trend in reliable simulation that can be used to predict behaviour. We present a simulation program that was developed to investigate how organic materials react to incident radiation, and reconstruct electronic signals anticipated when generated charge is read out. This simulation program can be used to guide device fabrication, in addition we present our recent efforts in exploring how the data from the simulation could potentially be used to estimate the detector response for prospective samples read out electronic combinations.

Primary authors: BEVAN, Adrian (Queen Mary University of London (GB)); Dr KREOUZIS, Theo (Queen Mary University of London); Mr ALI, Muhammad (Queen Mary University of London)

Presenter: Mr ALI, Muhammad (Queen Mary University of London)

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **21** Type: **Pilot Project Poster**

Development of a Pulse Shape Discrimination Algorithm

Monday, 15 April 2019 18:15 (15 minutes)

Pulse Shape Discrimination (PSD) is the process of distinguishing between radiation types such as neutrons or gamma-rays. Dual detector scintillators can be used as they fluoresce from both neutron and gamma-ray interactions. Once the light has been collected on the photo sensor and its electric signal gets digitised, discrimination algorithms can be applied to identify the radiation type on a event-by-event basis. Several types of algorithms exist, each with benefits and disadvantages. As the requirements of detector systems change, so do the PSD algorithms. This project explores the creation of a database of reference pulses to compare to neutron/gamma-ray events for PSD purposes.

Primary authors: Mr WOOD, Jack (University of York); Dr PASCHALIS, S (University of York); Dr JOSHI, Pankaj (University of York); Dr ALLWORK, Chris (AWE); PITMAN-WEYMOUTH, D. (University of York)

Presenter: PITMAN-WEYMOUTH, D. (University of York)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **22** Type: **Oral Presentation**

Neutron efficiency and gamma rejection of pulse shape discriminating multi mode radiation detectors

Monday, 15 April 2019 17:00 (15 minutes)

This work investigates the performance of multi-mode detector crystals which can discriminate between neutron and gamma radiation within the same volume. Knowledge of performance metrics such as intrinsic neutron efficiency and gamma rejection ratio are vital when using such crystals hand held detection systems. As a result, the scatter corrected neutron efficiency to a ²⁵²Cf source and the change in the detection efficiency in the presence of an increased gamma field was assessed for the 6 materials (EJ-299, EJ-309, Stilbene, Cs₂LiYCl₆ (CLYC), P-terphenyl and EJ-270). These materials are of interest as they can detect neutron and gamma radiation and discriminate between them via pulse shape discrimination (PSD). For most detectors, the neutron efficiency was not found to change significantly in the presence of large gamma field. A 30 % increase in counts was observed for crystalline PSD scintillator, CLYC. This was assumed to be due to the different PSD characteristic and higher gamma sensitivity of CLYC. In addition, the absolute detection efficiency was measured for the 6 candidate materials and compared to the FLIR Identifinder 2 NGH. A two orders of magnitude increase was observed for the dual mode detectors compared to the Identifinder 2 thus highlighting the benefit of using larger dual mode detectors in any compact detection system in the future.

Primary authors: ALLWORK, Chris (AWE); Dr KENDALL, Paul (AWE)

Presenter: ALLWORK, Chris (AWE)

Session Classification: Session 3 Monitoring and Inspection (Session Chair Andrew Boston)

Track Classification: Detectors & Systems

Contribution ID: **23** Type: **Pilot Project Poster**

Enhancing source localisation for threat detection

Monday, 15 April 2019 18:15 (15 minutes)

Highly sensitive neutron detectors with directional information could improve the timeliness of detection and localisation of special nuclear material (SNM) at national ports of entry and for deriving operational and protection quantities in the field of neutron dosimetry.
In this context, two neutron source localisation algorithms, for use with a novel plastic segmented scintillator detector, nFacet 3D, were developed and evaluated as part of this study. Experimental data from Cf, AmBe and AmLi sources at different angles to the nFacet 3D detector were collected at the National Physical Laboratory (UK). Detection and localisation algorithms based on multilayer perceptron (MLP) and convolutional neural network (CNN) architectures were modelled and tested on data simulated from experimental records.
Results of this study includes prediction of the presence of a neutron source, estimation of a direction towards its location, and identification of the source from a set of given possibilities, supporting the feasibility of using machine learning methods in autonomous decision-making for threat detection.

Primary authors: VACHERET, Antonin (Imperial College London); BONOMALLY, Shameena (Imperial College (GB)); Dr IHANTOLA, Sakari (STUK)

Presenter: VACHERET, Antonin (Imperial College London)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **24** Type: **Submitted Poster**

Development of Compact Neutron-Gamma Detectors: A Source Narrative

Monday, 15 April 2019 18:10 (20 minutes)

This contribution is currently undergoing the AWE's clearance process.

Primary author: Dr TAGGART, Matt (University of Surrey)

Co-authors: Dr ALLWORK, Chris; Mr COLLETT, Michael; Mr HUBBARD, Michael (University of Surrey); SELLIN, Paul (University of Surrey)

Presenter: Dr TAGGART, Matt (University of Surrey)

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **25** Type: **Oral Presentation**

Neutron-capture prompt-gamma activation analysis (PGAA) using diverse machine learning methods

Tuesday, 16 April 2019 12:45 (15 minutes)

The detection of radiological materials is key to ensuring a robust second line of defense in nuclear security. Neutron-capture prompt-gamma activation analysis (PGAA) is an efficient non-destructive radio-analytical technique in the measurement of elements that do not form neutron capture products with delayed gamma-ray emissions. PGAA is a useful for in-situ multi-elemental detection technique for radioactive materials across the entire Periodic Table, from hydrogen to uranium and can be used to develop low cost detectors for application in nuclear forensics. However, the unavailability of accurate and complete data posed a significant challenge in the qualitative and quantitative analysis of complicated capture-gamma spectra by means of PGAA. As a consequence of the various recommendations and coordinated effort, International atomic energy agency (IAEA) initiated the development of a database for Prompt Gamma-ray Neutron Activation Analysis in 1999. In this study, diverse machine learning algorithms are developed to classify the elements such as Cobalt, Caesium, Iridium, Uranium and Thorium based on the PGAA energy spectra (Eγ) and effective capture cross section (σ). The classification algorithms employed in this work are based on K-nearest Neighbours (KNN), Artificial Neural Networks (ANN), Support Vector Machines (SVM), Classification Trees (CT), Random Forest (RF) and K-means clustering. The model performance is evaluated based on classification metrics namely accuracy, precision, recall and f1-score. The results are used to evaluate the classification performance of models developed using different machine learning algorithms and to enhance the understanding of the models that are best-suited for classifying elements using low dimensional data.

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Presenter: MATHEW, Jino (Coventry University)

Session Classification: Session 6: Imaging and Detection 2 (Session Chair Lee Thompson)

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **26** Type: **Submitted Poster**

Developing organic semiconducting sensors for thermal neutrons

Monday, 15 April 2019 18:15 (15 minutes)

The discovery of semiconducting polymers was followed by a rapidly growing commercial interest for many applications in electronic devices (polymer light-emitting-diodes, field-effect-transistors, polymer solar cells etc.) but not as much in the field of ionising radiation detection. The aim of the research presented here is the fabrication of an organic, semiconducting sensor for neutron detection.

Organic semiconductor-based sensors, although outperformed by their inorganic counterparts, benefit from low manufacturing cost and simple fabrication techniques.

Polytriarylamine (PTAA) is a p-type semiconducting polymer that belongs to the group of π-conjugated polymers and serves as the main active component of the sensor. This type of polymer exhibits interesting electrical properties due to the structure of the backbone that consists of an alternate sequence of single (σ) and double (σ and π) bonds enabling conductivity. In a radiation detector, the polymer is sandwiched between a transparent indium-tin-oxide (ITO) electrode and an aluminium electrode in a Metal-Semiconductor-Metal (MSM) configuration, that was found elsewhere [1]. Voltage is applied to the sensor electrodes in order to collect charge carriers after their excitation in the polymer.

Films thicker than 50 μm have been fabricated by drop-casting. Typical current-voltage (IV) analysis shows a diode-like behaviour of the sensor that is dependent on the particular work function of the metal in the top contact [2]. Visible light excitation results in photocurrent of up to two orders of magnitude larger than the dark current. The sensors are stable over time when stored in a dry, oxygen-free, light-tight environment.

In a novel material designed for thermal neutron detection, boron-10 (due to its high cross section) is blended in the polymer matrix in the form of natural boron nanopowder (19.8 % ^{10}B). At the presence of thermal neutrons, boron-10 undergoes the capture reaction ^{10}B(n,a) ^{7}Li. When the nanopowder is not well dispersed in the PTAA, so that there is a percolating path of the conducting boron phase, the composite has a high conductivity and Ohmic IV characteristics. However, the boron is dispersed homogeneously in the PTAA at concentrations below the percolation threshold [3], allowing the sensors to retain their rectifying electrical characteristics, despite boron loading reaching up to 10 vol. %. Boron-loaded PTAA films as thick as 80 μm have been achieved, which are capable of stopping the products of the neutron capture reaction. Quantum efficiencies of up to 2.8 % are expected. Plans are underway to test the neutron detectors at the ISIS thermal neutron source.

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3. M. D. Rintoul and S. Torquato (1997) 'Precise determination of the critical threshold and exponents in a three-dimensional continuum percolation model', *Journal of Physics A: Mathematical and General*, 30, no. 16, L585.

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Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **27** Type: **Oral Presentation**

Development of a Radiation Detector with Particle Discrimination for Nuclear Security Applications

Tuesday, 16 April 2019 10:15 (15 minutes)

The detection and analysis of multiple types of radiation is of paramount importance in nuclear safe-guarding and as such is a primary concern of sensor development. In the past, many nuclear safe-guarding have employed a combination of plastic scintillator and He-3 filled proportional gas counters for neutron and gamma detection, but since the increased use of He-3 for homeland security and science applications the world has been facing a shortage of this Nobel gas. Efforts have been made to find a suitable replacement for these detectors, most solutions to this problem have involved the use of Lithium or Boron for thermal neutrons and liquid or plastic scintillator for fast neutron solutions.

In this work two potential replacement materials were investigated, namely CLYC(Ce) and EJ299-33A coupled to SiPMs(Silicon photomultipliers) with the aim to produce a compact, low power, robust detection system for both neutron and gamma radiation. The response of the materials to neutron and gamma radiation was investigated to probe the pulse shape discrimination potential of the materials. Simulations were then performed in order to inform the design of a light guide to optimize light collection for coupling to arrays of SiPMs. The signals produced by the system were then digitized, and algorithms applied in order to discriminate between neutron and gamma radiation, and the possibility of using machine learning methods such as deep learning were also investigated.

It was found that both time domain and frequency domain algorithms had their strengths and weaknesses, with time domain methods such as charge comparison methods producing reasonable separation of spices and having very fast execution time, they were more susceptible to noise than methods which operated in the frequancy domain. Methods which take advantage of the ability to remove much of the noise in the signal tend to be more computationally expensive than that of the charge comparison method, but the results did benefit from the reduction in noise, which reduced the dispersion of the spieces distrabuitons, which can sometimes be seen in other methods. This results in the PSD performance being improved in some applications in comparison to other time domain methods such as charge comparison or pulse gradient analysis.

In this work, it has been shown that neutron-gamma PSD detectors can be constructed from the combination of CLYC and EJ299-33A scintillators and SiPM arrays which have the potential to replace He-3 detection systems in many applications while giving the benefit of reduction in detector size as well as an increase in the robustness of the detector system for in field deployment. It has also been shown that multiple approaches to the PSD analysis can yield favorable results and each have benefits which make it well suited to certain applications.

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Presenter: THOMSON, Francis (University of Glasgow)

Session Classification: Session 5: Imaging and Detection 1 (Session Chair Richard Hewitt)

Track Classification: Detectors & Systems

Contribution ID: **28** Type: **Submitted Poster**

Applications of Multibang Regularizaton in Weighted X-Ray imaging

Monday, 15 April 2019 18:15 (15 minutes)

Applications for accurate reconstructions from Passive Radiation Imaging are widespread from medical imaging to security. Unfortunately reconstructing such images are often ill-posed problems and require regularization to make sense of them. One recently developed regularizer known as Multibang makes use of a priori information about the possible attenuation values in an object to both improve reconstructions and reduce the amount of measured data required. This poster demonstrates the numerical effectiveness of combining this regularisation with Total variation as well as possible extensions.

Primary authors: Dr HOLMAN, Sean (University of Manchester); Mr RICHARDSON, Philip (University of Manchester)

Presenter: Mr RICHARDSON, Philip (University of Manchester)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **29** Type: **Submitted Poster**

Fission Reactor Antineutrino Emission ModellingUsing the 'ab initio' Method

Monday, 15 April 2019 18:10 (20 minutes)

Antineutrinos offer new possibilities for nuclear safeguards. Their abundant production in on-line fission reactors and the near impossibility of shielding them presents an opportunity for non-invasive on-line reactor monitoring. In support of this there have been numerous predictions of reactor antineutrino emissions, both based on the work of Schreckenbach *et al* and *ab initio* methods using fission fractions and known β-decay spectra. \\
This work discusses an *ab initio* generation of reactor antineutrino spectra using nuclide inventories taken from reactor modelling software. The resulting spectra are compared to the work of Schreckenbach *et al* and to other predictions. To put the work in a safeguards monitoring context, the daily antinuetrino flux density at the VIDARR detector during its proof of concept demonstration at Wylfa power station is calculated, using reactor data provided by Wylfa operators and FISPIN calculations by Robert Mills at the National Nuclear Laboratory. Also discussed is an application of the work to predict antineutrino flux densities from the Hartlepool Advanced Gas-cooled Reactor (AGR) at the WATCHMAN detector.

Primary author: Mr HOLT, George (University of Liverpool)

Presenter: Mr HOLT, George (University of Liverpool)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Core Monitoring & Cosmics

Contribution ID: **30** Type: **Oral Presentation**

nFacet 3D: Sensitive Neutron Detection for Timely Source Location and Identification

Tuesday, 16 April 2019 12:00 (15 minutes)

Fast neutrons from various sources, including special nuclear materials, have energy in the O(1-10) MeV range with attenuation length of up to 100 m in the air. As such, they potentially provide a strong signature of where they come from.
The relatively isotropic characteristic of the naturally-occurring neutron background makes directional measurements superior to simple neutron counters currently used in nuclear security. That information can also be used to derive a more realistic dose measurement providing a mean to improve on neutron dose estimates.
We will present the nFacet project and recent developments of a novel detector technology that provides high sensitivity to neutron detection combined with directional and spectral measurements.
The detector imaging capabilities is the result of many years of R&D for the a SoLid reactor neutrino experiment, an experiment that requires high neutron efficiency.
In this presentation, I will give an overview of the project and will describe the detector system and performance from recent measurement campaigns. I will develop on the new machine learning techniques we have applied from pulse shape discrimination to higher level analysis. Finally, I will conclude on the prospects for future use of this technology and currently pursued improvements towards dual a full gamma/neutron detector system.

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Presenter: VACHERET, Antonin (Imperial College London)

Session Classification: Session 6: Imaging and Detection 2 (Session Chair Lee Thompson)

Track Classification: Detectors & Systems

Contribution ID: **31** Type: **Pilot Project Poster**

Developments towards the stand-off detection of alpha emitting materials in daylight through the use of a UVTRON flame sensor.

Monday, 15 April 2019 18:15 (15 minutes)

Several isotopes of natural and man-made radioactive materials give off only alpha radiation, and although easily stopped by skin, ingestion of alpha particles is most hazardous to humans. It is, therefore, most important that detectors capable of detecting the presence of alpha emitting materials are available for use in the field, either for routine nuclear operations, accidental contamination or for security purposes. The short travel of alpha particles, around 5 cm in air, means that detection via direct interaction with a detector probe makes the process time consuming, makes checking complex morphologies difficult, and may put personnel in close proximity to potentially hazardous radioactive materials. A stand-off alpha detector moves personnel away from any radiation source, reduces scanning time and means that complex surfaces can be more easily checked for alpha contamination. Emitted alpha particles transfer energy to the surrounding atmosphere, causing gas atoms to excite and emit ultraviolet photons. Although the alpha particle itself travels only a few centimetres, these photons travel much further, meaning they can potentially be detected from a distance. They may also be scattered and reflect off surfaces, therefore aiding detection when the alpha source is out of view. In experiments carried out at the National Physical Laboratory (NPL), the ability of a UVTRON sensor (Hamamatsu) to detect photons in the UVC wavelength range (180-280 nm) was established. This wavelength range was used due to the high background from natural and artificial light in the UVA and UVB wavelength range (280-400 nm) which makes alpha-induced radioluminescence difficult to differentiate. The UVTRON has a very low background count in normal laboratory lighting, measured at 2.224 x 10-3 cps average at NPL. The count in the presence of a 6.95 MBq 210Po source was 0.328 cps at 20 mm distance from the sensor. A flow of gas was tested to determine if this would enhance the signal, which was found to be true, with the greatest increase from a flow of xenon which increased the signal by almost 90%, to a count of 0.851 cps. The conclusion of these experiments is that the UVTRON sensor has the potential for use in a detector system which could detect the presence of alpha emitting materials from a distance in normal daylight conditions, and that the use of a gas flow could increase the sensitivity of such a detector system.

Primary authors: Ms CROMPTON, Anita (Lancaster University); Dr GAMAGE, Kelum (University of Glasgow); TAYLOR, James (University of Lancaster)

Presenter: Dr GAMAGE, Kelum (University of Glasgow)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **32** Type: **Oral Presentation**

How a decade of active interrogation work led us to the need for mono-energetic sources, and why?

Monday, 15 April 2019 11:45 (15 minutes)

Active interrogation of shielded special nuclear material (SNM) for nuclear security applications has been the focus of a great deal of work since the beginning of the century by agencies worldwide. The Atomic Weapons Establishment (AWE) alongside the UK Government have maintained a programme to develop active interrogation techniques and technologies for border security since 2008. In this time, AWE – often in collaboration with other organisations – have trialled and assessed a range of radiation sources, radiation detectors, data acquisition systems, and data analysis tools. This body of work leads us invariably to the conclusion that currently available technologies, when correctly configured and integrated, can successfully detect shielded SNM in a wide variety of realistic configurations. Challenges however remain – both technological and operational – which limit the usefulness of active interrogation as a tool for securing a border.
We describe ten years of experimental campaigns: from bench-top trials to multimillion-pound demonstrator systems, show how the resulting data validates active interrogation as a technique, and discuss the remaining challenges and how mono-energetic radiation sources are a path forward for addressing them.

Primary author: CLEMETT, Ceri (AWE)

Presenter: CLEMETT, Ceri (AWE)

Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Track Classification: Other topics

Contribution ID: **33** Type: **Submitted Poster**

Spectral imaging for nuclear element detection

Monday, 15 April 2019 18:10 (20 minutes)

We propose a framework for nuclear element detection, using spectral X-ray CT, that utilises discrete tomography and machine learning algorithms to detect the inclusion of targeted materials within a sample. Assuming knowledge of a nominal list of materials and spectral CT data from a small number of angles, the proposed method proceeds to image and classify the materials using their known attenuation properties, and effectively quantifies the probability that an element of interest is present in the target. Numerical experiments showcase the performance of the framework.

Primary authors: Dr POLYDORIDES, Nick (University of Edinburgh); Dr KAMILIS, Dimitris (University of Edinburgh)

Presenter: Dr POLYDORIDES, Nick (University of Edinburgh)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **34** Type: **Pilot Project Poster**

Lead glass cherenkov detectors for gamma detection

Monday, 15 April 2019 18:15 (15 minutes)

Explosives can be detected by the neutron activation of nitrogen present in the material. Conventionally, inorganic scintillators are used, but in order to detect the characteristic 10.8MeV emission with any efficiency, large volume detectors are required. Lead glass cherenkov detectors have been constructed as an alternative to conventional inorganic scintillators. Such detectors are more cost effective but have poor energy resolution. The response of four lead glass detectors to different energy gammas and mixed gamma-neutron fields is presented.

Primary author: MCMILLAN, John (The University of Sheffield)

Presenter: MCMILLAN, John (The University of Sheffield)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **35** Type: **Submitted Poster**

Development of a fast neutron assay system

Systems based on fast neutron detectors have the potential to significantly reduce the time required to assay items containing SNM when compared with thermal, He3 based, systems. This poster will give an overview of a prototype fast neutron assay system being developed by AWE. The system uses an array of EJ309 liquid scintillator detectors and XIA Pixie4express electronics to carry out pulse the shape discrimination required to separate the gamma-ray and neutron signals, in real time. Preliminary results from recent measurements on bulk quantities of material will also be presented.

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Presenter: KELSALL, Nigel (AWE)

Session Classification: Temp

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **36** Type: **Submitted Poster**

Characterisation of Liquid Suspended Quantum Dots for Radiation Detection in Nuclear Security

Monday, 15 April 2019 18:10 (20 minutes)

Typical radiation detectors used in portal scanning employ plastic scintillators to effectively and inexpensively cover large areas.
To optimise performance the spectral range of scintillation should correspond to the maximum sensitivity of the photodetector.
Wavelength shifters can be employed to enhance this correlation but can be at the expense of scintillation efficiency.
Quantum dots have a tunable emission wavelength which may maintain, or even improve, scintillation efficiency.
This work reports characterisation measurements of four different quantum dot families: CdSe/ZnS, ZnCdSe/ZnS, ZnCdSeS, and ZnCuInS/ZnS.
In each case, the quantum dots were dispersed in liquid toluene with the aim to find the most appropriate for future loading within a plastic scintillator.

Emission and absorption measurements are necessary in order to understand and assess wavelength matching between the quantum dot emission and the coupled photodetector.
Powdered quantum dots, with wavelengths ranging from 440 nm to 670 nm, were suspended in a toluene solution.
To excite the entire range of quantum dots investigated a class 3B solid-state 405 nm laser was used to induce photoluminescence.
A spectrometer coupled to the sample vial via an optical fibre detected the emitted light.
Results showed that the cadmium-based quantum dots had a relatively narrow emission with FWHM of $\sim$30 nm compared to the cadmium-free quantum dots with FWHM of $\sim$100 nm.
However the brightness, found by integrating the emission peak, did not noticeably vary between each family.
By combining the experimentally observed emission maxima with the Brus equation, estimates of quantum dot diameters showed good agreement with the manufactured values.

Absorption spectra were measured using a broad spectrum UV lamp and monochromator, which transmitted a small wavelength range through each vial containing the different quantum dot dispersions.
A photodiode measured the transmission through each dispersion with an absorption spectra created by rotating the monochromator's diffraction grating to vary the output wavelength band.
Measurements indicated that simple core quantum dots such as CdSe/ZnS have absorption spectra with a more complex structure resulting from different electron transitions compared to the ZnCuInS/ZnS whose alloyed core manifested as a single absorption peak.
The absorption peak maxima were used to calculate Stokes shifts which showed good agreement with manufacturer estimates of $\sim$20 nm for cadmium-based and $\sim$125 nm for cadmium-free quantum dots.

Alongside optical characterisation, X-ray induced luminescence was applied to investigate the quantum dots response to radiation. Measurements were conducted using an Amptek Mini-X X-ray Tube at 20 kV with varying current, $0 - 200$ μA, directed towards a vial of dispersed quantum dots.
A photomultiplier tube, placed next to the vial, measured the photons emitted from the quantum dots as a photocurrent.
This paper will report on the radiation-induced response of liquid-suspended quantum dots in advance of solid scintillator studies.

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Presenter: Mr GROVE, Callum (University of Surrey)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **37** Type: **Submitted Poster**

Lithium Loaded Plastic Scintillators for Thermal Neutron Detection

Monday, 15 April 2019 18:10 (20 minutes)

EJ-270 is a 6Li loaded PVT-based plastic scintillator developed by Eljen Technologies and Lawrence Livermore National Laboratories. The 6Li makes it sensitive to thermal neutrons and pulse shape discrimination (PSD) can be utilized to separate the neutron events from γ-ray events. The low cost, large available volumes and environmental stability of EJ-270 makes it an attractive alternative to other fast PSD scintillators such as CLYC. A 48 mm diameter x 15 mm thick cylinder of EJ-270 was coupled to a Hamamatsu R6231-100 PMT biased to 1 kV. Measurements were taken with a moderated 241Am–Be source, on the EMMA instrument at the ISIS Pulsed Neutron and Muon source. EJ-270's sensitivity to γ-rays was evaluated using a 60Co source. The pulses from the detector were digitised using an Acqiris 12-bit digitizer at 400 MSps.
The high thermal neutron rates on the EMMA instrument necessitated the development of alternative PSD algorithms to the conventional charge integration method favouring speed over raw separation efficiency. Figures of merit of 1.3 for thermal neutrons (˜350 keVee) have been demonstrated by other authors using the charge integration method and 500 ns long windows. The first alternative method is by measuring the time to 10% of peak amplitude: for EJ-270 10% of peak amplitude is where neutron and gamma pulse shapes diverge. The second method is called tail sum which is achieved by summing a small number of samples in the tail of the decay. A PSD figure of merit for thermal neutron detector of 1.09 was achieved by using the time to 10% method and 1.26 for the tail sum method using 25 samples, higher figures of merit were achievable for more samples but at the cost of rate capability.

Primary authors: Dr RICHARDS, Sion (Science & Technology Facilities Council); TAGGART, Matt (University of Surrey); Dr SYKORA, Garrett Jeffrey (Science and Technolgy Facilities Council)

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Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **38** Type: **Oral Presentation**

Enhanced Resolution in Large Volume $SrI_2 : Eu$ Detectors

Tuesday, 16 April 2019 12:30 (15 minutes)

Strontium Iodide ($SrI_2 : Eu$) shows great promise as a high-resolution scintillator material for gamma ray detection, principally due to it's exceptional brightness – ˜120,000 photons/MeV[1], cf. 63,000 photons/MeV for $LaBr_3 : Ce$ [2]. Resolutions <2.7% FWHM (@ 662 keV) have been reported for small (<1cm3) $SrI_2 : Eu$ crystals [3] – comparable to $LaBr_3 : Ce$ – and the material exhibits a number of other advantageous properties such as: high Z_{eff}, low internal radioactivity, suitability to grow large crystals, excellent proportionality, and an emission spectrum (435 nm peak emission) well matched to many leading silicon photomultipliers (420-450 nm, cf. 380 nm for $LaBr_3 : Ce$). This makes $SrI_2 : Eu$ of interest for nuclear security applications for its ability to clearly identify gamma rays over a broad range of energies, thus making it suitable for the detection and discrimination of special and naturally occurring nuclear material. However, this potential has not been realised in large volume crystals (˜10 cm3). This is due to self-absorption/re-emission processes creating significant non-uniformity in light collection for interactions at different points within the crystal. Peak shifts in excess of 1% have been observed for different interaction positions [4] leading to significant degradation of the energy resolution (>2.9%). These effects can be mitigated to some extent through manipulation of the dopant concentration [5], however this leads to a compromise between brightness and light collection uniformity.

We propose an alternative method to enhance the energy resolution of large $SrI_2 : Eu$ crystals by applying a position dependant energy correction. A full treatment of this would require 3D position determination, and should yield energy resolutions comparable to that achieved for small crystals, without compromising the light yield. In this work, we will demonstrate the principle in one dimension through experimental and simulation work, and identify the challenges in extending and generalising to two and three dimensions.

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[5] C. M. Wilson, et al. (2008). Strontium iodide scintillators for high energy resolution gamma ray spectroscopy. Proc. SPIE, 7079, 707917.

Primary author: BROWN, Jamie (University of York)

Co-authors: Dr PASCHALIS, Stefanos (University of York); Dr JOSHI, Pankaj (University of York); Prof. JENKINS, David (University of York)

Presenter: BROWN, Jamie (University of York)

Session Classification: Session 6: Imaging and Detection 2 (Session Chair Lee Thompson)

Track Classification: Detectors & Systems

Contribution ID: **39** Type: **Pilot Project Poster**

Pulse-shape analysis for temperature dependent scintillators

Monday, 15 April 2019 18:10 (20 minutes)

In this project, we have measured and studied the pulse shapes of signals originating from inorganic scintillators
coupled to Silicon Photomultipliers for a varying temperature. In particular, we performed measurements for
CsI, NaI, CeBr3 and CLYC scintillating crystals. The measurements took place inside a controlled atmosphere
station that allowed handling of the bare hygroscopic crystals. The temperature was controlled by Peltier
element. The analysis was carried out using a simple pulse shape analysis method based on the ratio of two
different integration regions. The results show that in most cases this simple method is adequate to capture the
change in the signal pulse shapes caused by the temperature changes.

Primary authors: BELL, A. (Kromek Group PLC); PITMAN-WEYMOUTH, D. (University of York); MARSDEN, E. (Kromek Group PLC); HORSMAN, H. (University of York); RADLEY, I. (Kromek Group PLC); WOOD, Jack (University of York); JOSHI , P. (University of York); PASCHALIS, S (University of York)

Presenter: WOOD, Jack (University of York)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **40** Type: **Oral Presentation**

Beta-Gamma Coincidence Spectrometry in Support of the CTBT

Monday, 15 April 2019 17:15 (15 minutes)

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) has seen the installation of a global network of highly sensitive detection equipment, designed with the aim of detecting a nuclear explosion. The International Monitoring System (IMS) incorporates a number of technologies for detection of particulate and noble gas radionuclides, including high resolution gamma-ray spectroscopy. As a result of the International Noble Gas Experiment (INGE), beta-gamma coincidence measurements have become an important part of the Verification Regime, delivering greatly improved detection limits for measurements of radioxenon isotopes of interest. The UK CTBT Radionuclide Laboratory (GBL15), operated by scientists at AWE Aldermaston, has a history of research and development in radiometric science, focussing on signatures from post-detonation of a nuclear device.

A PhD studentship in collaboration with the University of Surrey has been established to develop a beta-gamma detection system for use in GBL15. This presentation covers the theory of this method of detection and the results of preliminary work in developing a high resolution coincidence detection system.

Primary author: GOODWIN, Matthew (AWE)

Presenter: GOODWIN, Matthew (AWE)

Session Classification: Session 3 Monitoring and Inspection (Session Chair Andrew Boston)

Track Classification: Detectors & Systems

Contribution ID: **41** Type: **Pilot Project Poster**

Compact X-ray sources

Monday, 15 April 2019 17:50 (20 minutes)

X-ray sources are used in radiography in order to scan cargo coming through ports around the world in much the same way as x-ray machines in hospitals. Additionally, knowledge of nuclear physics allows not just the shape, but the material properties of the objects to be determined by such scanners. All such scanners involve generating x-rays using electron beams which could potentially be generated using a laser instead of conventional technology. Due to the ultrafast and highly focusable nature of a pulsed laser it could be possible
to produce a shorter bunch of x-rays with improved imaging capability using this new laser-based accelerator technology.
This project studied one such scheme of using laser generated electrons to produce highly penetrating x-rays for imaging applications. It was found that careful control of laser and target parameters allows an x-ray source to be produced capable of imaging details down to 5 μm – around one tenth the width of a human hair.

Primary authors: MURPHY, C.D. (University of York); JENKINS, David (University of York)

Presenter: JENKINS, David (University of York)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Other topics

Contribution ID: **42** Type: **Submitted Poster**

Position reconstruction of gamma- ray interactions in monolithic scintillator's

Monday, 15 April 2019 18:10 (20 minutes)

In this paper, A 6x6x76.2mm CsI:Tl crystal coupled to two SiPMs at each end and coated with PTFE, high reflective 3M and black tape were prepared and tested. Energy and spatial resolution of the three detectors were measured and the effect of the coating material on the interaction position was investigated. Spatial resolution measurements were carried out using a computer motorized scanning table build at the university of York. The gamma ray source was a collimated 1mm 137Cs mounted on the top of the scanning table. Measurements of the gamma ray interaction were obtained for 15 different positions. The light ratio gradient and the FWHM of the light ratio were measured for each configuration to calculate the interaction position. The PTFE coated detector was simulated, and its spatial resolution was calculated using the same parameters as our experiment which showed a good agreement.The scintillator's surface treatment was also explored and its effect on improving the gamma ray interaction position reconstruction.

Primary authors: Ms ALSOMALI, Faten; Dr PASCHALIS, Stefanos; Prof. JENKINS, david; Dr BROWN, Jamie; Dr JOSHI, Pankaj

Presenter: Ms ALSOMALI, Faten

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **43** Type: **Pilot Project Poster**

A Study of Van Allen Belt Signatures of Nuclear Weapon Tests for Future CTBT Technologies

Monday, 15 April 2019 17:30 (20 minutes)

There are a number of measurement techniques employed to enforce the Comprehensive Test Ban Treaty (CTBT), with complementary measurements of seismic and atmospheric radionuclide data being foremost. The potential for decoupling and trapping of radionuclide gases in underground nuclear tests places importance on the identification and characterization of new techniques. Earlier studies of charged particle data in low Earth orbit satellites have shown that seismic events can result in particle bursts, that can be detected. There is strong evidence for the precipitation of charged particles in the van Allen belts caused by seismic events. Particle bursts, that are coincident in time and expected location, in satellite-borne detectors have been observed with a >5-sigma significance with earthquake activity at the corresponding location in SAMPEX/PET, MARIA/SALYUT–7, GAMMA–1, and DEMETER. In this study, we first identified seismic signals in the data and then electron energy correlations around the
times of Democratic People's Republic of Korea (DPRK) nuclear tests. Given the low numbers of DPRK nuclear tests, we first analyzed the data to examine temporal correlations with seismic activity. We observe temporally and spatially-correlated particle bursts starting just before seismic events and continuing throughout the period of activity. The correlations have a periodic character due to the eccentric GPS satellite orbit, where it dips into and out of the Van Allen belt during the seismic activity. Then we analyzed the times around the DPRK nuclear tests. For a very simple detection method, we find that we are unable to explain the cross-correlations in electron energy channels as being due to natural variability for four out of five DPRK tests. This suggests that the energy band cross-correlations, around the time of DPRK tests, appear to have a distinct charactrer than from all other natural periods (of, say, even seismic activity).

Primary authors: STEER, C.A. (St Mary's University); WACH, F.M. (University of Bristol); VELTHUIS, Jaap

Presenter: STEER, C.A. (St Mary's University)

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **44** Type: **Submitted Poster**

Cosmic-ray Muography for Nuclear Security Detection

Monday, 15 April 2019 18:15 (15 minutes)

In recent years, there has been a surge in the number of academic research groups and commercial companies exploiting cosmic-ray muons for imaging purposes in a range of applications. Typically, these involve shielded containers and/or large, complex structures that cannot be investigated using conventional imaging techniques. Many of these applications relate to nuclear security and non-proliferation e.g. waste characterisation, cargo scanning and spent fuel safeguarding.

Since 2009, researchers at the University of Glasgow and the UK National Nuclear Laboratory have pioneered the field of 'muography' for the characterisation of shielded nuclear waste containers. This technique uses muons that are produced naturally in the upper atmosphere from cosmic ray interactions. These particles are observed at sea level with a flux of approximately one per second for an area the size of a human hand. By tracking the muon paths through an unknown structure, a 3-dimensional density distribution of the constituent materials can be reconstructed with positional accuracy and resolution of less than a centimetre.

Lynkeos Technology spun-out from the University of Glasgow in 2016 and subsequently commercialised its technology under an Innovate UK First of A Kind Deployment of Innovation contract. In September 2018, the first Lynkeos Muon Imaging System was installed on the Sellafield site and is currently undertaking a series of nuclear industry trials. In parallel, Lynkeos is evaluating the capability of its technology for new applications in a range of different industries, including dry storage cask monitoring for international safeguards.

Results from nuclear industry trials will be presented alongside simulations showcasing the potential of muography for safeguards applications.

Primary authors: KAISER, Ralf (Lynkeos); YANG, Guangliang; Dr GARDNER, Simon (University of Glasgow); Mr CLARKSON, Anthony (University of Glasgow); Prof. IRELAND, David (University of Glasgow); AL JEBALI, Ramsey (University of Glasgow); Dr RYAN, Matt (National Nuclear Laboratory); Mr SHEARER, Craig (National Nuclear laboratory)

Presenter: KAISER, Ralf (Lynkeos)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Core Monitoring & Cosmics

Contribution ID: **45** Type: **Oral Presentation**

Figures Of Merit for the Application of Muon Tomography to the Characterization of Nuclear Waste Drums

Monday, 15 April 2019 16:45 (15 minutes)

Muon Tomography (MT) has been shown to be a viable candidate for the assay of nuclear storage containers [1]. By reconstructing the trajectories of muons both entering and exiting a volume of interest, a 3D gradient density map can be built from the reconstructed scattering angle distributions. This technique is particularly useful when imaging shielded nuclear waste containers where discontinuity of knowledge or loss of pointer cannot be ruled out, capable of non-destructively confirming the contents of a container whilst avoiding the cost and safety concerns involved with explicitly opening it. However, work is still needed to understand the different experimental factors that can affect the techniques ability to discriminate between different materials. In particular, a suitable Figure Of Merit (FOM) is needed for waste characterization that can be used to compare the performance of competing detector systems and algorithms for the detection and evaluation of radioactive material hidden inside large waste volume containers.

We present our work on the application of "optical" resolution tests (see [2]) to understand size and feature resolution in a muon tomography system. By imaging test objects with decreasing features sizes, the number of easily distinguishable objects is an indicator of the resolution of a given tomography technique when interpreting the reconstructed density matrix. This method allows comparisons to be made between significantly different algorithms by converting their qualitative outputs into discrete figures of merit.

The expected signals for these testing methods are presented from simulations of a representative muon tomography system. Three different commonly used tomography algorithms are considered for testing (binned clustering [3], angle statistics back-projection [4], and simple point-of-closest-approach [5]). The results highlight the importance of understanding feature resolution in muon tomography systems when imaging heterogenous nuclear waste storage containers. In the future an experimental testing apparatus for the production of these FOMs will be developed and used to further calibrate and characterize the performance of a muon tomography system being commissioned at the University of Bristol for the CHANCE Horizon-2020 project [6].

[1] Jonkmans, G., et al. (2013). Annals of Nuclear Energy, 53, 267-273.

[2] Camera Optics ISO Testing : https://www.techradar.com/news/photography-video-capture/cameras/camera-testing-resolution-charts-explained-1027585]

[3] Thomay, C., et al. (2013). Journal of Instrumentation, 8(10), P10013.

[4] Stapleton, M., et al. (2014). Journal of Instrumentation, 9(11), P11019.

[5] Riggi, S., et al. (2013). Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 728, 59-68.

[6] CHANCE 2020 : http://chance-h2020.eu. Future work will be funded by the European NFRP7 program, grant no. 755371 (CHANCE).

Primary authors: STOWELL, Patrick (University of Sheffield); Prof. THOMPSON, Lee (University of Sheffield); Dr KOPP, Anna (University of Bristol); Mr WEEKES, Michael (University of Sheffield); Mr

ALRHELI , Ahmad (University of Sheffield); Dr KIKOLA, Daniel (University of Warsaw); Prof. TIETZE-JAENSCH, Holger (Forschungszentrum Julich GmbH); Mr MHAIDRA, Mohammed (University of Warsaw); Dr VALCKE, Elie (SCK•CEN, Belgian Nuclear Research Centre); Dr VELTHUIS, Jaap (University of Bristol)

Presenter: STOWELL, Patrick (University of Sheffield)

Session Classification: Session 3 Monitoring and Inspection (Session Chair Andrew Boston)

Track Classification: Core Monitoring & Cosmics

Contribution ID: **46** Type: **Oral Presentation**

RIID'ing the World of Nuclear Threats: The Next Generation of Radioisotope Identification Detectors

Tuesday, 16 April 2019 10:30 (15 minutes)

Efforts to counter Weapons of Mass Destruction drive the development of highly sensitive state-of-the-art radiation detectors that can rapidly and accurately classify the nature of nuclear threats through identification of radionuclide species with high certainty. The requirements for detectors such as Radio-Isotope Identification Detectors (RIIDs) necessitate a device that can resolve closely-spaced photo peaks in busy spectra, demonstrate high detection efficiency, and include thermal neutron sensitivity to detect the presence of fissile radionuclides that exhibit little or no gamma-ray profile. These devices also need to demonstrate versatility in order to function across a wide range of operations and in harsh environmental conditions.

Kromek has recently developed its own bespoke Application Specific Integrated Circuit (ASIC), "Apollo", designed to be utilised as a multipurpose processor across many signal processing applications in its nuclear detection products. This ASIC, in addition to technology developed by Kromek for DTRA funded programmes, has allowed the creation of a detection system with a Pulse Shape Discrimination (PSD) capability, which displays stability across a large operational temperature range. The system utilises two novel technologies: A $Cs_2LiLaBr_{6-x}Cl_x$:Ce (CLLBC) belonging to the Elpasolite scintillator family and an ideal material for this application due to the high gamma-ray energy resolution and thermal neutron sensitivity offered. The CLLBC crystal is also coupled to solid state Silicon Photomultipliers (SiPMs) which allow such a device to meet the low power, low voltage, and small form factor metrics that are difficult to achieve using standard photomultiplier tubes.

We demonstrate how this system performs against what is required of a RIID-type device, including an evaluation of the energy resolution as a function of temperature, and the PSD ability characterised by a figure of merit. We also present the challenges of optimising a system such as this to perform with restrictions of low power requirements, and the potential of these systems to form the core of next generation detectors of compact, dual mode RIIDs.

Primary authors: TUFF, Adam (Kromek Ltd); Dr MARSDEN, Ed (Kromek Ltd.)

Co-authors: Mr DUFF, Craig (Kromek Ltd.); Mr MCGRATH, Patrick (Kromek Ltd.); Mr RADLEY, Ian (Kromek Ltd.)

Presenter: TUFF, Adam (Kromek Ltd)

Session Classification: Session 5: Imaging and Detection 1 (Session Chair Richard Hewitt)

Track Classification: Detectors & Systems

Contribution ID: **47** Type: **Oral Presentation**

AMIR: Antineutrino Measurement of Isotopes in Reactors

Monday, 15 April 2019 16:30 (15 minutes)

Antineutrino emissions carry information about the core nuclide ratio in an active reactor core as the emitted antineutrino energy spectrum is directly dependent on the core isotope content. Of special interest are small changes in core content over time, as these directly relate to burn-up and material insertion or extraction, e.g. during refuelling. However, the sensitivity of a detection system to such small changes is critically dependent on the reactor power, stand-off distance and allowed measurement period.

The AMIR (Antineutrino Measurement of Isotopes in Reactors) study determines the spectral sensitivity of a model 1-ton near field detector system, based on existing anti-neutrino monitoring efforts, for a number of model reactors. Among these reactors are small research reactors as well as the Wylfa Magnox Power Plant, where a prototype antineutrino monitoring system has been deployed in the past, providing a known benchmark. For each model core, a sensitivity map has been produced, allowing the comparison of sensitivity to core change against measurement time and distance. This work is also extended for generic reactor cores is presented. This general model uses core fission ratios, thermal power and reactor building size as well as a desired confidence level and time window for the measurement as inputs to the code to determine the maximum distance for the desired sensitivity or maximum sensitivity achievable at a fixed distance.

Primary authors: SCHNELLBACH, Yan Jie (University of Liverpool); COLEMAN, Jonathon (Physics Dept, University of Liverpool)

Presenter: SCHNELLBACH, Yan Jie (University of Liverpool)

Session Classification: Session 3 Monitoring and Inspection (Session Chair Andrew Boston)

Track Classification: Core Monitoring & Cosmics

Contribution ID: **48** Type: **Submitted Poster**

Verification Instrument for the Direct Assay of Reactors at Range

Monday, 15 April 2019 18:10 (20 minutes)

The Verification Instrument for the Direct Assay of Reactors at Range (VIDARR) is a reactor monitoring tool based on solid plastic scintillator. Reactors produce c. 10ˆ20 anti-neutrinos per gigawatt (thermal). These anti-neutrinos can then be captured by protons in the detector via inverse beta decay (IBD). This produces a distinct double coincidence signal in the VIDARR detector. The GEANT4 detector simulation is used to estimate the improvements made by the ongoing upgrade to VIDARR. The new geometry of the detector sees a significant improvement in containment of the Gadolinium gamma cascade, showing c. 25% more high-containment events. A traditional optimisation of a neutron trigger is conducted using simulated detector results with two different thresholds and is compared to a machine learning approach using a Support Vector Machine (SVM). Which improves neutron signal efficiency by ˜ 5% and purity by ˜10%. Finally, a data driven dark noise model is added to increase the simulation accuracy and to fold in electronics effects. This is further augmented using a more accurate background model.

Primary author: COLLINS, Ron (University of Liverpool)

Presenter: COLLINS, Ron (University of Liverpool)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Core Monitoring & Cosmics

Contribution ID: **49** Type: **Oral Presentation**

Simulation of novel high-quality radiation sources for industrial use

Monday, 15 April 2019 11:30 (15 minutes)

Recent simulation and experimental results have demonstrated that hard x-ray sources (>1 MeV) from laser-plasma wakefield accelerated (LWFA) electrons can generate a small source x-ray source for radiography. Other laser-plasma x-rays sources have been shown to be of a high enough quality to demonstrate phase contrast imaging (PCI). This project aims at bringing together these two important results.

In order to fully understand the injection and acceleration of the electrons, the generation of the photon source and the potential for imaging, a large range of time and spatial scales must be simulated. Hydro, particle-in-cell, Monte-Carlo and ray tracing codes each provide part of the solution to this simulation challenge.

We present start-to-end modeling demonstrating the feasibility of x-ray imaging at high photon energy, high resolution and high signal to noise.

Primary authors: MURPHY, C.D. (University of York); ANTONELLI, L. (University of York); UNDERWOOD, C.I.D. (University of York)

Presenter: MURPHY, C.D. (University of York)

Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **50** Type: **Submitted Poster**

Novel Perovskite X-ray/Gamma Detectors and Potential Applications

Monday, 15 April 2019 18:10 (20 minutes)

Novel Perovskite X-ray/Gamma Detectors and Potential Applications

X-ray imaging has been the mainstay of non-invasive diagnostics in fields such as medicine, security and defence, non-destructive testing and production line quality control. The development of new detectors that offer greater sensitive, energy resolution, radiation hardness and mechanical robustness continues to be a priority to further develop or create new imaging techniques. High energy X-ray and gamma ray detection is particularly important in nuclear security to permit the interception of illegally transported nuclear and radiological materials at the borders, as well as mapping the spread of these materials after a radiological event (accidental or otherwise). The materials used in the construction of new high energy photon detectors must be chosen carefully to ensure efficiency, cost effectiveness and sensitivity, particularly where they must be produced consistently and in volume as in the case for nuclear security applications.

Current research into Perovskite semiconductor materials for solar cell technology has been driven by their excellent light conversion properties; ease and reliability of manufacture; and their relatively low cost. These properties have given rise to significant interest in their potential alternative uses, one of which is in direct X-ray detection 1, owing primarily to their high-Z elemental composition. In this study we present the initial results of two perovskite-based devices exposed to X-rays. Perovskite CsPbBr₃ has been synthesised through hydraulic compression or through thermal evaporation and annealing based crystal formation as in 2. The samples formed were either granular powders or single crystals, of 1mm thickness and 5mm thickness respectively, with layers of silver contacts laid down for charge collection. The samples were connected to a voltage source (to provide bias) and a picoameter (to measure photogenerated current). The samples were then exposed to X-ray from a conventional X-ray generator. The current was measured for a range of different bias voltages and X-ray tube potentials. Figure 1 shows the acquired response of the crushed powder Perovskite sample. The dark current was measured to be 0.85 nA (at V_{Bias} = 5V) and a response ratio (I_{on}/I_{off}) of up to 86.2 was achieved. The single crystal device demonstrated a higher dark current of 845 nA (at VBias = -5V) and achieved a maximum response ratio of 1.23. The results from both devices are promising, as this production method is cost effective, repeatable and scalable. Further applications of such materials for nuclear security could be in solid state neutron detection by incorporation of Boron-10 in the Perovskite structure.

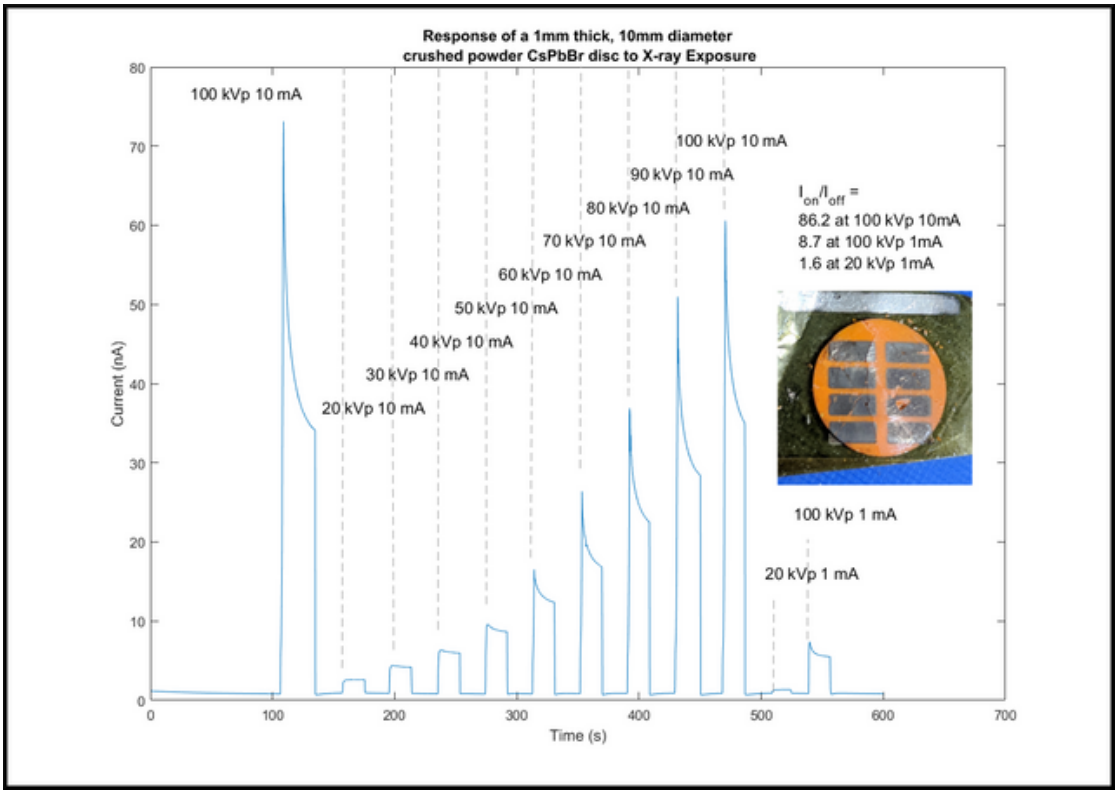

Figure 1: Figure 1: Response of a Crushed Powder sample of CsPbBr_3 to a Tungsten target X-ray source at high and low exposure rates

Primary authors: FORTH, Logan; Prof. SPELLER, Robert (University College London); Dr MOSS, Robert (University College London)

Presenter: FORTH, Logan

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **51** Type: **Submitted Poster**

Generalized gamma spectrometry simulator for forward and reverse problems in nuclide identification

Monday, 15 April 2019 18:10 (20 minutes)

Accurate automated characterisation of radioactive material is crucial for applications in decommissioning and the detection of illicit material. While detection hardware rarely changes outside of bespoke solutions, improvements in Radio-isotope˜IDentification (RID) algorithms have become a significant research focus. A generalised gamma simulator has been built using the GEANT4 toolkit to provide a rapid development environment. With a high-fidelity model using Monte-Carlo based radiation transport, a diverse range of radiation sources and shielding scenarios may be considered. Data derived from facilities such as the Birmingham MC40 cyclotron and Culham Centre for Fusion Energy will provide this diversity for RID performance testing. Experimental validation of the simulator is also performed against real data. An overview of simulation techniques for gamma spectrometry will be presented, along with how the simulator is currently being used to research more robust and reliable RID algorithms.

Primary author: Mr TURNER, A (University of Birmingham)

Co-authors: Dr WHELDON, C (University of Birmingham); Dr GILBERT, M.R (UKAEA); Mr PACKER, L.W (UKAEA); Dr BURNS, J (AWE plc.); Prof. FREER, M (University of Birmingham)

Presenter: Mr TURNER, A (University of Birmingham)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: DAQ, Algorithms & Modelling

Contribution ID: **52** Type: **not specified**

Opening Remarks

Monday, 15 April 2019 10:30 (15 minutes)

Presenter: SELLIN, Paul (University of Surrey)

Session Classification: Session 1: Applications in Nuclear Security (Session Chair Paul Sellin)

Contribution ID: **53** Type: **Pilot Project Poster**

Investigation of neutron and gamma sensitivity in Gadolinium- doped plastic scintillator

Monday, 15 April 2019 18:15 (15 minutes)

The detection and discrimination properties of two different plastic scintillator detectors were investigated, namely one constructed from standard plastic scintillator and another of the same scintillator doped with Gadolinium. The response of these detectors to exposure to neutrons and gammas from 137Cs and 252Cf sources is assessed.

Primary authors: CIMADOM, Diego (University of Sheffield); THOMPSON, Lee (University of Sheffield); FARGHER, Sam (University of Sheffield); DEAKIN, Tom (LabLogic Systems)

Presenter: CIMADOM, Diego (University of Sheffield)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials

Contribution ID: **54** Type: **Pilot Project Poster**

Development of a Neutron-Gamma Telescope

Monday, 15 April 2019 18:15 (15 minutes)

In this paper we discuss developments in pulse shape discriminating plastic scintillators for neutron-gamma separation. Three independent PSD sensitive detectors were constructed and tested, providing typical figures of merit of 1.09 at 1 MeVee.

Primary authors: PATERSON, H. (University of Surrey); TAGGART, Matt (University of Surrey)

Presenter: TAGGART, Matt (University of Surrey)

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detectors & Systems

Contribution ID: **55** Type: **Oral Presentation**

Overview of CBRN-UK

Monday, 15 April 2019 13:30 (10 minutes)

Primary author: EDWARDS, Jeremy (NNL)

Presenter: EDWARDS, Jeremy (NNL)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **56** Type: **Oral Presentation**

Industry Challenges

Monday, 15 April 2019 13:40 (10 minutes)

Primary authors: CROUCH, David (3M); HILLER, Peter (NNL)

Presenter: CROUCH, David (3M)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **57** Type: **Oral Presentation**

Pharos/University of Manchester-industry stand-off detection

Monday, 15 April 2019 13:50 (15 minutes)

Primary authors: TRIVEDI, Divyesh (National Nuclear Laboratory); SMITH, Nick (University of Manchester)

Presenter: TRIVEDI, Divyesh (National Nuclear Laboratory)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **58** Type: **Oral Presentation**

UK-US technology development and exploitation – digital camera radiation detection

Monday, 15 April 2019 14:05 (15 minutes)

GammaPix™ technologies detect ionising radiation using unmodified digital cameras, security cameras, smartphones, tablets and laptops. This unique low cost radioactivity protection capability allows law enforcement and military agencies to interdict acts of radiological terrorism, and first responders to manage radioactivity emergencies caused by accidents or terrorism.

GammaPix takes advantage of the inherent sensitivity of digital cameras to ionising radiation. The software allows millions of unmodified and internet connected surveillance cameras, webcams, smartphones & tablets to detect the telltale signatures created when gamma rays interact with the camera's sensor chip.

Primary author: SCHOLES, John (Observant Innovations)

Presenter: SCHOLES, John (Observant Innovations)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **60** Type: **Oral Presentation**

3D pipe scanning

Primary author: TBC

Presenter: TBC

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **61** Type: **not specified**

Panel Session Q&A

Monday, 15 April 2019 14:50 (25 minutes)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **62** Type: **Oral Presentation**

CVD diamond sensors for neutron detection

Tuesday, 16 April 2019 14:00 (20 minutes)

Primary author: LEFEUVRE, Gwenaelle (Micron Semiconductor)

Presenter: LEFEUVRE, Gwenaelle (Micron Semiconductor)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **63** Type: **Oral Presentation**

Neutron Detection Technologies

Tuesday, 16 April 2019 14:20 (20 minutes)

Primary author: FOSTER, Mark (Symetrica)

Presenter: FOSTER, Mark (Symetrica)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **64** Type: **Oral Presentation**

Overview of Neutron Detection for Nuclear Threat Reduction

Tuesday, 16 April 2019 14:40 (20 minutes)

Primary author: HOLLOWAY, Steve (AWE)

Presenter: HOLLOWAY, Steve (AWE)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **65** Type: **Oral Presentation**

DTRA-sponsored Helium-3 Alternative Technologies: mature and mass producible technologies

Tuesday, 16 April 2019 15:00 (20 minutes)

Primary author: ZHU, Hank (DTRA)

Presenter: ZHU, Hank (DTRA)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **66** Type: **not specified**

Panel Session Q&A

Tuesday, 16 April 2019 15:20 (30 minutes)

Primary author: GASPAR, Neil (University of Surrey)

Presenter: GASPAR, Neil (University of Surrey)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **67** Type: **Oral Presentation**

Closing Presentation: Engagement with Nuclear Security

Tuesday, 16 April 2019 15:50 (30 minutes)

To close the workshop we will discuss the continuation of NuSec for the period 2019-2022 and the opportunities for PhD funding from the network. We will also have a wider discussion and Q&A session focusing on Academic, Industrial and Government Engagement with Nuclear Security.

Primary author: SELLIN, Paul (University of Surrey)

Presenter: SELLIN, Paul (University of Surrey)

Session Classification: Session 7: AWE session on 3He alternatives (Session Chair Neil Gaspar)

Contribution ID: **68** Type: **Pilot Project Poster**

NESSY – A prototype Neutron Energy Spectrometer for Security

Monday, 15 April 2019 18:15 (15 minutes)

A liquid scintillator fast neutron detector has been built at Sheffield Hallam University, which can improve neutron spectrometry for homeland security. This ambitious project utilises an EJ-331 (gadolinium loaded liquid scintillator), which permits differentiation between neutron, gamma and charged particle radiation, and allows the energy of the incident radiation to be determined. The geometry of the detector and dual photomultiplier tube set-up has been designed such that the position of incident radiation can be determined using precision timing. The set-up will be used with a digital pulse processing unit to perform timing and pulse shape discrimination measurements.

Primary authors: MAXFIELD, Adam (Sheffield Hallam University); WHELDON, Carl (University of Birmingham); SMITH, Robin (Sheffield Hallam University); KOKALOVA, Tzany (University of Birmingham)

Presenter: MAXFIELD, Adam (Sheffield Hallam University)

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **69** Type: **Pilot Project Poster**

Comparing Wavelength Shifting Fibres and Strips for SoLid

Monday, 15 April 2019 18:15 (15 minutes)

This project compared the current wavelength shifting fibres used in SoLid to the proposed wavelength shifting strips. The relative light yield of the strips compared to the fibres was investigated, and the results seem to indicate that the strips are at least as good, if not marginally better than, the current fibres. However taking into account the relatively crude methods involved in using constructing the strips compared to the fibres, it seems likely that if the methods for creating the strips could be refined than was possible due to the limited timescale of this project then the strips could indeed perform notably better than the fibres.

Primary authors: WRIGHT, Christopher (University of Bristol); Prof. NEWBOLD, Dave (STFC Rutherford Appleton Laboratory (GB)); CUSSANS, David (University of Bristol (GB))

Presenter: WRIGHT, Christopher (University of Bristol)

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **70** Type: **Pilot Project Poster**

Thallium Bromide Radiation Sensors

Monday, 15 April 2019 18:15 (15 minutes)

This poster details the outcome of the NuSec Netwowrk Summer 2016 Pilot Project which investigated the use of Thallium Bromide as a room temperature semiconductor detector. With the help of NuSec funding a functional gamma ray detector was developed, utilising a Thallium Bromide crystal, that ultimately gave spectroscopic performance comparable to current market detectors. Applications
of these types of sensors are diverse, ranging from use in medical, industrial and security imaging; nuclear safety and characterisation of materials; astrophysics; and fundamental nuclear physics research. This proof of concept has also paved the way for a PhD project to investigate the properties of these crystals further.

Primary author: O'BRIEN, Josiah

Presenter: O'BRIEN, Josiah

Session Classification: Session 4: Poster session and drinks reception

Contribution ID: **71** Type: **Oral Presentation**

Thermal-neutron detection with GAGG:Ce

Tuesday, 16 April 2019 10:00 (15 minutes)

The focus on the scintillator Gd3Al2Ga3O12 (GAGG) has generally been on its exploitation for medical physics applications, predominantly positron emission tomography. GAGG has brightness comparable to other high-light yield scintillators at 40-55,000 ph/MeV (depending on the exact formulation), and with a density of 6.63g/cm3 coupled to an effective Z-number of 54 results in a scintillator with high stopping power and sensitivity to gamma rays. More importantly however, is the gadolinium content. The isotope Gd-157 has one of the highest thermal-neutron capture cross sections known at 250,000 barns, which means that even relatively small pieces of GAGG will retain an almost 100% efficiency for thermal-neutron detection. GAGG therefore has the potential as an extremely suitable material for compact neutron detection systems. In this work we present the findings of a NuSec PDRA grant and discuss the suitability of GAGG for neutron detection applications.

Primary authors: TAGGART, Matt (University of Surrey); NAKHOSTIN, Mohammad; SELLIN, Paul (University of Surrey)

Presenter: TAGGART, Matt (University of Surrey)

Session Classification: Session 5: Imaging and Detection 1 (Session Chair Richard Hewitt)

Contribution ID: **72** Type: **Oral Presentation**

Improving the win-win rate for Suppliers and Customers involved in the expanding radiometric marketplace

Monday, 15 April 2019 14:35 (15 minutes)

Even within the specialist area of radiation detection applied to nuclear security and safety, the marketplace is flooded with instrument offerings; from hand-held RID's through to extensive arrays of RPM's and other networked detector arrays. Whilst such offerings reap the benefits of Supplier skills and investment in quality instrument design and manufacture, less attention is often paid to establishing and publicising the necessary performance characteristics to attract a Customer. This problem - of failure to secure Customer confidence and thereby purchasing commitment - can also be exacerbated by a lack of detailed Customer requirements, borne often of a corresponding lack of expertise to be able to convey requirements to a Supplier in the appropriate technical language. This situation can lead to an impasse which slows the overall procurement process; Supplier and Customer iterating tentatively towards an eventual solution which, even if technically correct, may be non-ideal for many other non-technical reasons, e.g. cost and time over-runs. A perspective is presented on how to address these challenges and thereby improve the win-win rate from both Supplier and Customer viewpoints.

Primary author: HOLLOWAY, Steve (AWE)

Presenter: HOLLOWAY, Steve (AWE)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **73** Type: **Oral Presentation**

CBRN Information Management as a Service

Monday, 15 April 2019 14:20 (15 minutes)

With the evolving threat of terrorism from individual, extremist groups and state-based actors as well as the consequences of accidents which produce life endangering amounts of toxic industrial materials, there is an increasing need for improved local control of CBRN incidents. Consequently, there is an escalating need for first responders, local government and other agencies, as well as commercial entities concerned with risk management and insurance to have access to the type of CBRN IM capabilities available to the military. In order to tackle this issue, Riskaware is leading a consortium, joint funded by the European Space Agency (ESA) and the European Defence Agency (EDA), to investigate the feasibility of developing the next generation of CBRN Information Management Systems, leveraging both existing and emerging space based data. The resulting capability concept, EuroSIM CBRN, will enable a wide user community to have access to the type of advanced CBRN IM technology already available to the military in the UK. Our approach takes advantage of the latest developments in evolving technologies, such as cloud computing and Modelling and Simulation as a Service (MSaaS), to provide a highly flexible and customisable web-based service offering specifically tailored to meet different user community needs. Following the successful delivery of the feasibility study, the project is now moving into the development phase and pilot trials, with key user community stakeholders, scheduled for late 2020. Our presentation will provide an overview of the EuroSIM CBRN concept along with the finding of the feasibility study, focusing on its applicability to Nuclear Security.

Primary author: GORDON, Robert (Riskaware Ltd)

Presenter: GORDON, Robert (Riskaware Ltd)

Session Classification: Session 2: CBRN-UK Industry/Academia session (Session Chair Jeremy Edwards)

Contribution ID: **74** Type: **Submitted Poster**

Spectroscopic and Timing Performances of SrI2:Eu Scintillation Crystal Coupled to PMT and SiPM

Monday, 15 April 2019 18:15 (15 minutes)

The europium-doped strontium iodide (SrI2:Eu) scintillator was first discovered in 1968 by Hofstadter 1. In recent years, owing to the significant improvements in the technology of crystal grow of this scintillator, it has emerged as a strong candidate for gamma-ray spectroscopy applications 2. This crystal exhibits extremely high light yield, proportional response, and very low level of internal radiation which is of importance for low level radiation measurement applications. The energy resolution of this material is close to 3 % at 662 keV energy, about 2 times better than the commonly used members of the iodide family such as NaI:Tl. In particular, coupling this crystal to silicon
photomultipliers (SiPM) is very attractive due to compactness and low-voltage operation. In this work, we report on the spectroscopic and timing performance of a SrI2:Eu crystal separately coupled to a photomultiplier tube (PMT) and
a SiPM. The effects of the very long decay-time constant of >1 μs and large light output of SrI2:Eu on the readout and processing of the scintillation pulses are explored.

Primary author: NAKHOSTIN, Mohammad

Presenter: NAKHOSTIN, Mohammad

Session Classification: Session 4: Poster session and drinks reception

Track Classification: Detector Materials