Overview of Neutron Detection for Nuclear Threat Reduction

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Contents

Why Neutrons?

- Primary focus of SNM detection which emits neutrons (spontaneously and induced)
- Neutrons penetrate high atomic mass materials (steel, lead, tungsten)
- Limited sources of neutrons (cosmic, (α,n), spontaneous fission etc.) therefore more indicative of a threat
- Appropriate neutron measurements allow non destructive assay to quantify mass and material geometry

Neutrons provide complimentary measurements to gamma counting and spectroscopy

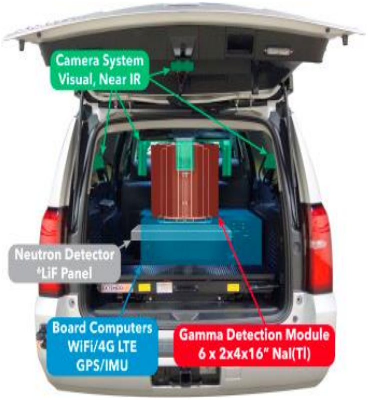
Nuclear Security Applications

EPDs

Handheld

Search

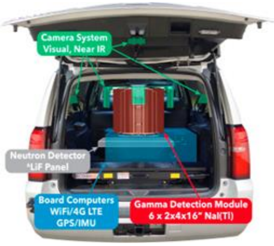
Assay



Vehicle

Radiation Portal Monitors

Nuclear Security Applications: Requirements



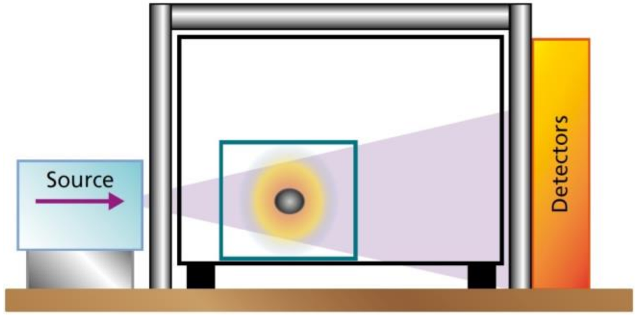
Low	Efficiency →	High
Low	Cost →	High
Small	Size/Weight →	Large
Low	Power Consumption →	High
Generic	← Multiple Functions/Uses	Specialist
Low	Training/Infrastructure required →	High

- Complexity
- Usability
- Communication / Data outputs
- Quality of data/analysis

Historical Focus Areas

Identification of technologies to meet a requirement:

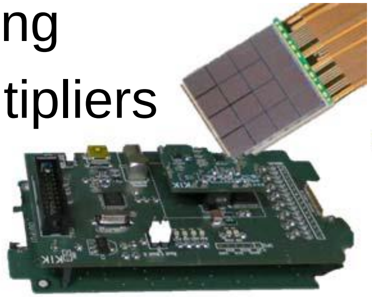
- ^{3}He Replacement Technologies
- Prototype technologies – Passive/Active demonstrators
- Evaluation of COTs systems
- Collaborative work with US agencies

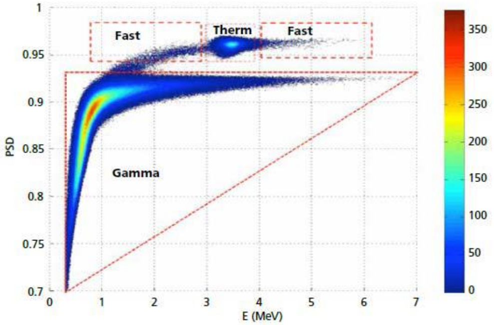


Low level underpinning research/intelligent customer

- Novel scintillators
- Multimodal detection
- DAQ
- Algorithms/digital pulse processing
- Light collection/Silicon Photomultipliers

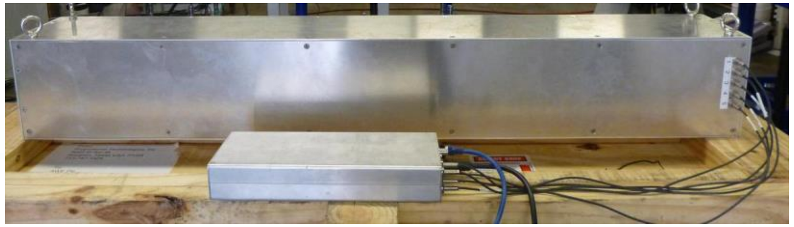
Promising technologies demonstrated as prototypes where appropriate





^{3}He Replacements

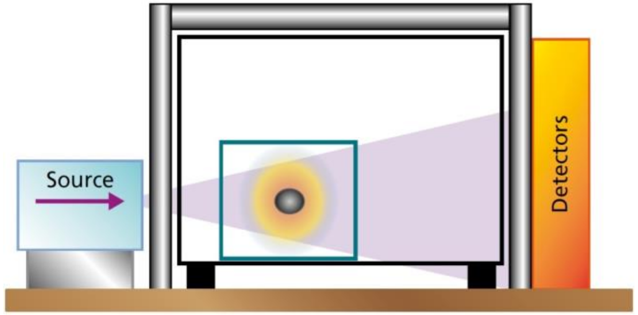
- State of neutron detection technologies evaluated to reduce future dependence on ^{3}He supply
  - ‘Drop in’ thermal neutron detector technologies (Boron straws, ^{6}LiF:ZnS(Ag))
  - Fast neutron and multimode detector technologies (Liquid scintillators, PSD plastics, CLYC, CLLB)
- Collaborative working with academia (Oxford University, Imperial College London) and industry (PTI, Arktis) and US partners.



Passive/Active Demonstrators

- Developed radiation detector demonstrators and/or subsystems for passive detection and active interrogation of SNM

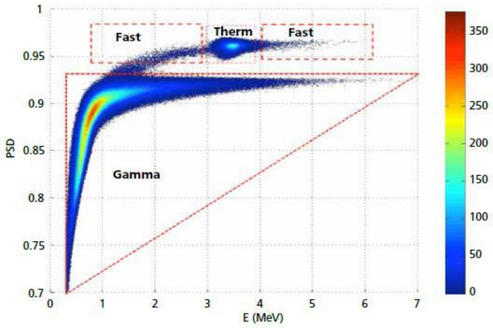
- Delivered through a combination of:
  - Defining technical system requirements
  - Identification of suitable detection technologies
  - Identification of analysis techniques to enhance decision making for end users
  - Engagement with Industry and Academia with expertise in relevant areas
  - Collaboration with US partners

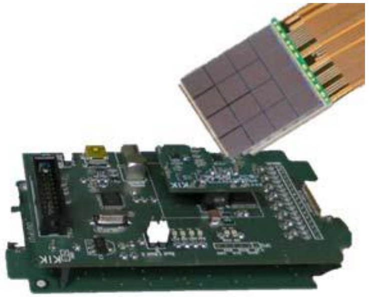


Underpinning research

- Underpinning research is key in enabling AWE to maintain expertise in the area of radiation detection as technology moves on.

- Through this underpinning research we hope to:
  - Evaluate the potential benefits and consequences of new developments for a wide range of applications
  - Steer new technologies towards providing solutions to existing problems





Future of Neutron Detection

How do we ensure that we stimulate and fully exploit developments in neutron detector technologies and techniques to benefit the user community and enhance nuclear security?

- Doing more with what we have
- Challenges beyond the detector
- Testing, evidence and IP

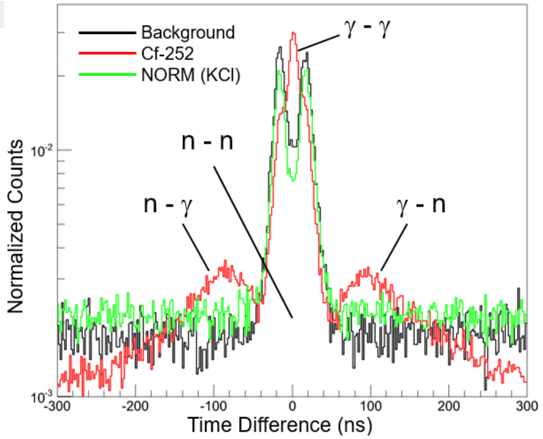
Doing more with what we have

- Gross counting systems are most common
- Measurements of other physical properties may add value
  - Time
  - Energy
  - Multiplication
  - Localisation
- Utilisation of these properties may significantly impact detector material requirements

Communication of end goal and requirements is key in ensuring suitability of detectors.

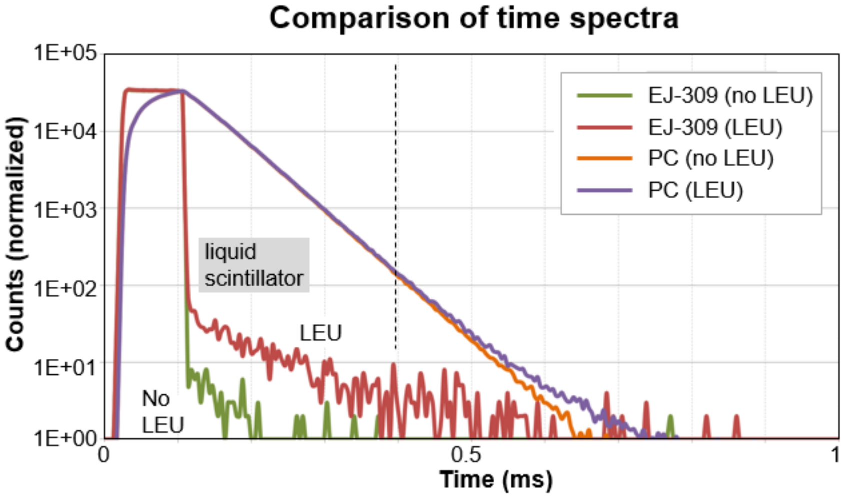
Advanced techniques may allow progress where improvements from detector efficiency stalls.

Passive Demonstrator



Time difference between correlated events measured on two PVT portals separated by 5m

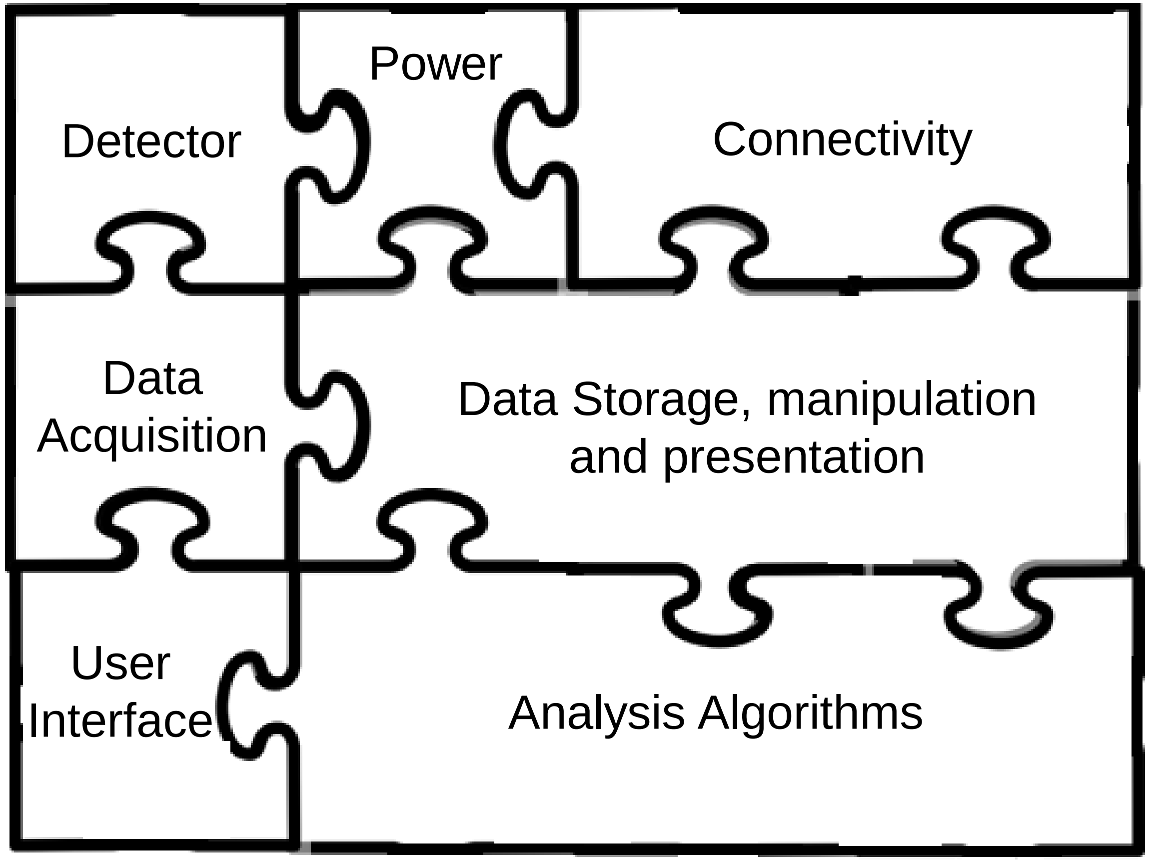
Active Demonstrator



^{3}He (PC) vs Liquid scintillator for differential die-away measurements with DT generator

Challenges Beyond Radiation Detection

- Radiation detection elements are only one part of the picture
- Radiation detection problem solved by comparing known detector properties against performance criteria dictated by the system requirements
- Many other aspects of radiation detection equipment may be improved by looking to draw on expertise from other industries.



Academic and industrial engagement beyond our native areas of expertise is vital for delivering complete, modern solutions

Testing, evidence and IP

- ‘Black box’ test regimes usually required to address IP matters

- NTR presents an increased challenge in this respect compared to product realisation in traditional Safeguards (IAEA / EURATOM inspection regimes)
  - Effort weighted on design of test plan; detailed, comprehensive (but could be unknowingly deficient)
  - Associated cost and material burden
  - Risk that aspects of performance remain undisclosed

- These activities are costly (time and money) and limit out ability to understand whether a technology/technique/system satisfies our customers’ requirements

Engagement and provision of high quality, evidence based performance assessments are key

Summary

- Neutron detection is important nuclear security applications

- Nuclear security applications cover a wide problem space

- AWE’s role is to:
    - Maintain expertise in emerging technologies
    - Understand and identify where technologies show promise
    - Enable the development of solutions to current and future applications
    - Technically assess technologies/systems against radiation detection requirements

- This can be achieved by strong engagement with academia and industry