Chapter 11
Active Interrogation Testing Standards

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Abstract Active interrogation systems for cargo inspection are designed to automatically determine the presence of special nuclear material (SNM) in transport by observing the radiation emitted by an object when exposed to an external radiation source. Active interrogation systems are contrasted with passive detection systems, such as radiation portal monitor systems, that detect the neutron and gamma radiation spontaneously emitted by SNM. Operational limitations to not interfere with commerce can restrict the use any interdiction system, including passive detection, active-interrogation and imaging systems. Because of their cost and complexity, active interrogation systems are intended for applications where SNM may be in shielded configurations that may not normally be detectable by passive systems. Active interrogation systems range from those that only indicate the presence of high-Z materials, to fissionable material detection, to those that detect specific SNM materials. The decision to deploy an AI system will depend on its ability to meet standards and specifications, its effectiveness, and its ability to fit into the operational environment. To ensure AI systems are designed and tested to a consistent level, minimum performance standards have been developed for evaluating these systems. Development of an active interrogation system that has the sensitivity to SNM that is needed while also being deployable is a challenge. It is the aim of standards to define a set of tests that can be performed on a system in an economic manner while challenging the capability of the system.

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11.1 Introduction

Active interrogation refers to techniques that use an external source of radiation to induce an interaction with or excitation of the material of interest and detect any resulting outgoing radiation signature, noting that the type of ingoing and outgoing radiation may be different. AI systems for cargo inspection are designed to automatically determine the presence of SNM in transport (e.g., an intermodal cargo container) by observing the radiation emitted by an object when exposed to an external radiation source.[1] The term SNM includes plutonium, especially ^{239}Pu, or uranium enriched in the isotopes ^{233}U or ^{235}U. The term highly enriched uranium (HEU) refers to uranium enriched to contain more than 20% ^{235}U. Active interrogation systems are contrasted with passive detection systems, such as radiation portal monitor (RPM) systems, that detect the neutron and gamma radiation spontaneously emitted by SNM. There are over 3000 such passive RPM systems deployed worldwide for interdiction applications since they are inexpensive, robust and effective for many interdiction scenarios. Passive detection systems are often paired with imaging systems that can detect contraband and shielding material that could be used to attempt to hide SNM. Operational limitations to not interfere with commerce can restrict the use of any interdiction system, including passive detection and imaging systems.

Because of their cost and complexity, AI systems are intended for applications where SNM may be in shielded configurations that may not normally be detectable by passive systems. Active interrogation systems range from those that only indicate the presence of high-Z materials, to fissionable material detection, to those that detect specific SNM materials [1]. These inspection systems use photon or neutron interrogating beams, where outgoing photons and/or neutrons are detected. Radiography systems that produce images of cargo may complement the capabilities of AI and passive systems. Cosmic-ray muon based systems, where muon scattering is detected, can be used for SNM detection, and may be considered active though no external man-made interrogating beam is used.

A convenient method to categorize AI systems is to consider the interrogation particle (photon, neutron or muon) and the detected particle (photon, neutron, or muon). For example, a technology that exploits photofission may use a photon source as the interrogation beam with the intent to induce fission in the object and to examine either outgoing photon or neutron signatures to identify material as SNM. Further categorization is possible by subdividing the observed particles as either prompt or delayed (Chap. 2). These distinctions are important when considering materials for use in testing and shielding material since SNM is often not available and very difficult to manage for testing.

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[1] While AI systems are also used for other contraband detection, the focus here is only on standards for SNM detection.

An AI system should also localize any detected suspect material. The localization requirement is meant to aid follow-on interdiction efforts. This localization is thus at a coarser resolution than is tested by image-quality metrics in other standards (e.g., standards for imaging systems [2]). It is possible that an AI system is part of a cascade or linear grouping of subsystems in which an early step is the rapid determination of a suspect region of a container, with a follow-on step to determine if SNM is present in the suspect region. All of these considerations are applied to the development of standardized testing requirements for AI systems. The decision to deploy an AI system will depend on its ability to meet standards and specifications, its effectiveness, and its ability to fit into the operational environment. To ensure AI systems are designed and tested to a consistent level, performance standards have been developed for evaluating these systems. Standards typically provide a minimal set of requirements for acceptance.

11.2 Specific AI Systems

Specific realizations of AI systems based on probing and detected radiation have been demonstrated, though none are currently deployed. These AI systems are generally differentiated from non-intrusive inspection systems (single or dual-energy) that produce only radiography images. There are many categories of AI systems based on the interrogating particle (photon, neutron, or muon), the detected particle (photon, neutron, or muon), whether detection is of prompt or delayed particles, and the nature of the physics process being observed [1]. However, only a limited number of AI systems have been implemented. The AI systems, categorized by physics process, considered for standard based testing are:

- *High-Z* detection involves systems that utilize photons of one or more endpoint energies to interrogate cargo, generally associated with radiography. The material can be differentiated based on its atomic number through absorption and/or backscatter detection of photons. Such systems can localize the presence of high atomic number (Z) materials.
- *Photofission (PF)* is the process of photon-induced fission of fissionable material, followed by the detection of the resulting prompt or delayed fast-neutron or delayed photon signature.
- *Nuclear resonance fluorescence (NRF)* is based on the resonant nuclear absorption and reemission of photons, where the resonant energy for the photons is indicative of each specific nuclide. The NRF method can be applied to detection of various types of contraband, including SNM.
- *Differential die-away (DDA)* uses a pulsed neutron interrogation source directed into inspected cargo. The neutrons are thermalized and absorbed, decaying with a time constant on the order of hundreds of microseconds. If fissile material is present, the thermalized neutrons from the source cause fissions that produce a new, delayed source of fast neutrons.

- *Muon scattering* systems rely upon the high-energy cosmic ray muons that are naturally present impinging on a transport. The muons undergo scattering within any material, with much larger angle scattering occurring for high-Z materials, such as SNM.

Active interrogation systems also vary depending on the type of object to be scanned and the scanning geometry. Different test configurations and procedures may be required for different geometries. Scanning geometries include:

- *Portals*, in which the object that is scanned while driven or pulled through a stationary measurement device;
- *Gantries*, where the measuring device either moves past the object under interrogation or is large enough to fully enclose the object and the object remains stationary;
- Steerable *Point-and-shoot beam* directed at a region of the object under interrogation. This category might be usable for objects too large for a portal or gantry.

Developing standards for testing of AI systems is challenging because of this variety of modalities and input and output particles is so varied. However, one common theme among testing standards is that any AI system must meet the same minimum detection criteria in order to be included for acceptance as a system for consideration.

11.2.1 Targets

The targeted mass of SNM for detection is the most crucial specification of an AI standard. The targeted mass needs to be small enough that any and all threat quantities of serious impact can be detected. Physics can limit the ability to detect very small, shielded masses, so the mass must be large enough to detect in meaningful scenarios. Any mass of SNM can be shielded from passive or active detection with a large enough shield. However, such a shield itself can be detected with imaging technology, so there is some range of shielding size that may not be obvious, but would be sufficient to shield some useful mass of SNM. The AI systems that are considered in standards development need to be sensitive to the size, material composition, and, to some extent, the shape of the test objects. Test objects that have been developed for passive-inspection systems focus on radioactivity and spectral features. It is this difference that drives the need for unique test objects for AI systems. For AI systems used to exploit signatures of SNM, the cross section of the test item that is presented to the beam, the elemental composition, and sometimes the isotopic composition of the test item impact the magnitude of the signature.

Table 11.1 lists some possible target quantities of SNM. Target masses of SNM could be the DOE quantities [3] "sufficient for a nuclear explosive device", the

Table 11.1 Potential SNM targeted masses

Agency	HEU mass	^{239}Pu mass
DOE: sufficient for a nuclear explosive device [3]	25 kg HEU	4 kg ^{239}Pu
IAEA: Significant quantity [4]	25 kg HEU with >20% ^{235}U	8 kg ^{239}Pu
IAEA: Category 1 [4]	5 kg HEU with >20% ^{235}U	2 kg ^{239}Pu

International Atomic Energy Agency (IAEA) "Significant Quantity," or the IAEA "Category 1" quantities [4]. The absolute minimum level of performance for all AI systems should be better than the IAEA "Significant Quantities" of SNM [4]. Even better would be the IAEA Category 1 values as the target for detection by an AI system.

Plutonium and HEU are both fissile materials and, thus, most AI systems are approximately equally sensitive to equal masses of these materials. Therefore, it may be possible to pick the lesser of the masses of SNM as the targeted threat quantity to be the goal for detection by AI systems.

Since handling of large masses of SNM can be problematic for testing, surrogates are usually defined that replace the SNM for testing purposes in standards. Surrogates may be fissile materials like low enriched uranium (LEU), defined as uranium enriched to less than 20% ^{235}U, fissionable materials like depleted uranium (DU) with less than the 0.7% enrichment of natural uranium, or simply high atomic number materials like Pb or W for systems that only detect the presence of high-Z materials.

11.3 Testing of AI Systems

Testing involves target materials to verify the detection capability, false-alarm items to assure that the system can discriminate target materials from other materials that might appear in commerce, and shielding and/or cargo scenarios to evaluate performance in likely scenarios to be encountered during deployment. Standards specify the conditions under which measurements are to be made, and the specific tests to be performed. Standards usually try to minimize the number and complexity of tests in order to allow the tests to be performed in an economical manner without going to extraordinary steps. Thus, surrogates are used instead of actual materials; shielding scenarios are kept simple and limited to a few typical cases; and the number of repeated measurements may be kept small, which limits the statistical significance of measurements. The overall goal is to provide a minimal, but meaningful, set of requirements that must be met by systems that aspire to be used in homeland security applications. Shielding of the input and/or output radiation, either by design or due to the presence of cargo, will affect AI system performance. In some AI implementations, shielding and matrix material (cargo) are used to create a secondary source of interrogating radiation (e.g., thermalization of fast neutrons by hydrogenous material to increase the cross section of an interrogating neutron beam). Thus, some form of shielding and surrogate-cargo is needed for testing AI systems. Testing has sometimes been done with a wide range of “cargo” configurations intended to simulate real world situations, but this is not usually done for standards since repeatability by independent testers is required of a standard and economy of testing is a consideration. Testing to standards is often performed at a facility, such as a national laboratory or commercial test organization, which has experience performing such tests. Since AI systems are so large and few will be built, standards testing may have to be performed on a site with limited access to target materials. This again means that standards need to use surrogate materials that do not require special handling, and a limited number of shielding or cargo scenarios.

11.4 Existing Related Standards

There is a need to develop performance requirements and test standards for AI systems that detect SNM in unshielded and shielded configurations within a container or conveyance. Previous American National Standards Institute (ANSI) standards [2, 5] and International Electrotechnical Commission (IEC) standards [6] have considered testing requirements for radiography and AI systems.

11.4.1 ANSI N42.41

The *American National Standard Minimum Performance Criteria for Active Interrogation Systems Used for Homeland Security* (ANSI N42.41) standard [5] was approved in 2008 with the following scope:

> “This standard specifies the operational and performance requirements for active interrogation systems for use in homeland security applications. These systems employ penetrating ionizing radiation (e.g., neutrons, high-energy x-rays, gamma-rays) to detect and identify hidden chemical, nuclear, and explosive agents by detection of stimulated secondary radiations or by nuclear resonance contrast, giving elemental and/or nuclidic identification of the composition of the substances-of-interest. These inspection systems may be designed for open inspection zones of various sizes or for various sizes of containers such as small packages, briefcases, suitcases, air cargo containers, passenger vehicles, two-axle trucks, intermodal cargo containers, semi-trailers/tractor rigs, or rail cars. The systems may be designed for operation in indoor, outdoor, or mobile facilities.”

This ANSI N42.41 standard thus has a broad reach in terms of the size of targets and transports considered (packages to containers), referred to as *container* *category*, and the range of materials to be identified (chemicals, explosives, and nuclear material). It includes neutron (fast and thermal) and high-energy photon interrogation in fixed, mobile and portable systems. Simulants (surrogates) for the targeted materials are defined because of the difficulty of handling actual target materials. For the SNM threat, LEU with 19.5% ^{235}U (surrogate for HEU) and tungsten carbide spherical shells (surrogate for Pu) are used as simulants. Inspection times of 90–900 s are defined, depending on the container category, with the longest times being for rail inspection. Four loading configurations are used for simulated cargo at specified densities, including bare, newsprint, aluminum and steel. Testing with a minimum of ten trials for each configuration is required.

The mass of the simulant for each container category is specified. For trucks and intermodal cargo container (IMCC) configurations, the targeted masses are 200 kg for explosives, 200 kg for chemical agents, 25 kg for fissionable material, and 16 kg for weapons shells. The target SNM value is currently considered to be too massive for large conveyance screening with AI systems, as discussed in the previous section.

In addition to these threat related specifications, like all ANSI standards, there are many additional requirements for environmental and electromagnetic effects. There are additional specifications for radiation exposure to workers and to stowaways. For unmonitored workers, the general public and stowaways, the radiation dose limit is no more than 100 mrem (1 mSv) per year.

11.4.2 ANSI N42.46

The *American National Standard for Determination of the Imaging Performance of X-Ray and Gamma-Ray Systems for Cargo and Vehicle Security Screening* (ANSI N42.46) standard [2] was approved in 2008 with the following scope:

> "This standard is intended to be used to determine the imaging performance of x-ray and gamma-ray systems utilized to inspect loaded or empty vehicles, including personal and commercial vehicles of any type; marine and air cargo containers of any size; railroad cars; and palletized or unpalletized cargo larger than 1 meter by 1 meter in cross-section."

This standard is not specific to active interrogation, though similar single or multiple energy photon sources are used. Both transmission and backscatter detection are included. The system requirements are primarily for imaging but these systems also may have complementary features such as material discrimination and automatic active or passive threat alerts. Such features include identification of high-Z elements, so the standard does overlap with the AI standards. The standard focuses on image quality, resolution and object localization.

11.4.3 IEC 62523

The IEC Radiation Protection Instrumentation—Cargo/Vehicle Radiographic Inspection System (IEC 62523) standard [6] was approved in 2010 with the following scope:

> "This international standard applies to radiographic inspection systems with photon radiation energy of at least 500 keV for inspection of cargo, vehicles and cargo containers. Such inspection systems generally consist of radiation source(s), detectors, control system, image processing system, radiation safety system and other auxiliary devices/facilities. The object of this standard is to define the tests and the relevant testing methods for determining the performance characteristics of the radiographic inspection systems. This standard is not applicable to those cargo/vehicle inspection systems using neutron source radiography, computed tomography or backscatter technology."

This standard is not specific to active interrogation, though similar single or multiple energy photon sources are used. Only transmission and detection is included. The standard focuses on image quality, resolution and object localization.

11.5 Development of an AI Technical Capability Standard

A Technical Capability Standard (TCS) is a government unique standard that establishes targeted performance requirements for radiation detection and non-intrusive imaging systems. The purpose of a TCS is to establish, where practical, requirements and applicable test methods that are based on threat-informed unclassified source materials and test configurations that are not addressed in consensus standards. Technical Capability Standards are developed by an inter-agency Technical Capability Standard Working Group, which includes representatives from the Department of Homeland Security Domestic Nuclear Detection Office (DNDO), National Institute of Standards and Technology (NIST), Customs and Border Protection (CBP), the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Federal Bureau of Investigation (FBI), Office of Assistant Secretary of Defense for Homeland Defense and America's Security Affairs, Defense Threat Reduction Agency (DTRA), and several national laboratories (Los Alamos National Laboratory, Oak Ridge National Laboratory, Savannah River National Laboratory, Sandia National Laboratories, and Pacific Northwest National Laboratory). The DNDO works within the consensus standards arena to ensure that future ANSI N42 series consensus standards reflect the capabilities described by the TCS benchmarks, where applicable.

The proposed Technical Capability Standard for Special Nuclear Materials Detection and Localization by Active Interrogation [7] (still under development in 2018) has the following scope:

> "This TCS establishes performance requirements for systems that detect special nuclear materials (SNM) in unshielded (bare) and shielded configurations within a container or conveyance using radiation from a source that is external to that container or conveyance,

> often referred to as active interrogation (AI). This TCS includes a test against a bare configuration of SNM to verify system functionality. Systems considered in this TCS include those that detect high atomic number (High-Z) materials, fissionable materials, or specific special nuclear materials. These systems automatically evaluate signatures generated by the interaction of the interrogating radiation with the material in the container under interrogation to determine the presence of SNM. This TCS applies to systems that can provide automated detection (i.e., not requiring human interpretation) and localization of SNM. The required localization accuracy is intended to assist in physical inspection, if deemed safe, in accordance with the end-users' respective safety protocols, manuals, guidelines, and/or directives. This TCS applies to systems that inspect large conveyances such as cargo containers or truck-borne cargo using an external source of radiation."

The specific instantiations of AI systems considered in the TCS are photofission, nuclear resonance fluorescence, differential die-away, and High-Z detection. These systems are to be tested independently of any other systems (e.g., passive detection or radiography). A group of system-dependent surrogate test objects (cylinders or spheres of DU or HEU) sufficient for use when testing using the TCS was determined. Radiation transport modeling was used extensively to explore the detection capabilities of each of these AI approaches and to determine the specific surrogates for each detection modality.

These test objects are sufficient surrogates for SNM for the purposes of this testing for AI systems considered in the TCS. However, in order to minimize the number of different DU surrogate masses, the difference in the strength of the signature between SNM and the surrogate material requires the use of lead attenuators to achieve comparable signal strengths depending on the interrogation modality and cargo configuration for some approaches. Each lead attenuator is a uniform shell of lead surrounding the DU surrogate, which vary in thickness depending on the AI modality. Testing is performed with the surrogates and appropriate lead shielding for ten trials, and requires ten out of ten detections. Cargo may also shield the interrogation and resultant signature radiation. While the complexity of heterogeneous cargo may allow streaming paths for radiation, it is not the intent of this TCS to test cargo complexity. Instead, only two uniform "cargo" distributions, one of mild steel and one of high-density polyethylene (HDPE) as a substitute for wood, are used, configured as shown schematically in Fig. 11.1.

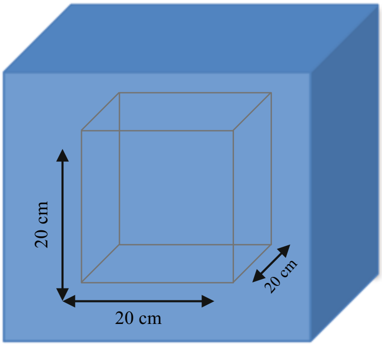

Fig. 11.1 Configuration of "cargo" for testing of surrogates and false-alarm items. The cube has an access cover, allowing for placement of the test object inside. The dimensions shown are nominal

The density of HDPE and mild steel are approximately 0.96 and 7.86 g/cm^3, respectively. This “cargo” is configured as a cube that can be located within an intermodal cargo container for testing. Testing is performed with the surrogates with the appropriate lead shielding in each of the cargo configurations for ten trials.

In addition to the SNM surrogates, systems are also tested with “false-alarm” objects that vary by AI modality. False-alarm items include W and Pb, which are high-Z materials that can be confused with threat objects in AI systems that are not specific to SNM. Materials such as heavy water and Be can cause large numbers of neutrons that can be mistaken for fissile material in neutron detection modalities. Some systems should not respond to these false-alarm objects, and the test is to verify such non-response. Some systems will respond to these false-alarm objects because they do not have the discrimination capability to separate threats from the false-alarm objects. Tests with these false-alarm items evaluate system performance with respect to these materials. The testing with false-alarm items follows the same testing approach as the SNM surrogates.

11.6 Modeling of AI Modalities

In the development of a standard for AI systems, an analytical approach was used to predict AI system response to targeted SNM, but further analysis was required for PF and DDA approaches. In order to determine the response of the various DDA and PF modalities to SNM, surrogates, cargo, and false-alarm items, extensive computer simulation was performed using GEANT4 [8], MCNP6 [9] and MCNPX [10].

11.6.1 Differential Die-Away Models

For DDA, an intense pulsed neutron beam is used as the interrogation source, and the resulting time-dependent neutron signal is observed. The approach to modeling DDA was validated against measurements discussed in references [11] and [12]. In the measurements, a sample of LEU enriched to 19.5% was placed in three locations within a cube of copy paper. The neutron source was a deuterium-tritium neutron generator capable of delivering 10^8 n/s with a 3-ms cycle starting with a 250-µs pulse of neutrons. The epithermal neutron detector was positioned in-line with the center of the beam and referenced as having a measured 23 µs thermal die-away time. Figure 11.2 shows a comparison of measurements from reference [12] and simulations for three different measured target positions, as well as a target-free background measurement.

The experimental and modeled signal shows the characteristic long decay time (relative to no target) of a DDA measurement. There is good agreement between the simulations and data for all measurements, except for the background measurement,

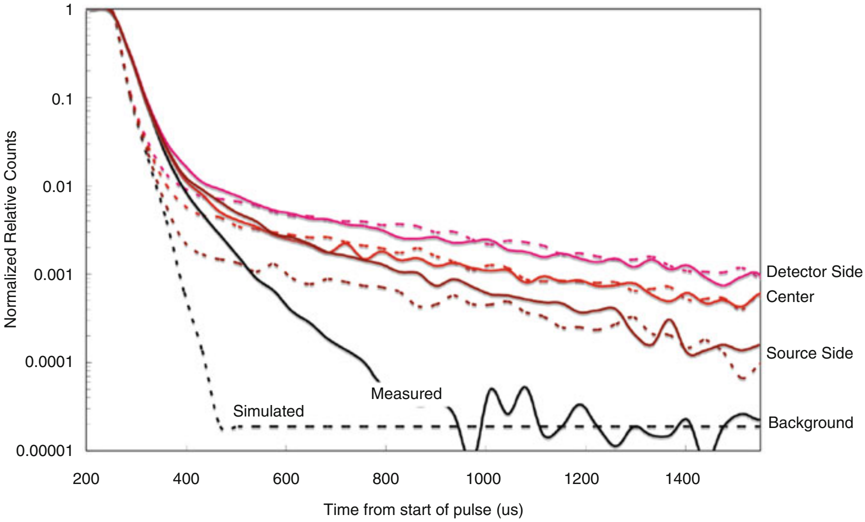

Fig. 11.2 Comparison of modeling results for benchmark measurement, as reported in [12]. The solid lines are the measurements and dashed lines the simulations

where the model did not include all elements of the room scatter. This benchmark model was used to validate the MCNP evaluation methods against the published results, and to define DDA performance metrics to be used for comparison of different surrogate targets.

There are many ways to record results from radiation transport modeling, called *tallies* in MCNP. All tally values in MCNP are normalized per starting particle, and in that sense can be considered as *efficiencies.* Three different types of tallies were used in this work: particle current, volume-averaged particle flux, and total capture efficiency. Of these tallies, the particle current is the least dependent upon on the details of the detection system, easiest to interpret and most computationally efficient. To use the particle currents in DDA analysis, one must demonstrate that the particle currents behave in a similar manner as the observed detector response. This validation was performed, and it was found that the neutron currents at the detectors for neutrons with kinetic energies greater than 0.5 eV provide an accurate analog to the rate of neutrons detected in a DDA measurement. As a result, these currents were used to evaluate the DDA surrogates. It was also shown that using a cylindrical neutron beam, rather than a more realistic isotropic neutron beam, improves computational performance without impacting the reliability of the results. For DDA, the surroundings can significantly impact the measurement, so a higher fidelity geometry (compared to photofission modeling) is appropriate.

The geometry for the DDA surrogate evaluation used a validated model of a 6.1 m (20-ft) IMCC mounted on a standard steel chassis, as seen in Fig. 11.3. The targets and shielding materials were centered 1 m above the floor of the IMCC and were pulsed with a 15-cm diameter circular beam of 14-MeV neutrons. The beam

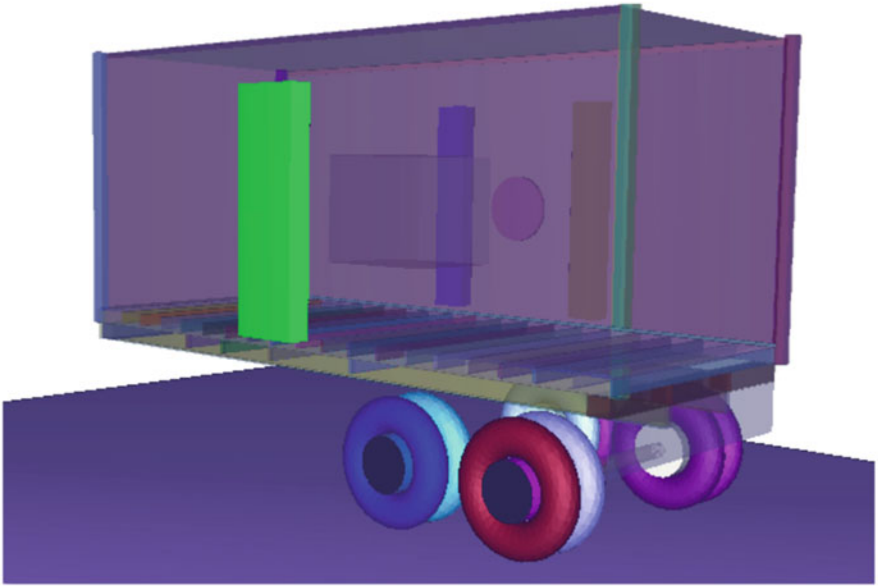

Fig. 11.3 Projection of DDA Cargo Model used for surrogate evaluations. The in-beam detector volume is the green box. The neutron source is shown as the magenta disk behind the IMCC.Two off-beam detectors are on either side of the source disk. The cargo is the gray box floating in the middle of the IMCC

was directed perpendicular to one side of the IMCC, and the currents were tallied entering an In-Beam detector on the opposite side of the IMCC and two Off-Beam detectors that straddle the beam port.

The results of the modeling effort indicate that the ideal mass of an LEU surrogate for DDA varies only slightly for each of the three cargo scenarios (bare, HDPE, and iron), which simplifies choosing an appropriate surrogate mass.

11.6.2 Photofission Models

For AI systems using photon beams, a bremsstrahlung beam such as the simulation shown in Fig. 11.4 was used. Such a photon source, extending to about 9 MeV maximum energy, is currently the only option for a high flux source. A high intensity monoenergetic photon source would be desirable, but not currently technologically feasible.

For PF, an interrogating photon beam of sufficient energy induces fission in SNM, and the observed signal can be prompt (within 1 µs of the photon striking that target material) neutrons (prompt gamma rays from photofission cannot be distinguished from the source photons scattered in the target through non-fission

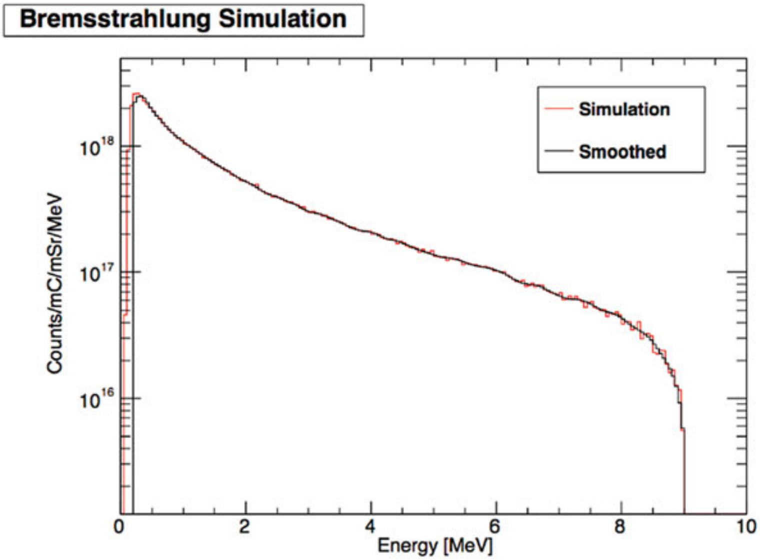

Fig. 11.4 Simulated bremsstrahlung photon energy distribution. The red line shows the spectrum as generated by the simulation and the black line is the smoothed spectrum

related processes), or delayed neutrons or gamma rays. The product particles can be binned in both energy ($E > 0.5\,\text{eV}$, $E > 1\,\text{MeV}$, $> 3\,\text{MeV}$) and the angle of their momentum with respect to the initial photon beam. A description of the photofission model used in MCNPX/MCNP6 is given in reference [13], along with associated photonuclear data and libraries.

Modeling showed that, for a DU-only surrogate to reasonably reproduce the SNM target rates in each of the test conditions (bare, HDPE cargo, Fe cargo), it would take up to nine different DU surrogates. A large number of DU surrogates would be difficult and expensive to manage operationally. Instead, modeling showed that only two different mass surrogates were required if various amounts of lead shielding was used around the DU to reduce the signal from the DU to the appropriate SNM signal being evaluated for the AI system under test.

Modeling was performed for SNM (HEU and Pu) targets in the three test conditions, and this was compared to model results for the DU surrogates in the same three test conditions, with various amounts of lead attenuator around the DU in order to match the SNM cases for each modality of the PF system. The ideal situation would be to have a unique lead attenuator for each of the neutron energy ranges and cargo loading scenarios. However, nine lead attenuators would be burdensome from an operational perspective without providing a significant benefit. Instead, modeling showed three different lead attenuators adequately span the range of attenuations necessary.

11.6.3 Conclusion

Development of an active interrogation system that has the sensitivity to SNM that is needed while also being deployable is a challenge. It is the aim of standards to define a set of tests that can be performed on a system in an economic manner while challenging the capability of the system.

Previous ANSI and IEC standards provide basic requirements, but do not require detection of the small target SNM masses that are meaningful when compared to masses of SNM that can produce potential harm. To justify the expense and operational impact that an AI system would have on a port-of-entry, the systems would have to be effective at detecting the demanding threat for which they are designed.

A Standard is being developed for AI systems in order to set specific requirements for detection of SNM across the differing capabilities of such systems. The purpose of the standard is to detail specific radiation detection requirements for a variety of AI systems using surrogate materials instead of SNM for testing. Both bare and shielded configurations were considered. Extensive modeling of the various AI modalities allowed for the definition of a limited number of surrogates to be used for testing.

The need now is to test specific AI implementations against the standards, which requires that one or more such systems be developed into a complete, robust system designed to meet the requirements of the standards that have been created.

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