IPNDV Working Group 3: Technical Challenges and Solutions
Special Nuclear Material (SNM) in a container - Monitoring Technologies Matrix
October 5, 2017

Technology	Information detected/determined	Key Limitations (Shielding issues, possible size restraints, etc.)	Approximate Measurement Time Scales	Equip Availability (TRL)/for Simple Scenario (TRL)	IB Needed (TRL?)	Comments	Related Technology Paper
Passive Gamma Detection	Instrument detects gamma radiation emitted that can be used to determine presence of Pu and Pu isotopics.	Vulnerable to significant external shielding. Requires homogenius isotopic composition.	30-60 minutes	Readily in use today (9) / For Dismantlement (7)	Yes (7)	Liquid nitrogen hazard, if used	NM2 - High Resolution Gamma-ray Spectrocopy (HRGS)
	Detection of U235	A small amout of shielding will block any potential signal of U235	days			NOT RECOMMENDED to use this method for detecting U235	NM2 - High Resolution Gamma-ray Spectrocopy (HRGS)
Passive Gamma-ray Imaging	Detects gamma radiation and can provide information as denoted under Passive Gamma Detection	Vulnerable to significant external shielding. Depends on how strong the source is.	30-60 minutes	Readily in use today (9) / For Dismantlement (7)	Yes (1)	Can be done in conjunction with location and/or shape analysis	NM3 - Gamma-ray Imaging
	Location of gamma-ray emitting object		several hours			takes longer to image than to do just gamma spectroscopy	NM3 - Gamma-ray Imaging
	Shape of gamma-ray emitting object		several hours			Possible mass approximation	NM3 - Gamma-ray Imaging
Nuclear Resonance Fluorescence	Isotopic composition of Pu and U	Can work with a large amount of shielding	Tens of minutes	Commercially available (9) / For Dismantlement (4)	Yes (1)	There will be a radiation safety concern. Relatively large physical footprint	HENM1 - Nuclear Resonance Fluorescence
Passive Neutron Counting	Detect total passive neutron emissions; presence of neutron source; could be used as a Pu or Pu/U absence measurement	Sensitive to amount of shielding. Does not tell what is the neutron source. Not likely to detect U source.	30 minutes or less	Readily in use today (9) / For Dismantlement (8)	Yes	Cannot discriminate between ^{240}Pu and other neutron sources	NM4 - Passive Neutron Counting
	Measuring neutron coincidence/ multiplicity will result in mass determination of ^{240}Pu	Dependent on the homogenatity of the source. However this is not a key limitation that will make the technique inapplicable especially in view of low accuracy required. Not likely to detect U source.	10-60 minutes	Readily in use today (9) / For Dismantlement (8)	Yes (7)	Used in conjunction with isotopic information or declaration of Pu239/Pu240 ratio to estimate total mass of Pu	NM4 - Passive Neutron Counting
	Measuring multiplicity with triplets will result in mass determination of total ^{240}Pu	Dependent on the homogenatity of the source. However this is not a key limitation that will make the technique inapplicable especially in view of low accuracy required. Not likely to detect U source.	few hours	Readily in use today (9) / For Dismantlement (7)	Yes (7)	Used in conjunction with isotopic information or declaration of Pu239/Pu240 ratio to estimate total mass of Pu	NM4 - Passive Neutron Counting

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Active Neutron Techniques	Detect delayed neutron emissions in response to bombardment with neutrons; used to determine U and Pu presence	Unable to separate parameters such as mass, density, shape, fissile isotope(s). Geometry is important.	4 minutes (1 min irradiation + 3 min counting) to tens of minutes.	Readily in use today (9)	Yes	Cannot determine isotopics. Can determine the ratio between U and Pu.	NM6 - Active Neutron Interrogation
	Detect prompt neutron emissions simultanuously with neutron beam excitation; used to determine U233, U235 and Pu239 presence	Unable to separate parameters such as mass, density, shape, fissile isotope(s). Geometry is important. Closer distances between source and NED are better.	few minutes	Readily in use today (9)/ For Dismantlement (6)	Yes	Technology has been proven in laboratory conditions; deployment for disarmament may introduce challenges.	NM6 - Active Neutron Interrogation
	Detect prompt/ or delayed gamma emissions simultanuously with/or following neutron activation; can be used to determine presence of U and U isotopics	Sensitive to amount of shielding. Depends on neutron flux and spectrum	few minutes uo to 30 minutes	Readily in use today (9)/ For Dismantlement (6)	Yes	Technology has been proven in laboratory conditions; deployment for disarmament may introduce challenges. Detection of gamma emissions may be used to indicate presence of explosives (low TRL).	NM6 - Active Neutron Interrogation
	Detect prompt/or delayed gamma emissions simultanuously with/or following neutron activation; can be used to determine presence of Pu and Pu isotopics	Sensitive to amount of shielding. Depends on neutron flux and spectrum	few minutes uo to 30 minutes	Readily in use today (9)/ For Dismantlement (6)	Yes	Technology has been proven in laboratory conditions; deployment for disarmament may introduce challenges. Detection of gamma emissions may be used to indicate presence of explosives (low TRL).	NM6 - Active Neutron Interrogation
	PULSED NEUTRON: Detects time sequence of prompt fission neutrons in response to pulsed neutrons; used to determine presence of fissile U and Pu including differentiation between the two. The differentiation between U and Pu may not be very sensitive, and requires a different measurement regime.	Unable to separate parameters such as mass, density, shape, fissile isotope(s). The inability to separate parameters is a strong point of the method and not a limitation. Large neutron shield is not a problem, but will only slow-down the source neutrons further towards thermal energy.	The proposed measurement time is 600-1000 seconds	Laboratory measurements (4)	Yes (2)	Technology has been proven in near ideal laboratory conditions with modeling	NM5 - Pulsed Neutron Interrogation
Fast Neutron Imaging	Fast neutron emission imaging: images neutron emitters; possible location and shape of Pu	This technique is only practical for plutonium assay.	One to several hours	Laboratory maintained systems (6) / For dismantlement (3)	Yes (2)	Images are much less detailed than those produced by transmission imaging. Intended for imaging distributed sources or an array of sources from a distance.	NM7 - Fast Neutron Imaging
	Fast neutron transmission imaging: active imaging technique from bombaring with fast neutrons; imaging of material without compositional detail	Although all materials can be imaged with this technique, it cannot identify specific materials, elements, or isotopes. Image contrast can be degraded when neutrons must penetrate a significant amount of low-Z material.	Ten minutes to several hours	Laboratory maintained systems (6) / For dismantlement (3)	Yes (2)	Measurement times are strongly dependent upon the size of the imaged object and desired feature(s) to measure. May be used ot verify that an item's internal geometry has changed when appropriate.	NM7 - Fast Neutron Imaging
	Stimulated emission imaging: imaging of induced neutron emissions of an item by bombarding with neutrons; location and shape of SNM	This technique can be used to assay uranium in the presence of plutonium or other neutron emitter, but the characterization may be more challenging. Low-Z materials significantly degrade the image quality.	Ten minutes to several hours	Laboratory maintained systems (6) / For dismantlement (3)	Yes (2)	Particularly useful for U. Measurement times are strongly dependent upon the size of the imaged object.	NM7 - Fast Neutron Imaging

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Muon Tomography	Imaging of muons, which are preferentially scattered by heavier elements	Muon tomography does not have the sensitivity to identify the exact mass. Depleted U cannot be distinguished from HEU or Pu.	20 minutes to several hours	Commercial systems available (9) / Laboratory measurements (4)	Yes (1), if measurements provide high resolution image	Useful for relative density imaging; possible verification of presence of high density material in container. Does not require an additional source.	NM8 - Muon Tomography
Radiation Templates	Data set of radiation signatures from NED components; provides unique set of signatures used to provide confirmatory verification of an inspectable item against a "trusted" item's data set	Template matching needs to account for time difference between initial template and next measurement. Method is geometry and background dependent.	several minutes	Demonstration completed (7)	Yes (7)	Not necessarily a measurement instrument but used in conjunction with a measurement instrument to enable comparision of a measurement with a known signature(s)	NM9 - Radiation Templates
Calorimetry	Measure of thermal power output of heat-producing nuclear materials; possibly used to confirm the presence of Pu or U if SNM separated into elements.	Cannot detect U in the presence of Pu. The calorimetry well needs to be correctly sized for the container.	hours	Readily in use today (9) / For Dismantlement (1)	Yes, for long measurement times	With isotopic information can be used to determine mass of Pu	NM1 - Calorimetry