



Alarm Interdiction and Adjudication

Techniques for searching a person, truck or cargo container and acquiring quality spectral data with Radioisotope Identifiers



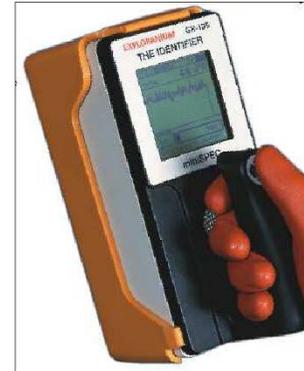
Objectives



- Low Resolution ID Systems
- High and Low Resolution Spectra
- RIID Accuracy
- Factors which Effect Spectra Quality
- Search/ID Concept of Operations
- Alarm Interdiction and Adjudication Checklist
- Radiation Alarm Log
- DOE Triage Checklist
- Unusual Signatures



Low Resolution ID Systems



Examples of several commercial low resolution **Radi**Isotope **ID**entifiers (**RIID**). Most use sodium iodide detectors for gamma ray detection and some contain a small neutron detector

Typical sodium iodide detector size – 3.8 cm x 5 cm (1.5 in x 2 in)

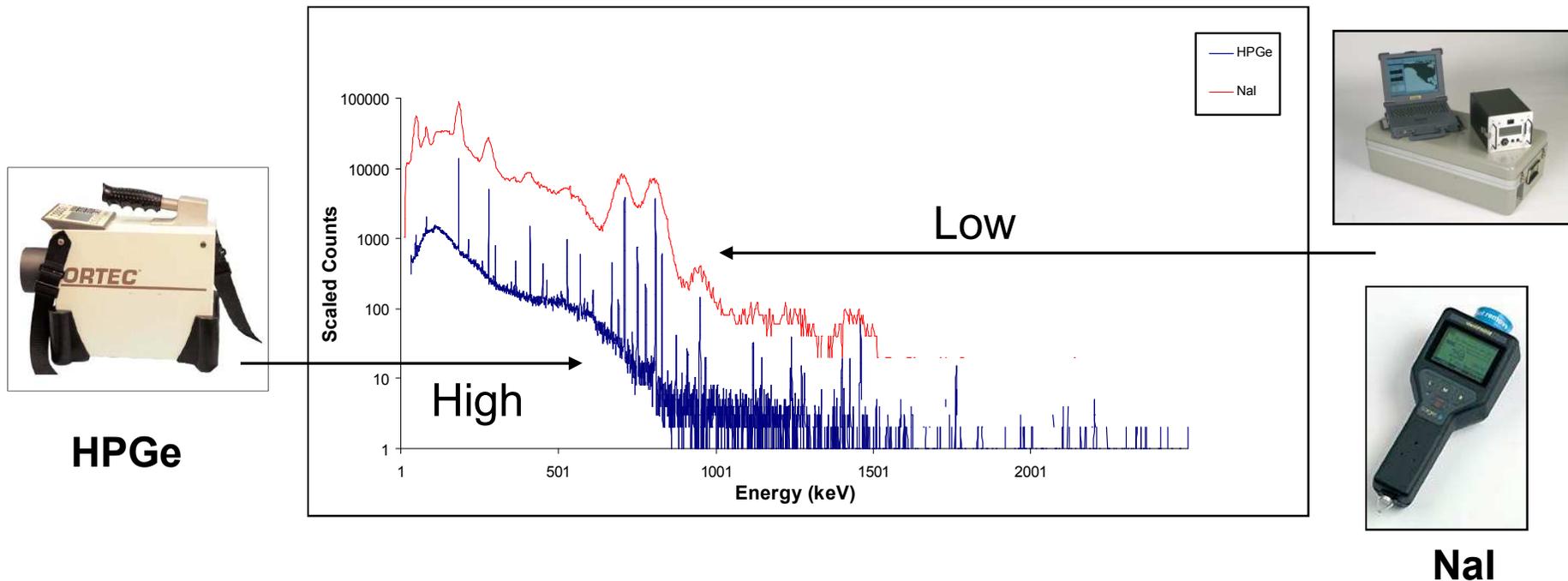
Typical neutron detector size – small cylinder or tube



High vs Low Resolution Spectra



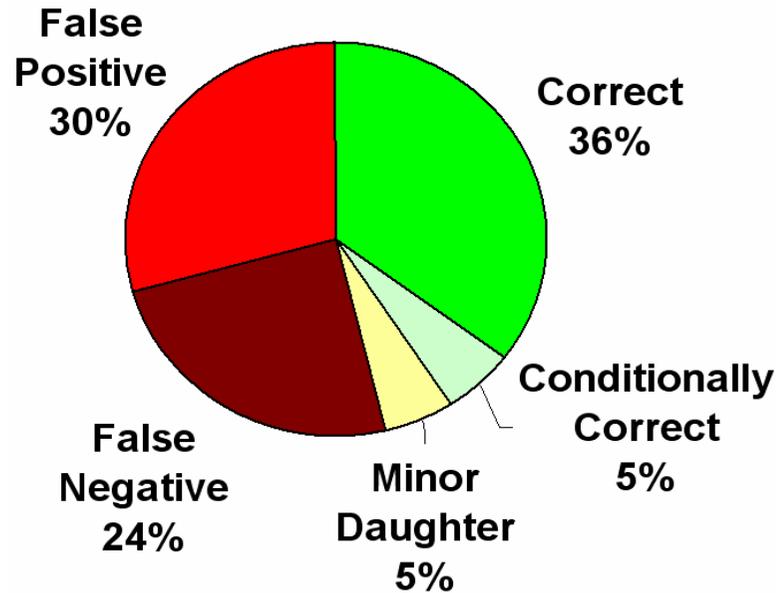
Use identification instrumentation to identify the radioisotope



Comparison of a sodium iodide spectrum (low resolution) to a high purity germanium spectrum (high resolution)



RIID Accuracy



15 models tested
1827 results



- RIIDs often misidentify
- Analysts more accurate
- Vendors continue to improve tools

Proper use of the RIID can greatly enhance the ability to correctly identify the radioactive material, especially for single sources.



Factors which can effect spectra quality

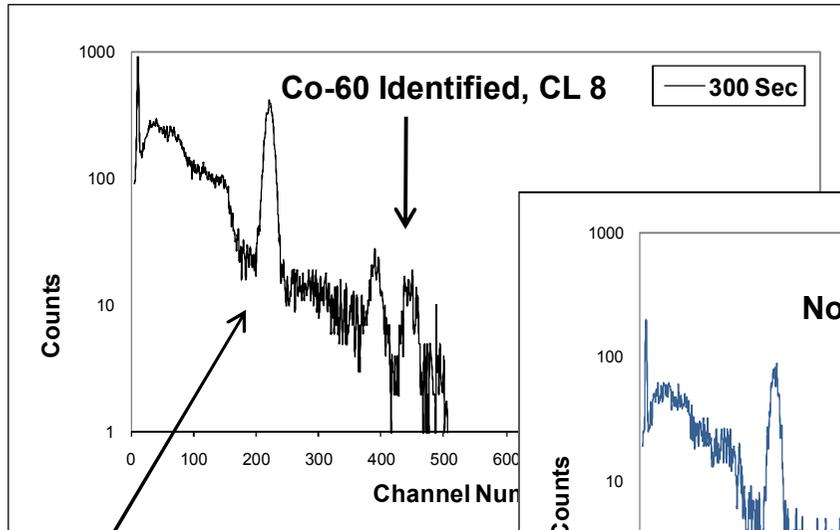


1. Count time - longer count times provide better statistics
2. Dead time - keep dead time low for best peak shape definition
3. Temperature changes – can cause the calibration to change

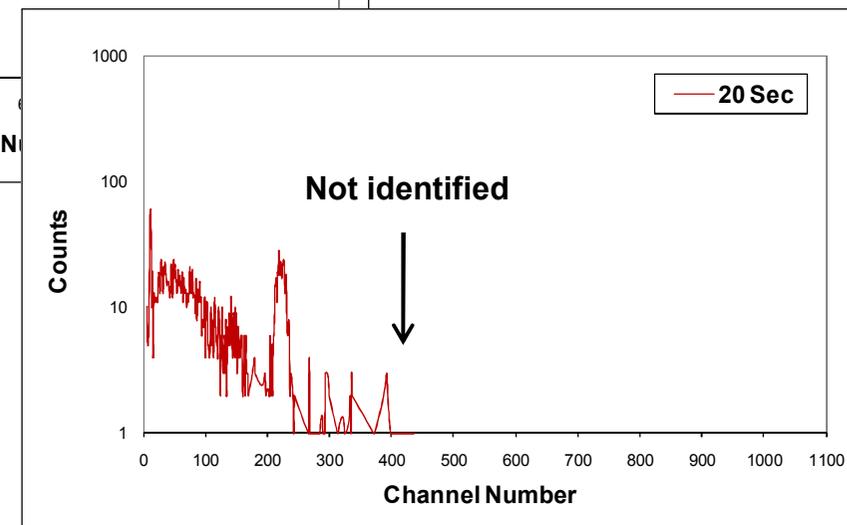
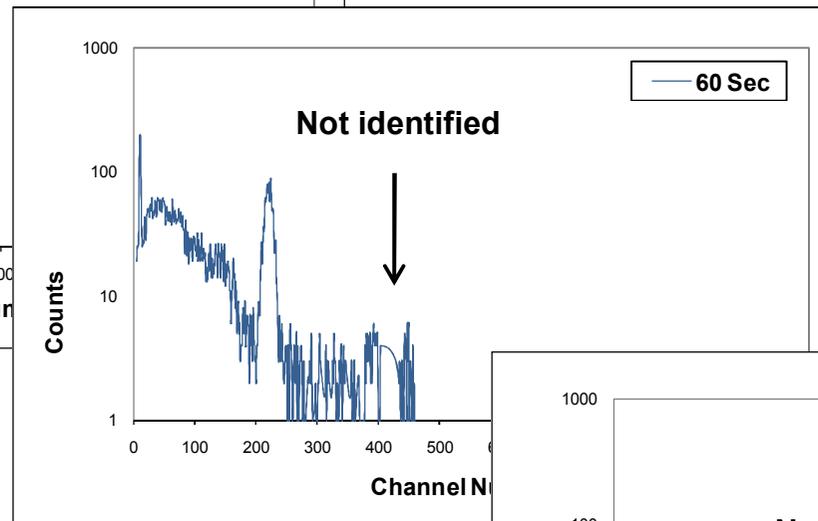


Co-60

Effect of Count Time



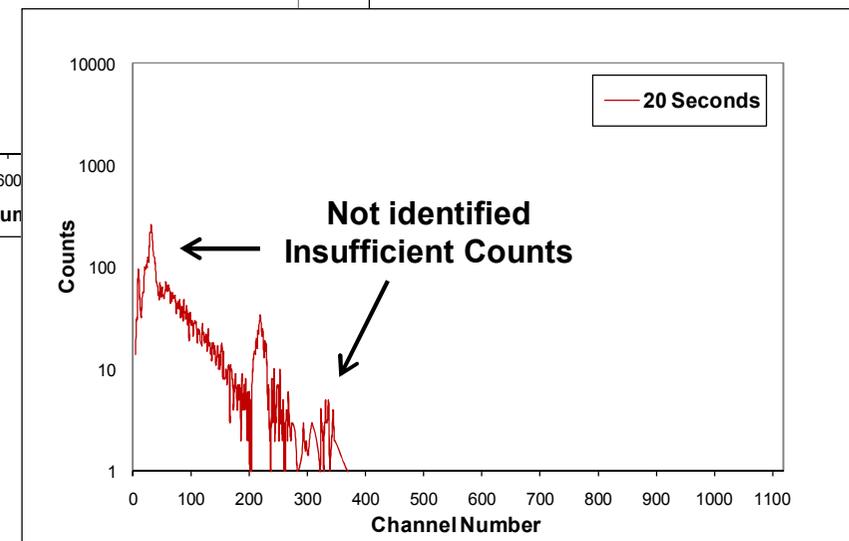
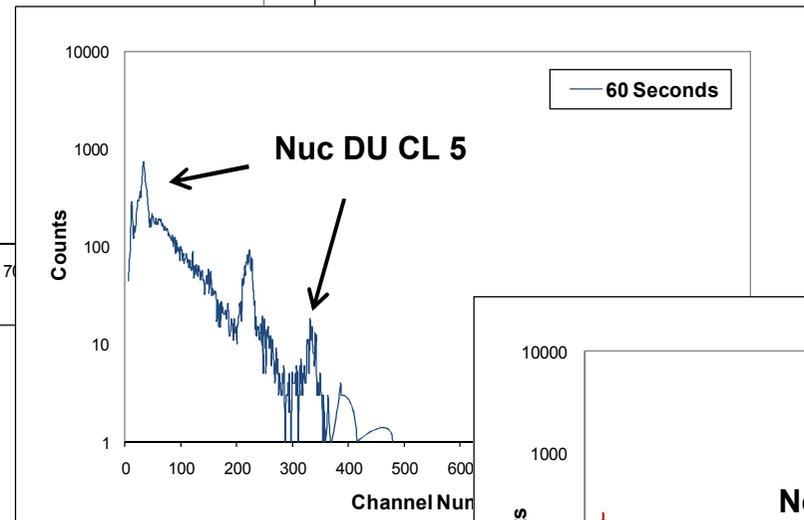
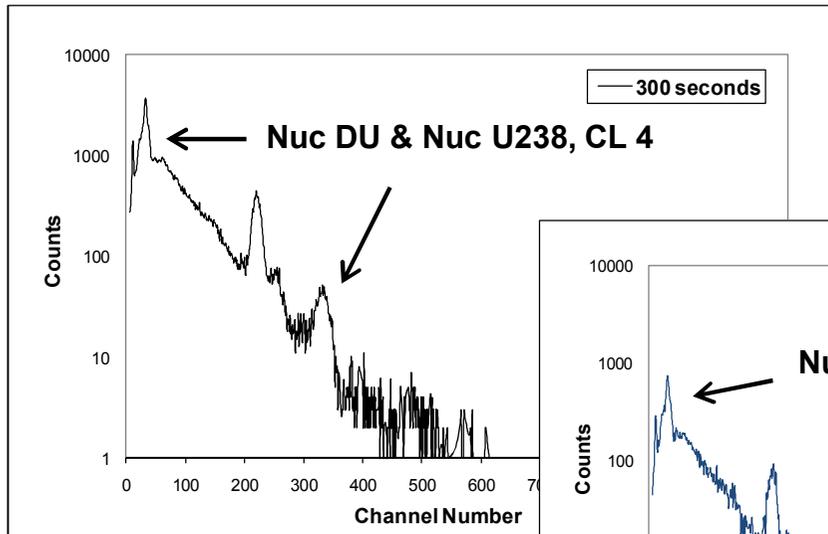
Cs-137 peak from internal calibration source



Cobalt-60 has two distinct gammas at 1173 and 1332 keV, longer count times provide the best definition of peak shapes



Depleted Uranium (DU) Effect of Count Time

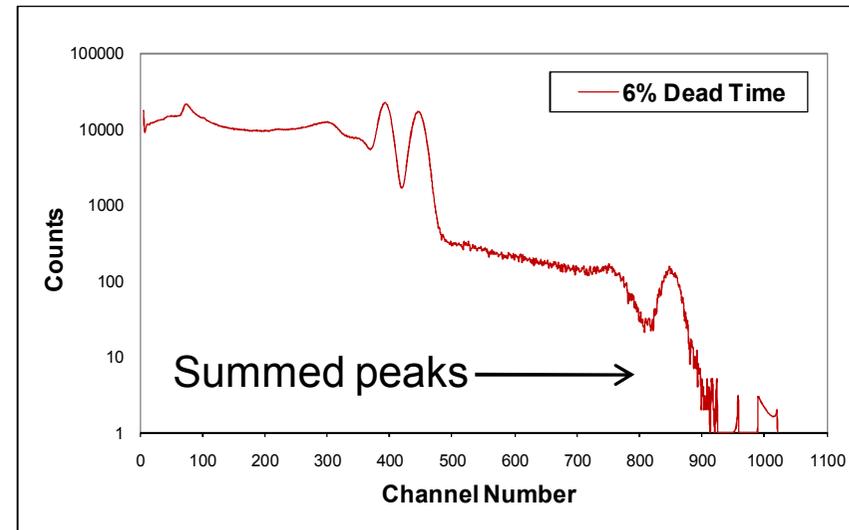
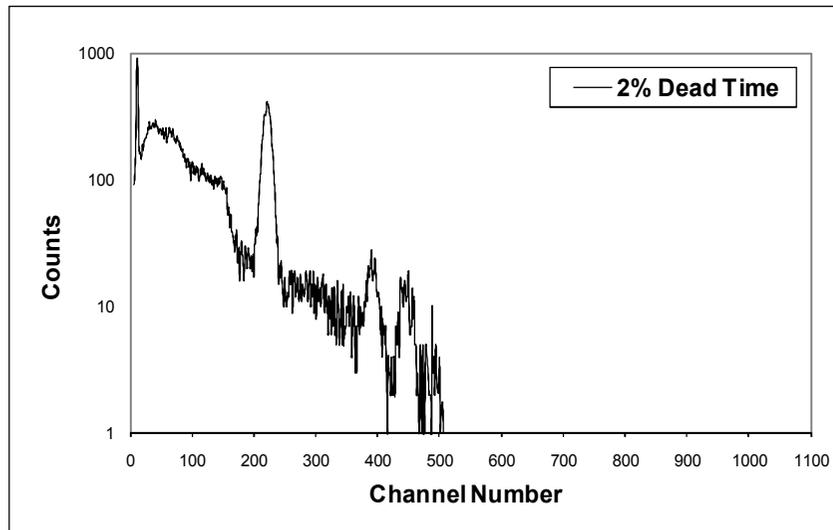


Uranium spectra can look like elevated background (i.e. natural U-238). Key indicators are enhanced low energy uranium x-rays and the 760 and 1001 keV gammas from Pa-234m, a decay product of U-238



Co-60

Effect of Dead Time



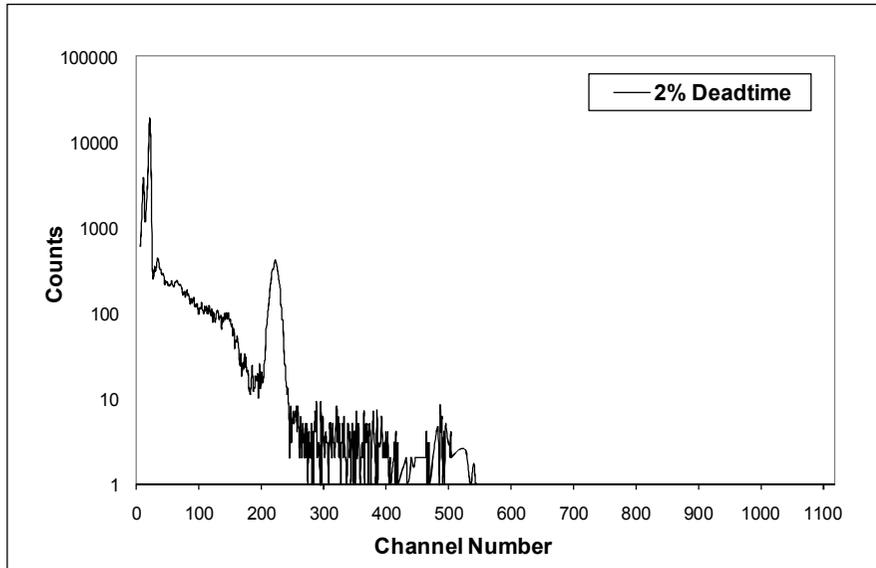
What is Dead Time? Dead time is the time in which the detector electronics cannot process the incoming data correctly. This results in a distorted spectrum with broadened peaks and electronic pile-up producing artificial summed peaks.

Keep dead time less than 5% by moving away from source

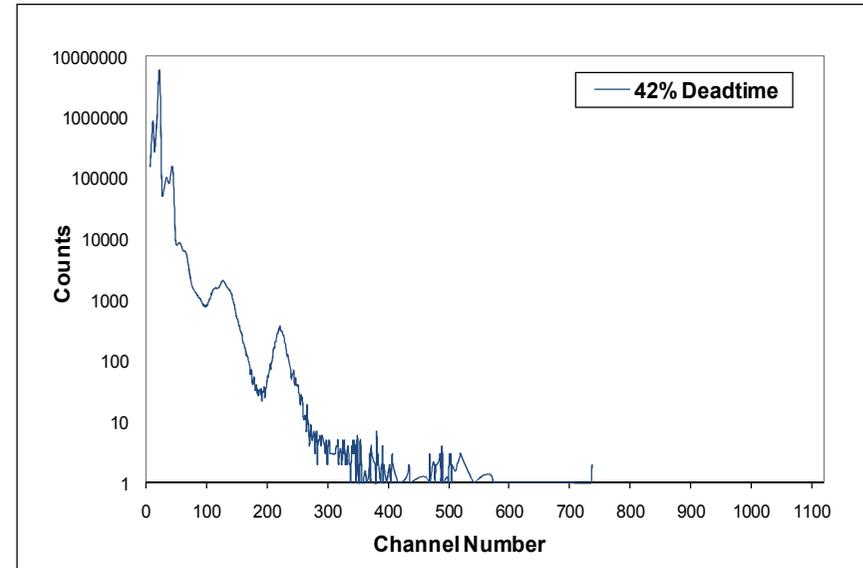


Pu-239

Effect of Dead Time



Correct identification



Mis-identification

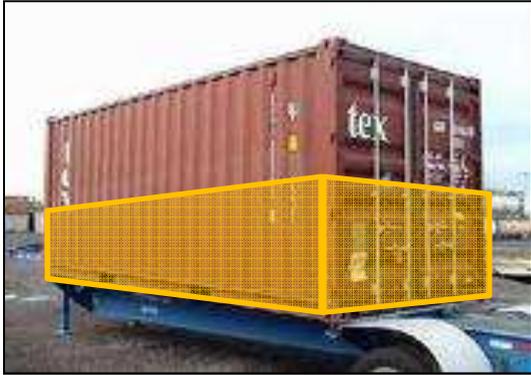
Spectrum on left is properly identified with low dead time.
Spectrum on right is distorted due to high dead time and results in mis-identification.

The Pu-239 spectrum on the right with 42% dead time identified the source as
Co-57 CL 4 and Medical TI-201



NORM Radiation Fields

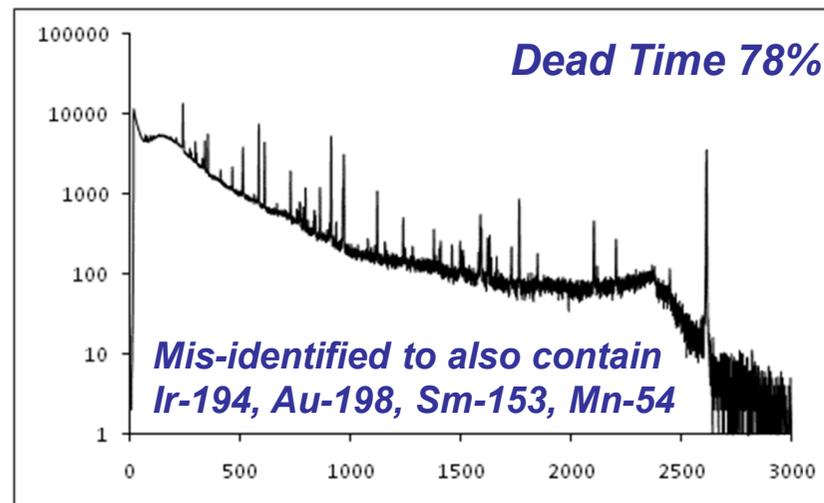
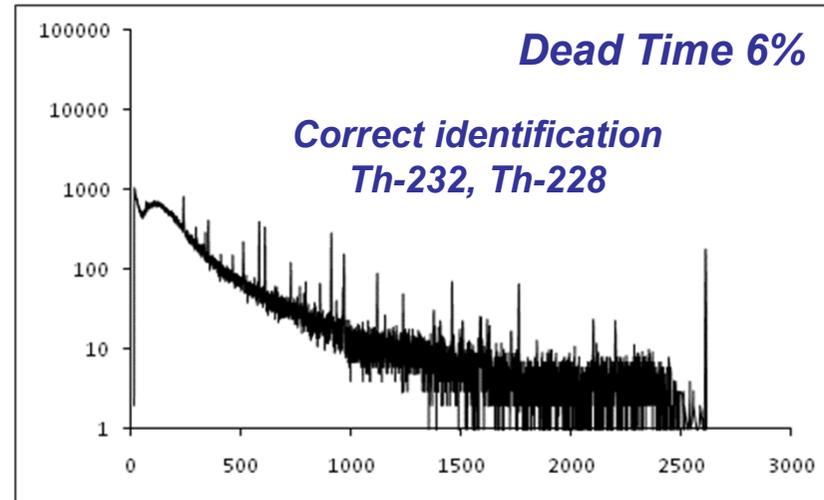
Effect of Dead Time



A cargo container filled with NORM can produce a *radiation field* significantly above background but still safe to ship

These radiation fields can cause the *dead time* of the detector to be quite high requiring measurements to be taken from over 10 m away

High dead time can produce artificial peaks in the gamma spectrum resulting in mis-identification





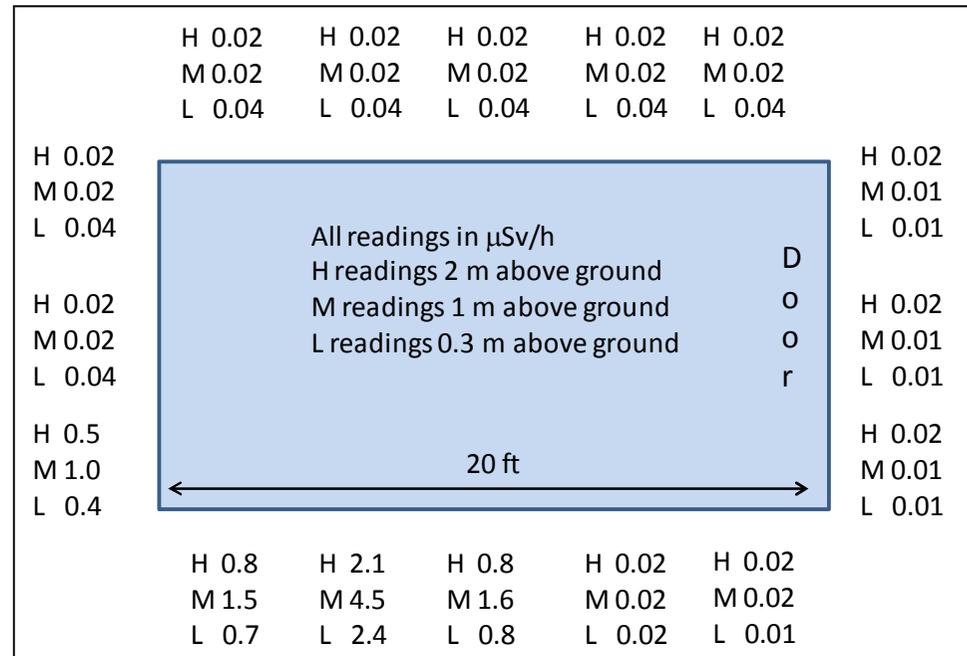
Point Source Characterization Map



A vehicle or cargo container with a point source may appear as a *localized source* in dose rate measurements

Point sources can be inadvertently mixed with other material; an example includes point sources in shipments of scrap metals

Radiological Characterization Map





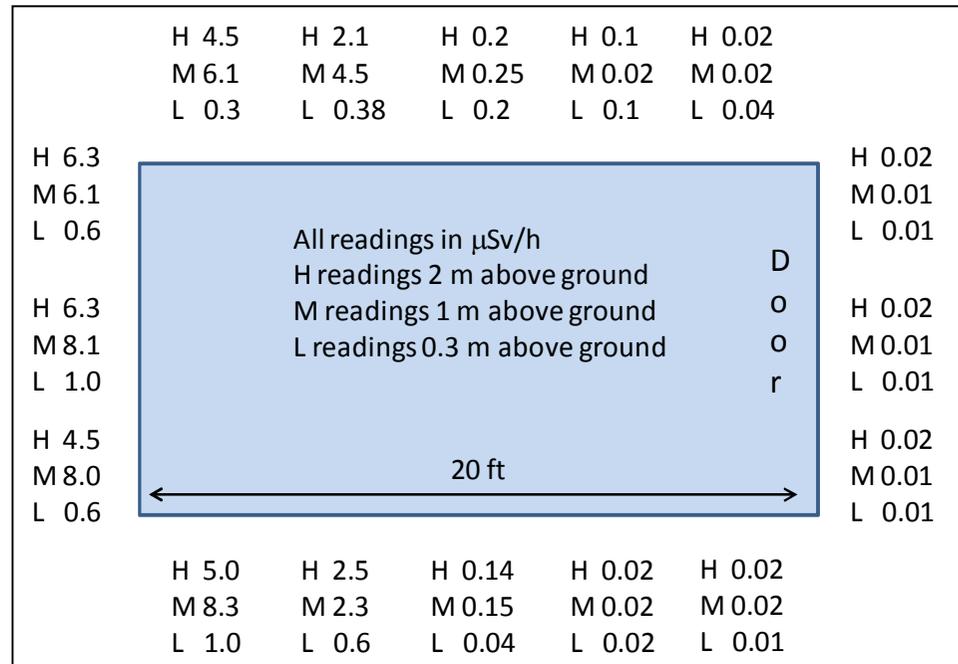
Distributed Source Characterization Map



A vehicle or cargo container with contaminated products may appear as a *distributed source* over part of the container

Metals are contaminated in blast furnaces when radioisotopes such as Co-60 are accidentally smelted; examples include rebar, water meters and elevator buttons

Radiological Characterization Map





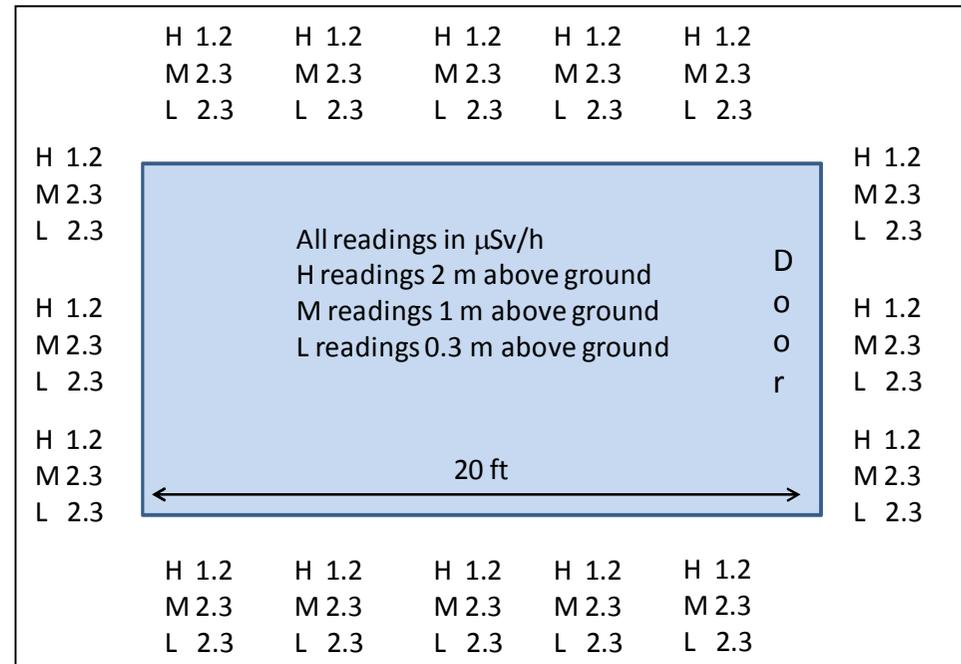
Uniformly Distributed Source Characterization Map



A vehicle or cargo container filled with NORM may appear as a *uniformly distributed* source with nearly equal dose rates on all sides

Dose rates may decrease near top of container when bulk of NORM at floor to mid-height level; examples include ores, fertilizers and ceramics

Radiological Characterization Map



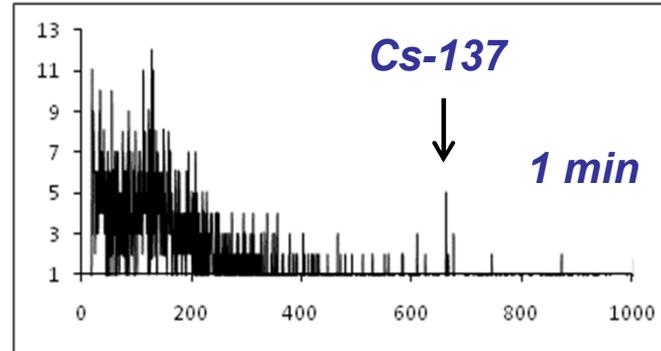


Cs-137 Pickup from RIID

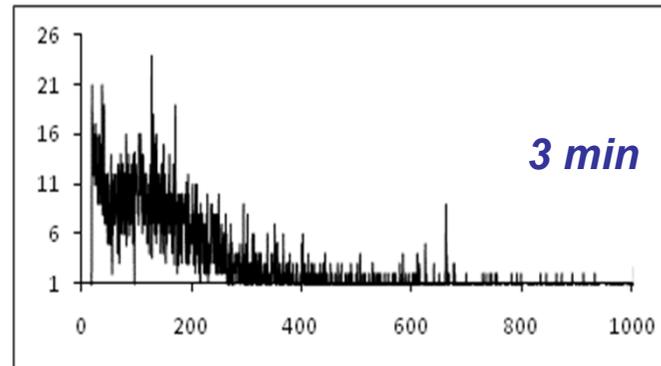


If a RIID is too close to the Detective during a measurement, then the Cs-137 calibration source in the RIID can be detected

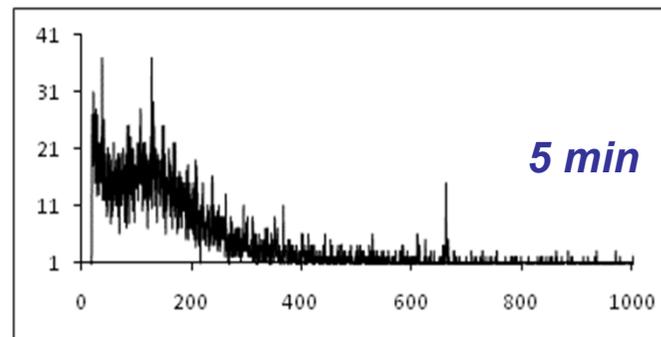
Keep RIID at least 5 meters away from Detectives



Background



Suspect: Cs-137



Found: Cs-137



Temperature Effect of Changes



1. Wide temperature changes can cause gain shifts and the calibration will be off.
2. A RIID with an internal calibration source can compensate for temperature shifts by constantly re-adjusting the calibration.
3. A RIID with calibration source in cradle will not compensate for temperature shifts.

Note: some RIIDs automatically turn off gain stabilization at high dose rates so that it will not attempt to stabilize on wrong peak.



Concept of Operations (CONOPS)



For any radiological search and ID operation, it is important to have a robust Concept of Operations

An effective CONOP should:

Be tailored to operators capabilities and procedures

Have concise checklists

Ensure equipment is operational

Be trained to and evaluated periodically

Clearly define when situation elevated to supervisor

Ensure responses are documented



Radioactive Sources in Commerce



Naturally-Occurring Radioactive Material (NORM)/Bulk Products

Form – fertilizer, kitty litter, ceramics/porcelain, welding rods, granite, brick, drywall, bananas
K-40, Th-232, U-238, Ra-226

Medical – Diagnostic (Imaging/Injected)

Form – saline solution, gas, dissovable capsule
Tc-99m, TI-201, Ga-67, In-110, Xe-133, Cr-51, I-125, I-131, F-18

Medical – Radiotherapy (Therapeutic/Inserted)

Form – thin wires, needles, seeds, microspheres
Cs-137, Ir-192, I-125, Ra-222, Au-198, Pb-103, Y-90

Medical – Brachytherapy/Teletherapy (Treatment/External)

Form – hospital irradiator equipment
Co-60, Cs-137, Ra-226

Industrial Equipment

Form – gauges, smoke detectors, well logging, sterilization units, radiography cameras, RTG
Cs-137, Co-60, Ir-192, Am-241, U-238, Cf-252, Ra-226, Yb-169, Sr-90

Contaminated Bulk Products

Form – metals, wood products
Co-60, Cs-137



Radioactive Isotopes of Concern



Special Nuclear Materials (SNM) due to use in nuclear weapons

Form – nuclear weapons, improvised nuclear device, smuggled materials

Pu-239, U-235, U-233, Np-237

Radioactive Isotopes of Concern due to their potential high activities

Form – hospital irradiators, sterilization units, radiography cameras, radioisotope thermal generators

Co-60, Cs-137, Ir-192, Sr-90



Unusual Radiation Signatures



Be aware of any unusual portal/secondary inspection signatures that may indicate malicious activity

Unusual signatures include:

Dual gamma and neutron alarm

Neutron alarm only

Gamma alarm that can't be identified

Special Nuclear Material detection

Radioactive isotopes of concern

High gamma or neutron count rates



Search/ID CONOPS

Stopped Cargo Container/Truck



To search and acquire a spectrum of a hotspot from a cargo container or truck which triggered a checkpoint or portal alarm:

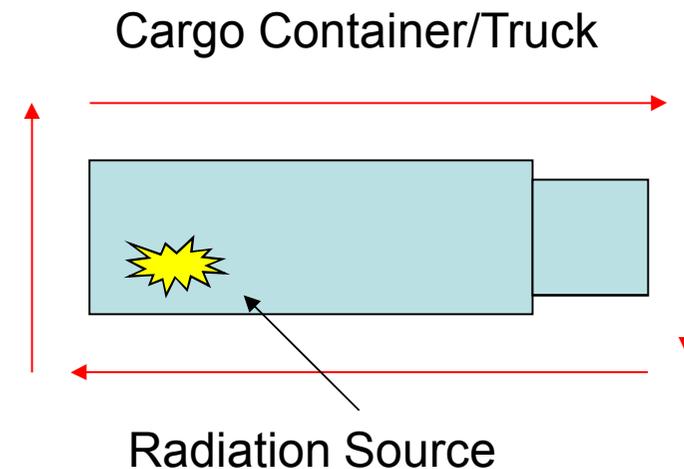
Step 1 – RIID Operational Check

Ensure battery charged.

Check count rate at storage location; is it the same as before (example 50 cps at 1 m).

Check calibration (if it has Cs-137 source embedded or part of cradle then single peak should be at about 661 keV).

If count rate and calibration are off, then not operating properly and needs repair.





Search/ID CONOPS

Stopped Cargo Container/Truck



Step 2 – Interdiction and Investigation

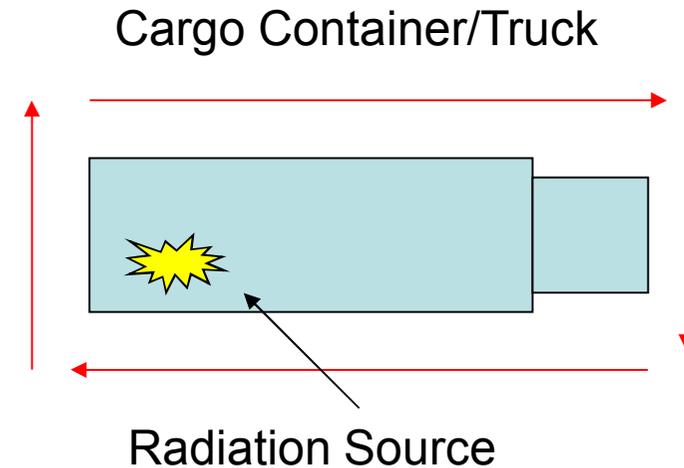
If cannot clear alarm with manifest review, direct truck to secondary inspection area.

Source could be from driver, passenger or truck.

Investigate and adjudicate using ***Alarm Interdiction and Adjudication Checklist***

Separate individuals (at least 10 m) from truck and scan with pager or RIID.

If get elevated reading or alarm from driver or passenger, acquire 5 min ID spectrum for medical at 25 cm; if dead time greater than 5%, move back; save spectrum.





Search/ID CONOPS

Stopped Cargo Container/Truck



Step 3 – Conduct a Cargo Container/Truck Inspection

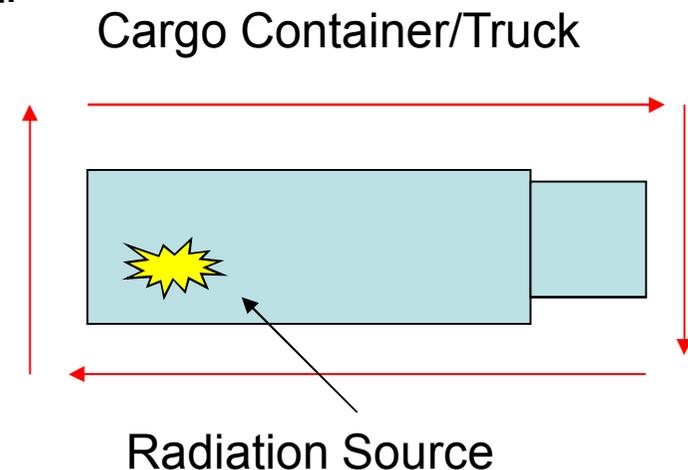
Proceed to walk around the truck with RIID holding it about 25 cm from entire truck and container. Use tones or strip chart mode to localize hotspot.

Once localized, use tones or strip chart mode to pinpoint hotspot.

Investigate and adjudicate using ***Alarm Interdiction and Adjudication Checklist***

Place RIID as close as possible to hotspot keeping dead time less than 5%; if greater than 5 % move back until less than 5%.

Acquire two 5 min spectra – one at contact and one at 1 m and save.





Search/ID CONOPS

Stopped Cargo Container/Truck



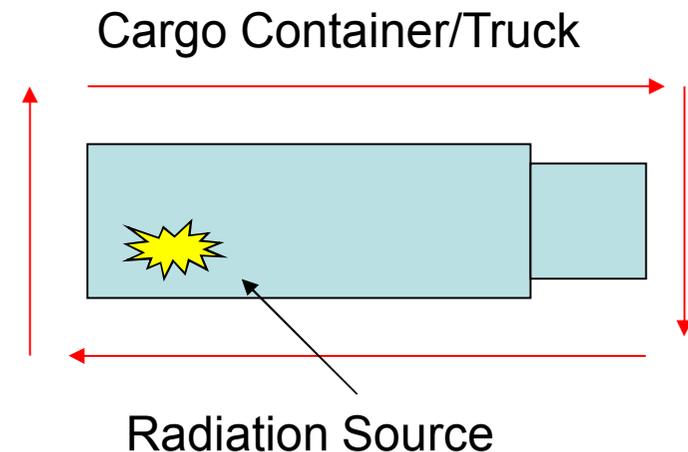
Step 4 – Coordination and Resolution

If unable to adjudicate with manifest, investigation and spectrum, detain individuals and truck and report to supervisor.

Following reporting protocols, download spectral data and request assistance from Competent Authority for analysis, guidance and adjudication.

The sender will need to include the 5 min calibration and 5 min background spectra, detector specifications and measurement information.

The background spectrum should be taken at least 10 m from vehicle.





Search/ID CONOPS

Stopped Cargo Container/Truck



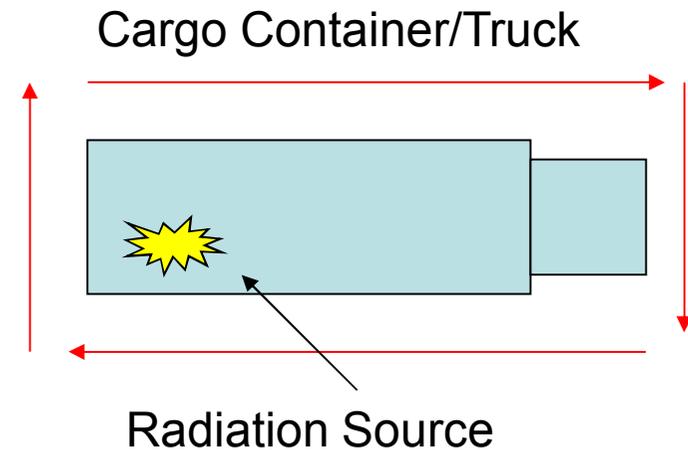
Step 5 – DOE Triage Assistance

If additional technical assistance or a confirmation of analysis is needed, the Competent Authority can contact DOE Triage.

Key indicators for assistance are SNM detection and Radioactive Isotopes of Concern.

To contact DOE Triage, call 001-202-586-8100 and request Triage assistance from the DOE Emergency Response Officer (ERO).

The ERO will guide the caller through the submission process and then provide feedback on the results within 1 hour.





Alarm Interdiction and Adjudication Checklist



The following checklist provides guidance to perform interdiction and adjudication of radiation alarms at security checkpoints and portals. Upon receiving a radiation alarm or elevated reading at a checkpoint or portal:

1) Identify, detain and isolate individual or vehicle; separate individual from vehicle at secondary inspection. *If the portal count rate is very high, request Health Physics support for radiological safety.*

2) Conduct interview

We believe you may have triggered an alarm on our radiation sensor and would like to ask you a few questions.

- a) What is your name?
- b) Have you had any medical treatments lately which involved a radioactive isotope, i.e. stress test, iodine treatment?
- c) We would like to take a quick measurement with our sensor to verify the reading.

3) Perform a 5 min ID spectrum of individual at close range; if dead time is high (> 5%); move back until less than 5%). Review results of ID for the following:

Medical - Tc-99m, Tl-201, Ga-67, I-123, I-125, I-131, In-111, Mo-99, Pd-103, Se-75, Sm-153, Xe-133, Lu-176
Industrial - Cs-137, Ir-192, Co-60, Ra-228, Am-241, U-238, Th-232
Special Nuclear Materials - Pu-239, U-235, U-233, Np-237



Alarm Interdiction and Adjudication Checklist



4) If ID confirms medical and story is corroborated, then notify individual:

Our reading confirms the medical isotope. Appreciate your cooperation. We will need to also inspect your vehicle. It will only take a few minutes.

5) Continue questioning

Are you transporting any radioactive materials?

6) Review the drivers manifest and inspect cargo and labeling. Walk around truck/cargo container with RIID and confirm negative or positive for a hotspot. If positive, localize hotspot and acquire 5 min ID spectra at contact and 1 m; if dead time is high (greater than 5%); move back until less than 5%. Review results of ID and save data.

Our measurement confirms the sensor reading and the cargo manifest. We appreciate your cooperation.

If situation is not resolved, detain and request supervisor assistance.

7) Request assistance with health physics radiation safety and source recovery.

8) Complete a Radiation Alarm Log for each interdiction and adjudication.



Radiation Alarm Log



Date: _____ Time: _____ Location: _____

Radiation Instrument (Make/Model): _____

Alarm Level: _____ Isotope ID: _____ Measurement Time: _____

Medical

Name: _____ Phone: _____

Address: _____

Physician: _____ Address: _____

Phone: _____ Treatment Type/Date: _____

Industrial/Naturally Occurring Radioactive Material (NORM)

Name: _____ Phone: _____

Company: _____ Address: _____

Vehicle Make/Model/License No: _____

Regulatory License #: _____ Device Make/Model: _____

Material listed on manifest: _____

Unknown/Not Identified/Suspect Source

Name: _____ Phone: _____

Company: _____ Address: _____

Vehicle Make/Model/License No: _____

Describe situation: _____



Sample Alarm Protocols Leading to DOE Triage



Alarm registered at portal and documented by portal officer.

Truck with cargo container directed to secondary inspection for manifest review, hotspot localization and spectral identification. If inspection does not adjudicate alarm, Customs notified.

Customs reviews and if additional technical assistance is required to adjudicate the alarm, Competent Authority is contacted.

Competent Authority reviews and if additional technical assistance or spectral confirmation warranted then DOE notified.

Competent Authority initiates Reachback to DOE Triage using established procedures.

Competent Authority works with DOE Triage to adjudicate alarm.



Special Case Confirmed Neutron Alarm



If a neutron alarm is generated in a portal, a second pass through the portal is conducted to confirm.

If confirmed, a survey is conducted with RIID or preferably an ORTEC Detective (high resolution RIID).

A series of five minute spectra are collected of the background (at least 100 m away), at the radiation hotspot, on the opposite side of container from the hotspot and several other locations around the container.

Daily data files, spectral data, camera images, manifest, description of event, etc., are transmitted to Customs for review and adjudication.



Summary



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