Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

International Radiological/Nuclear Training for Emergency Response – Major Public Events Virtual Workshop

U.S. Department of Energy, National Nuclear Security Administration
Office of Nuclear Incident Policy and Cooperation

Date 2022
Washington, D.C., U.S.A.



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Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

Workshop Overview

Day 1 Major Public Events Overview and Nuclear Security Threats

Day 2 Radiation Detection and Emergency Response Equipment

Day 3 Nuclear Security Planning and Operations

Day 4 Alarm Interdiction and Adjudication and Source Recovery

Monday – Thursday

09:00-11:00 Washington, DC Time

Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

Virtual Workshop Guidance

The chat box will be monitored for questions during presentations.

Please keep your microphone on mute. All microphones will be muted at the beginning and during presentations.

If not presenting, please turn off video to preserve bandwidth.

Questions?

Office of Counterterrorism and Counterproliferation

Nuclear Incident Policy and Cooperation

Radiation Detection Instrumentation

Objective

Familiarize participants with the different types of radiation detection systems and their practical applications for radiological emergency response.

Goals

- Understand the Three Step Process for Radiological Response
  - Search and/or Survey
  - Radioisotope Identification
  - Source Recovery
- Recognize the types of radiation detection equipment and their applications
- Provide examples of common radiation detection instrumentation with operational videos

Three Step Process for Radiological Response

Detection, identification and recovery of a radiation source

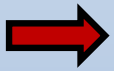
Step 1

Survey, Detection, Localization and Pinpointing

Radiation Pager

Radiation Backpack

SPARCS Mobile System

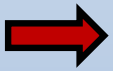


Step 2

Screening and Identification

Radioisotope Identifier (RIID)

High Resolution RIID



Step 3

Recovery

Tele-probe

Health Physics Kit

Personal Radiation Detector

Personal Radiation Detector (PRD) primarily for routine monitoring, detection, localization and pinpointing radioactive materials

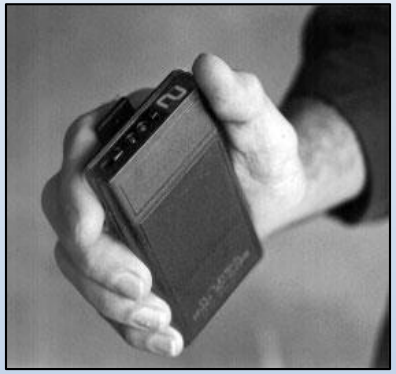
Also know as a radiation pager

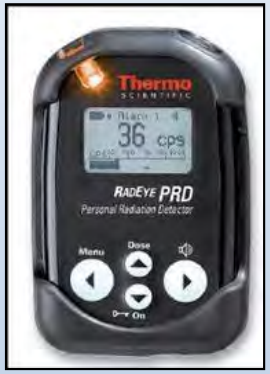
How is a PRD used at an MPE?

Primary Inspection at Venue Entrance

What Type of Instruments?

Personal Radiation Detector (PRD)





Lower sensitivity than larger backpacks

Typically, cesium iodide for gamma ray detection, most have no neutron detector

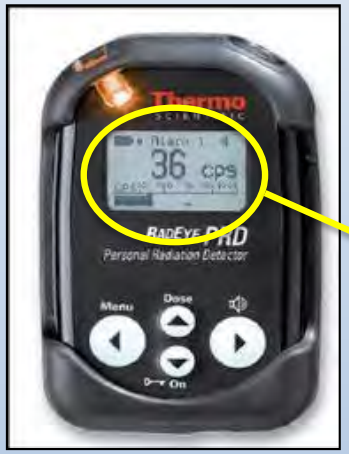
Low profile and easy to operate with minimal training

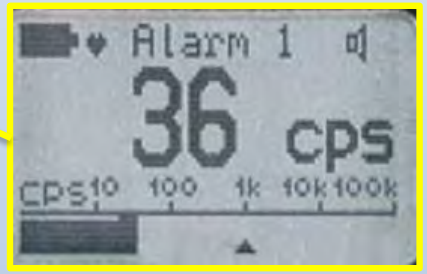
Interfaces – LCD display, audio, flashing light and vibration alarms

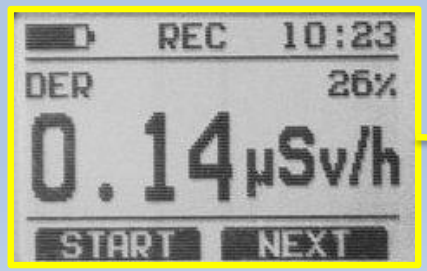
Types of PRD Displays

PRDs can be used for search, but some also function as a dosimeter

Search + Dosimeter

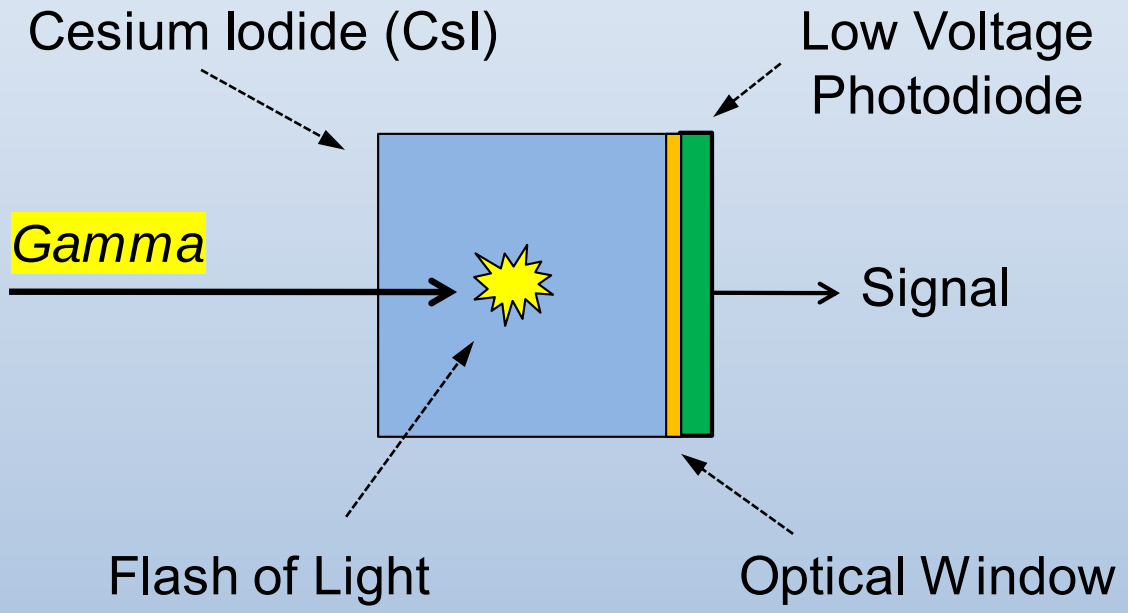


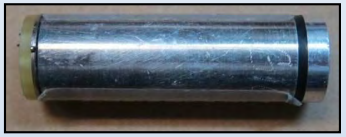




Search Only

Scintillation Gamma Detector (with Photodiode) – Small Size





Small, compact detectors with low voltage for pager type of units

PRD Example

Primarily a search tool
(Note: not a dosimeter for safety)

LED display shows alarm level. Two modes - audio tones and vibration

Alarm levels (0-9):

Less than 9 = safe
(9 or greater move away and report)

Update button resets background to current level extending range of unit

Alarm Level vs Dose Rate		
0 =	bkg	0.07 μSv/h
1 =	2x bkg	0.14 μSv/h
2 =	4x bkg	0.28 μSv/h
3 =	8x bkg	0.56 μSv/h
4 =	16x bkg	1.12 μSv/h
.....		
.....		
8 =	256x bkg	17.92 μSv/h
9 =	512x bkg	35.84 μSv/h

Detector Location

Cesium Iodide
3.8 x 1.3 cm

Highest Sensitivity Side

LED Switch

Batteries 2 AA

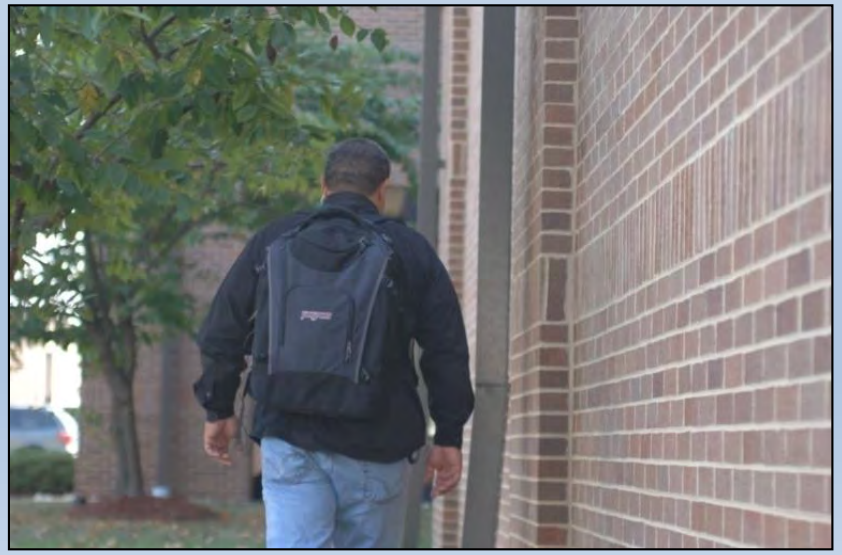
Detector Toward Front

Personal Radiation Detector (PRD)

Backpack Radiation Detector

Dual gamma and neutron detector for survey/search of radioactive materials, high sensitivity portable system

30 times more sensitive than pager or RIID



How is a backpack used at an MPE?

Venue Pre-Event Baseline Survey

Venue Main Event Expert Search

What Type of Instruments?

Backpack Radiation Detector





High sensitivity for both gammas and neutrons

Sodium iodide or plastic detectors for gamma ray detection, He-3 for neutron detection

Larger profile but easy to operate with minimal training

Interfaces – headphones, Smart phones, PDAs, speakers

Backpack Detector Example

Description

The Backpack Radiation Detector is a high sensitivity gamma and neutron search instrument designed for low profile, large area radiological searches and surveys.

Areas where the backpack can be used include office buildings, stadiums, warehouses, shipping ports, borders, cargo container ships and Major Public Events.

Applications include baseline background surveys, search operations, portal monitoring and emergency response.

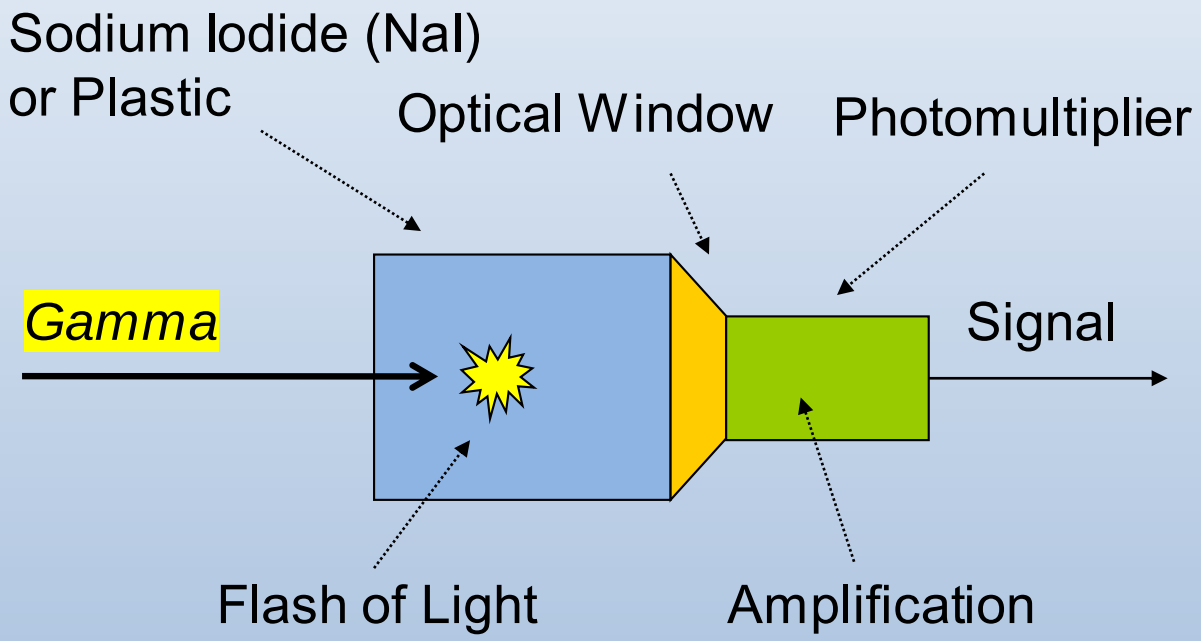
The unit is easy to operate and can be setup in less than 5 minutes.

Handheld Controller or Smartphone

- Backpacks operated with a handheld controller or smart phone
- The data can be plotted on geo-referenced street maps or satellite imagery to provide situation awareness products
- Data set can be sent to MEST expert team for further analysis

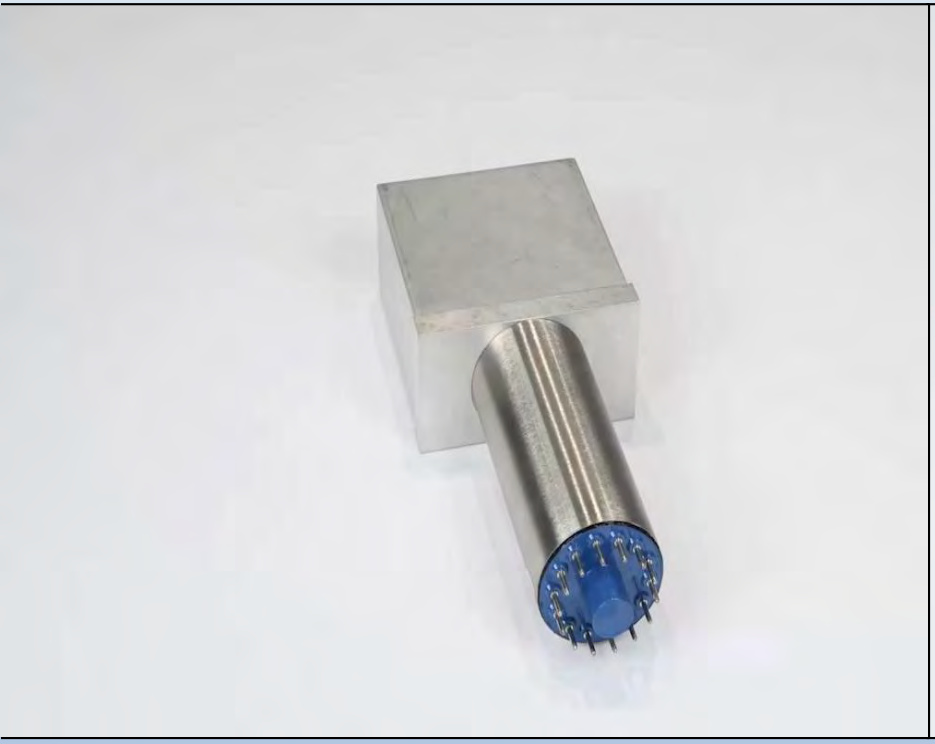
Backpack Radiation Detector

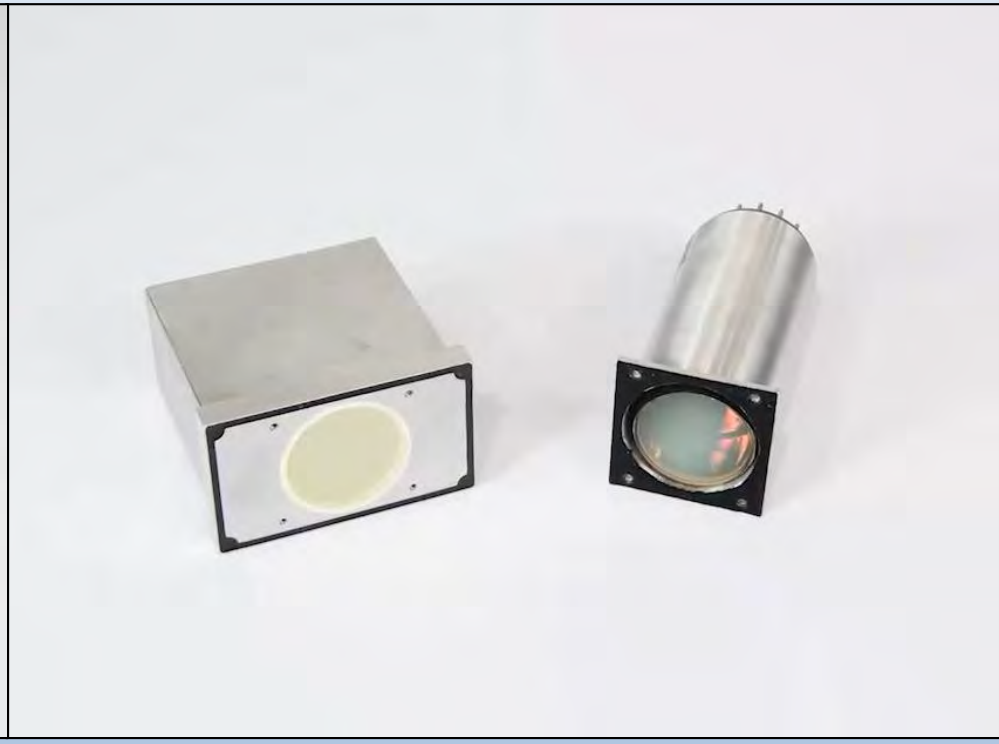
Scintillation Gamma Detector (with Photomultiplier) – Medium Size



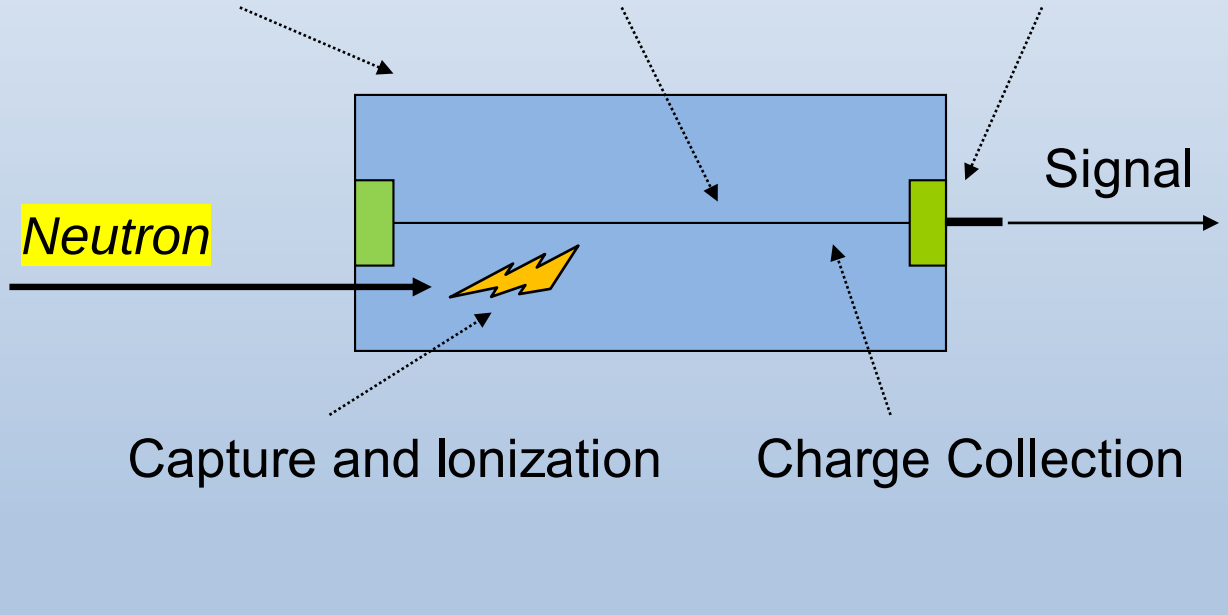
Medium size detectors for handheld meters and backpack systems

Medium Size Scintillation Gamma Detector
Sodium Iodide (NaI)
5 cm x 10 cm x 10 cm





Neutron Detector with Helium-3 Gas



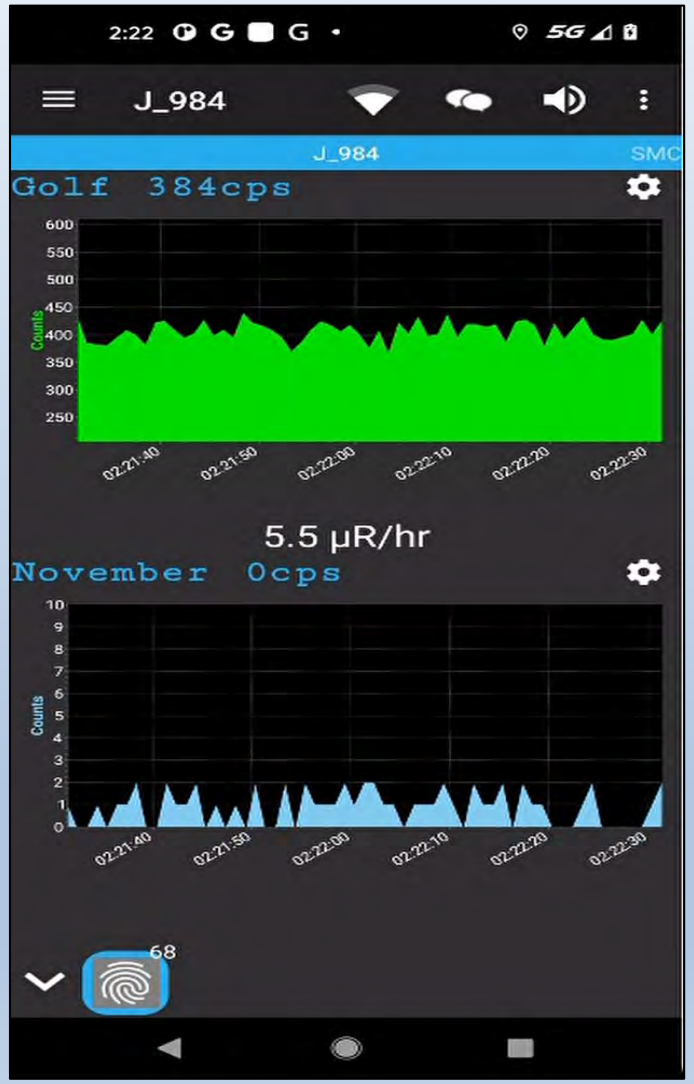
Small and large tubes for wide range of detection systems

Helium-3 (He-3) Gas Neutron Detector
Sizes: 1 cm x 12 cm to 5 cm x 30 cm

Phone App Main Operator Screen

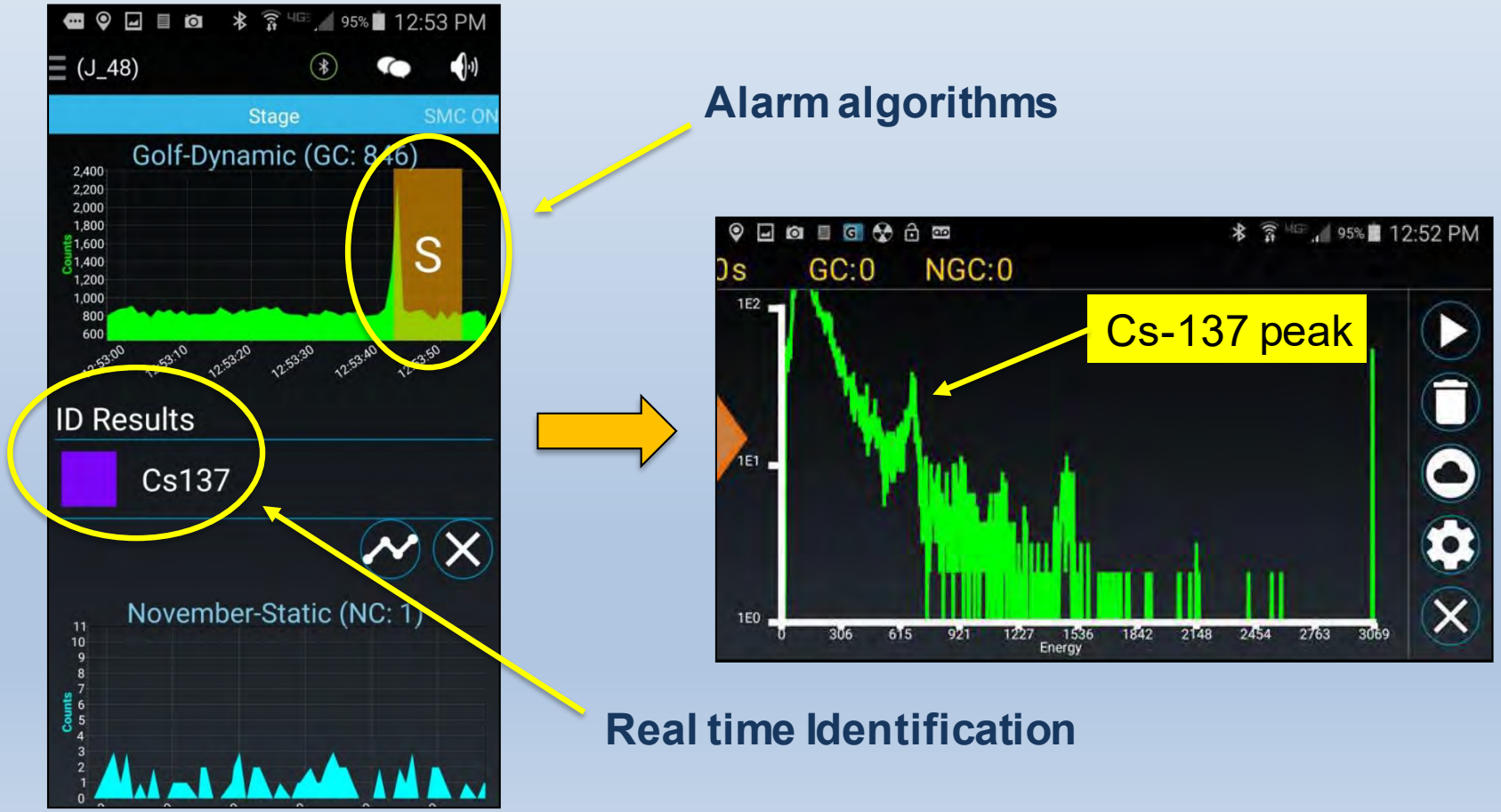
Main Operator Screen:

- Backpack ID number
- Blue tooth connection
- Volume adjust
- Strip chart for gammas
- Strip chart for neutrons (gross count versus time)
- Dose rate

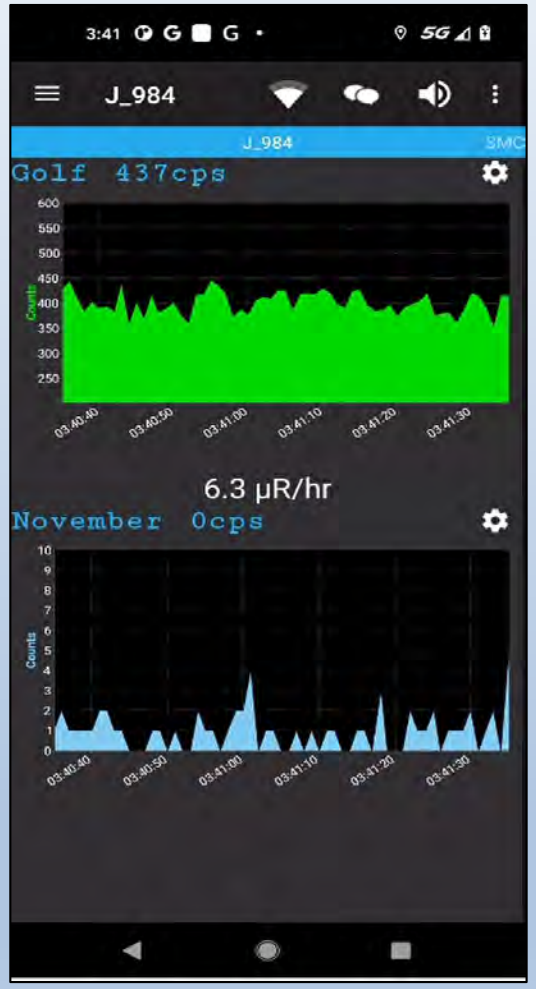


Alarm Detection and Analysis

App for real time radioisotope identification and spectral displays



Alarm Detection and Analysis



Dwell Mode

Detector Energy Calibration

App for energy calibration

Calibrate on Cs-137, 661 keV (5-10 μCi) at ~1 foot (count rate 3-4 times bkg):

- Open fly-out menu
- Press Device Settings
- Press Gamma Calibration
- Introduce source before starting the calibration routine

Radiation Data Products

- The radiation data is recorded simultaneously with the GPS coordinates
- The data can be plotted on geo-referenced street maps or satellite imagery to provide situation awareness products
- Data set can be sent to expert team (MEST) for further analysis

Mobile Detection System

Modular, readily deployable system for gamma detection at temporary portals such as border crossings:

- Data is correlated with GPS coordinates
- Rapidly installed in vehicles, boats or aircraft

Large Size Scintillation Gamma Detector
Sodium Iodide (NaI)
5 cm x 10 cm x 40 cm

How is a mobile system used at an MPE?

Venue Pre-Event
Roadway/Parking Area Survey

Venue Main Event
Roadblock Portal Monitor

What Type of Instruments?

Mobile Detection Systems

High sensitivity for both gammas and neutrons

Sodium iodide or plastic detectors for gamma ray detection, He-3 for neutron detection

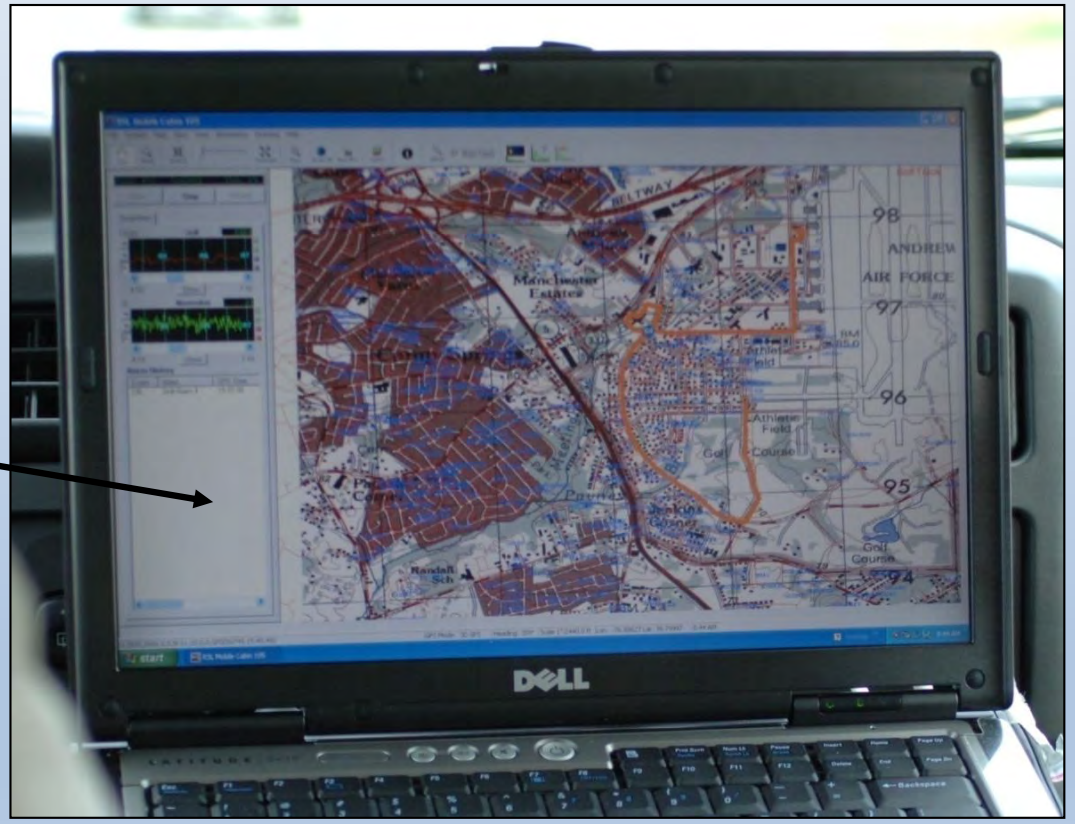
Larger profile but easy to operate with minimal training

Interfaces – laptops. tablets, speakers

Laptop Display

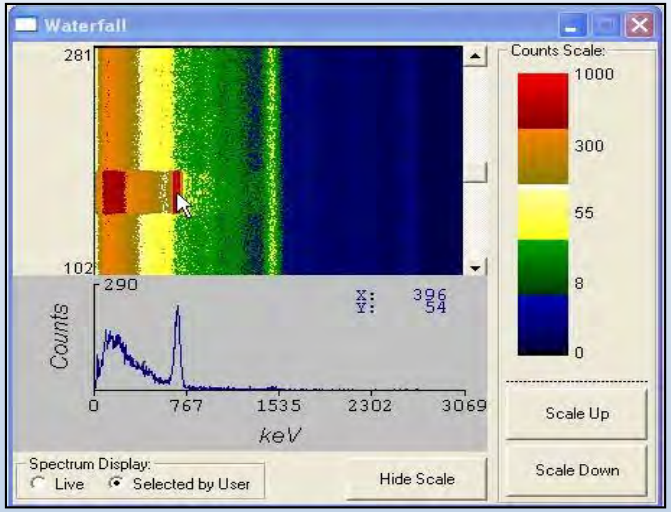
- Graphical display showing GPS map overlay, alarm levels and count rate strip charts

- Real time identification of common radioisotopes, spectral acquisition and email to experts for advice

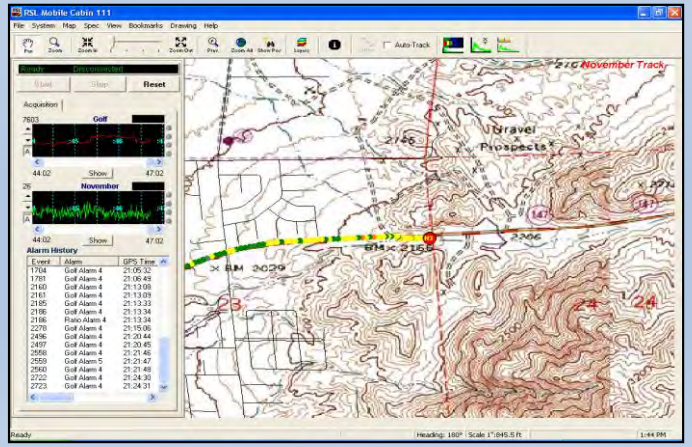


Display Options

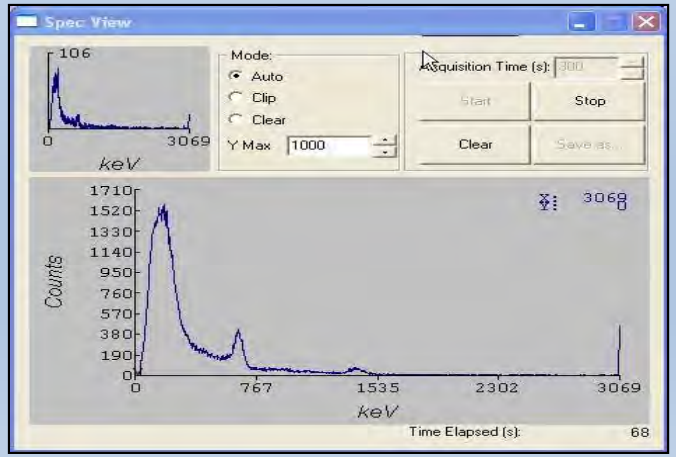
Strip Charts



Waterfall Chart

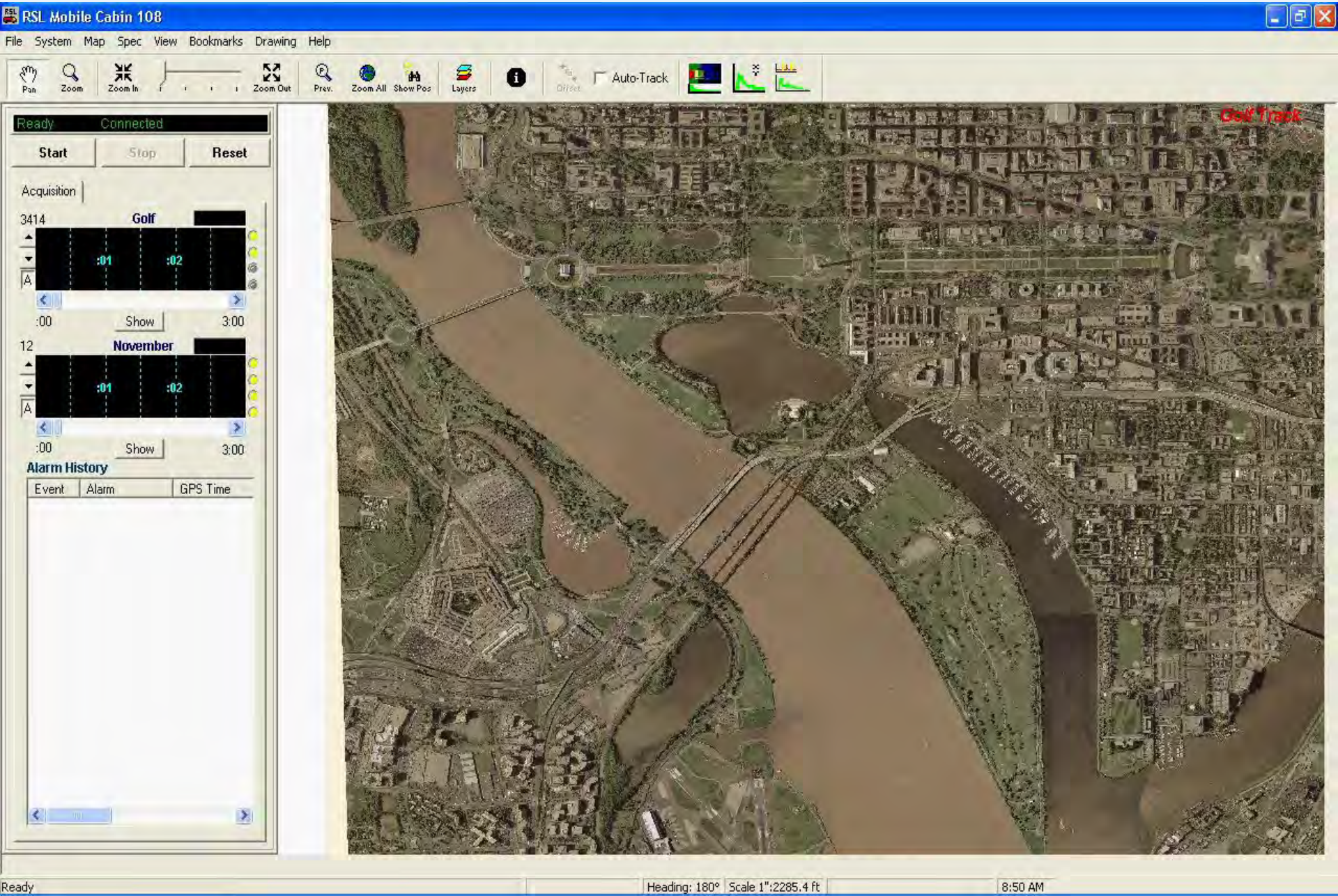


Street Map/Aerial Photo Overlay

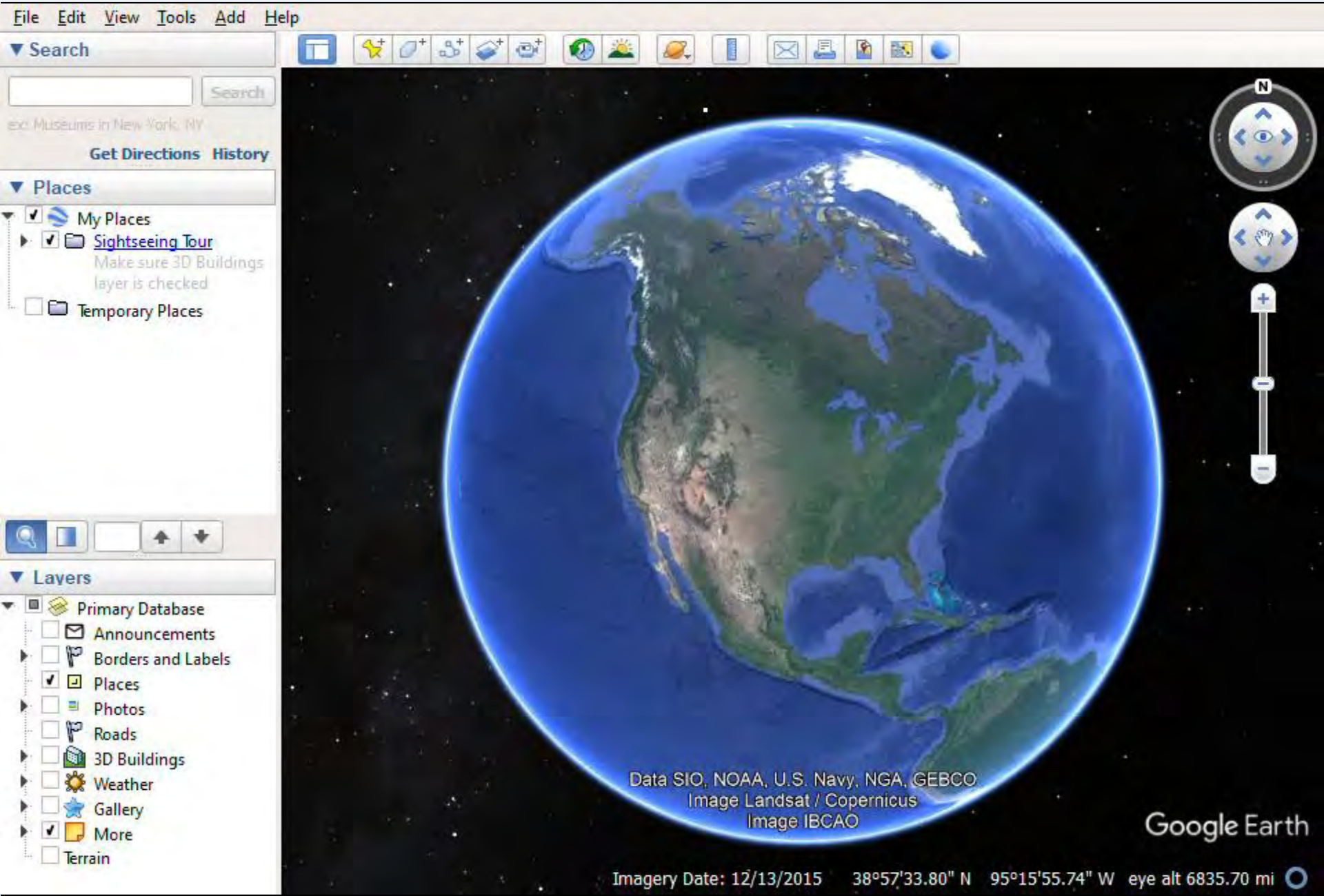


Gamma Spectrum

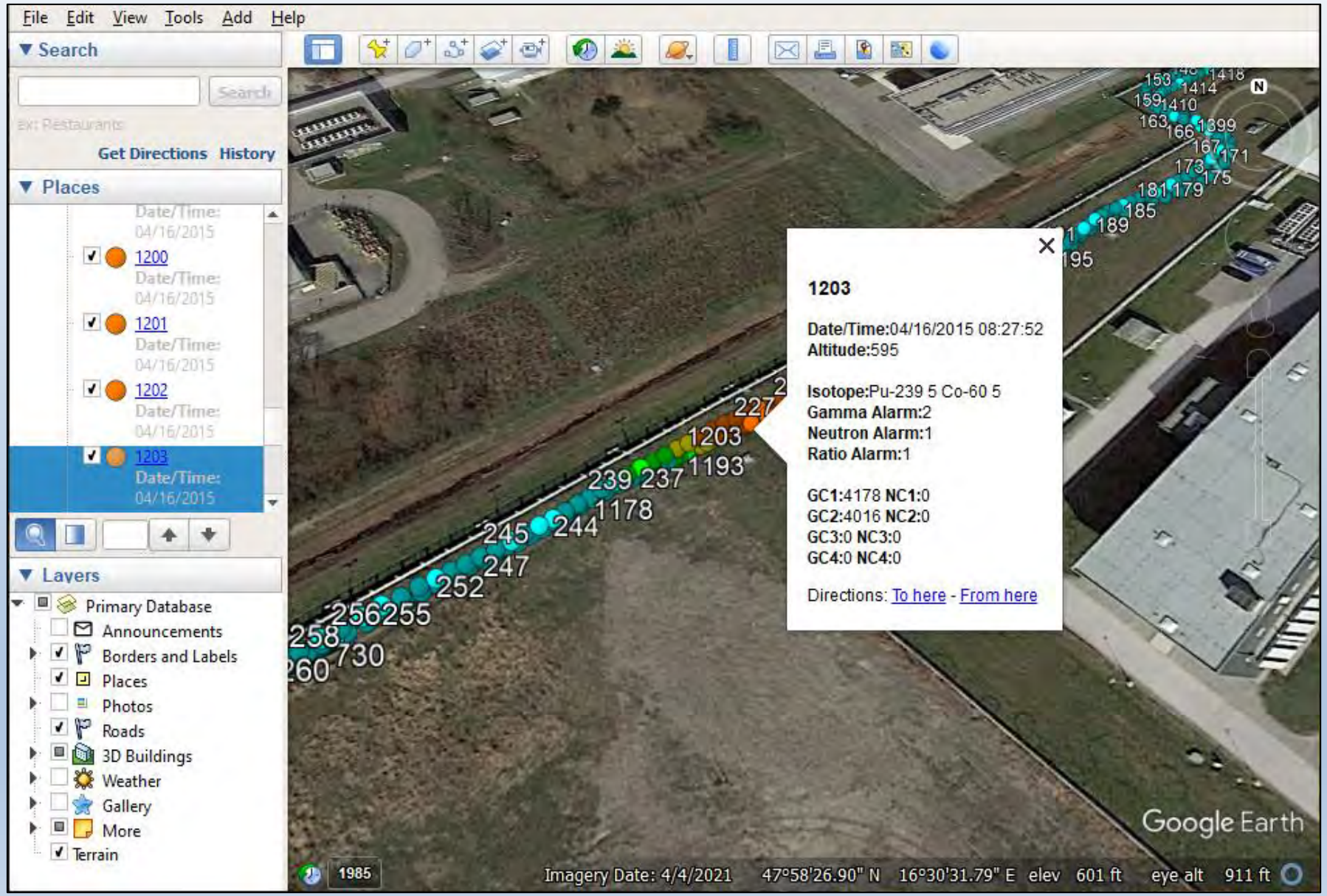
Mobile System Laptop Display



Google Earth Data View



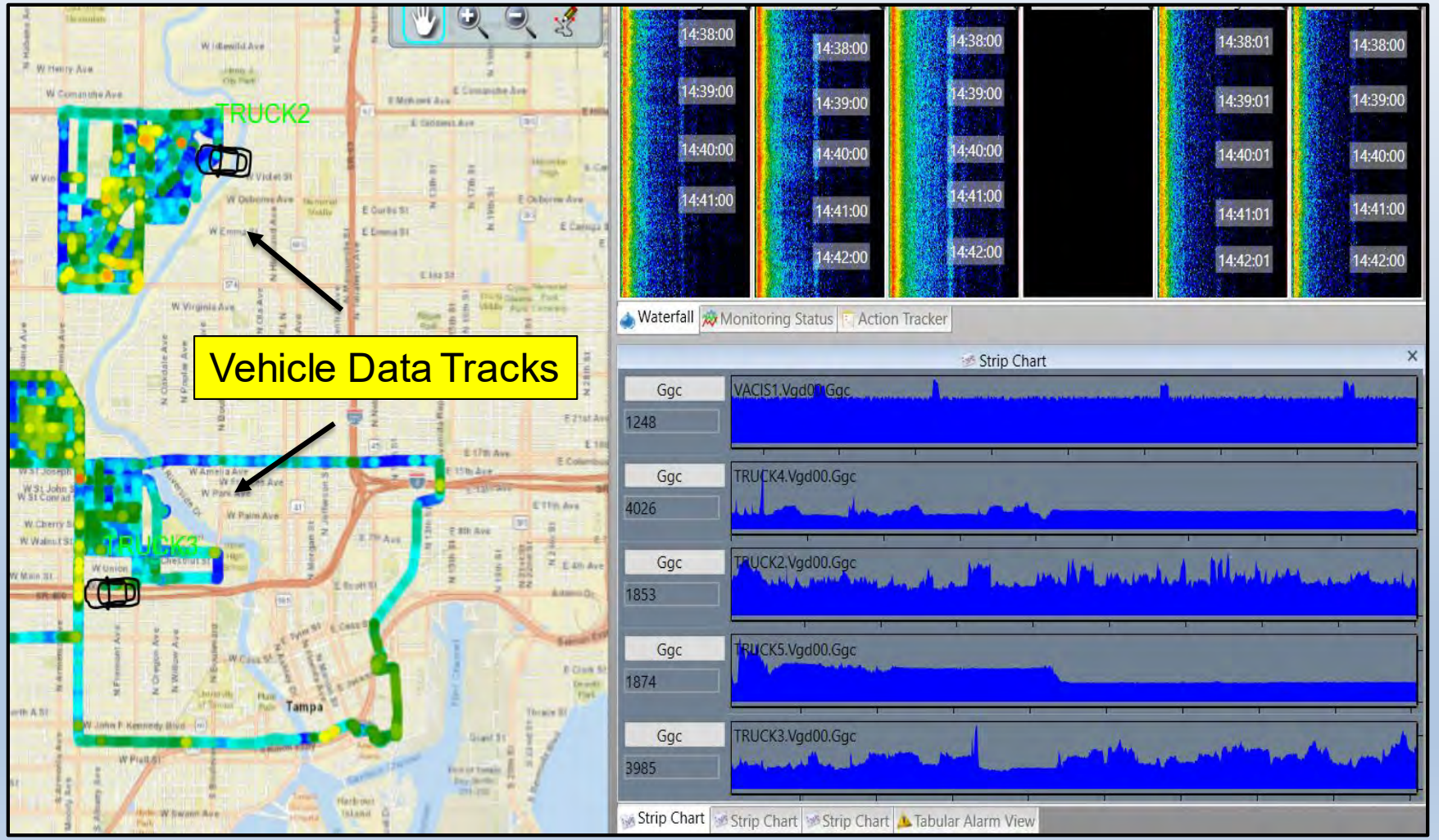
Radiation Data Alarm Review



Radiation Data for Multiple Mobile Systems

Street Map Overlay

Waterfall Charts – Gamma Spectra



Strip Charts - Gamma Counts vs Time

Three Step Process for Radiological Response

Detection, identification and recovery of a radiation source

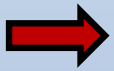
Step 1

Survey, Detection, Localization and Pinpointing

Radiation Pager

Radiation Backpack

SPARCS Mobile System

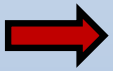


Step 2

Screening and Identification

Radioisotope Identifier (RIID)

High Resolution RIID



Step 3

Recovery

Tele-probe

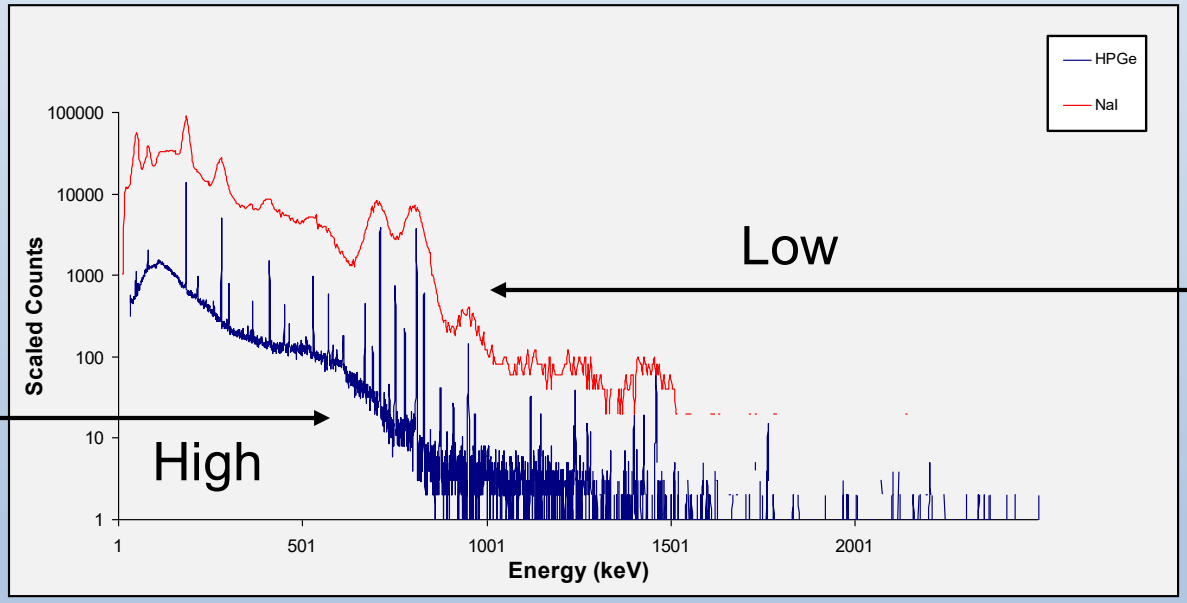
Health Physics Kit

Radioactive Material Identification

High Resolution versus Low Resolution Gamma Spectroscopy

"ability to resolve adjacent gamma peaks"

HPGe



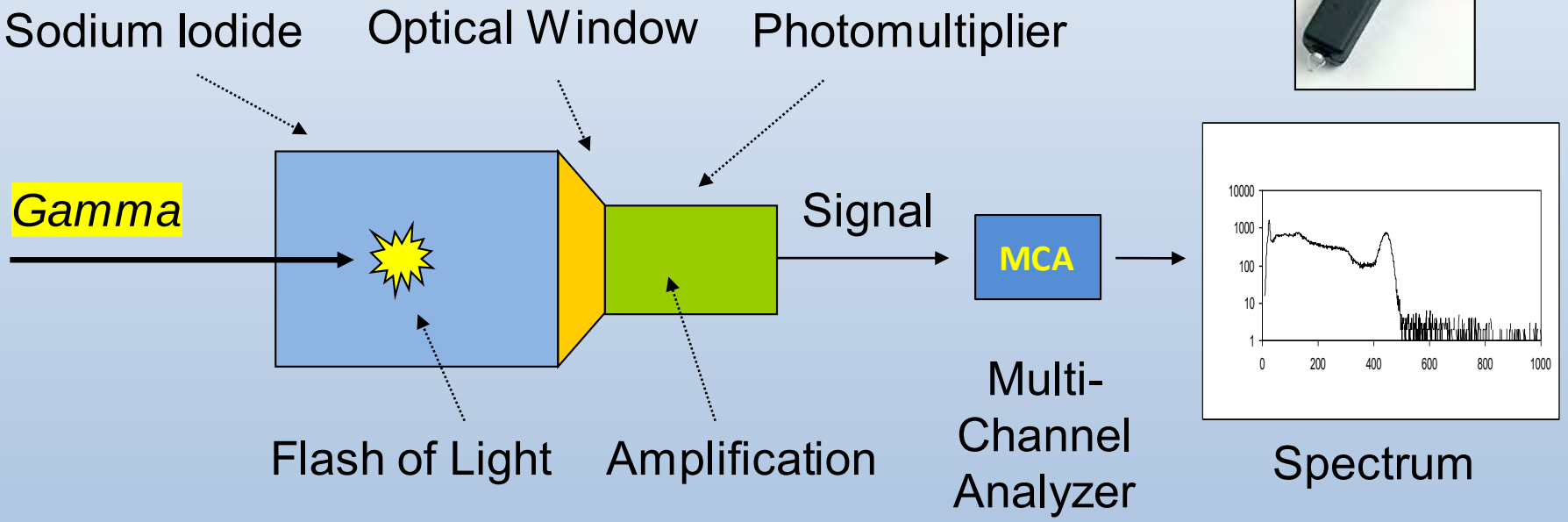
NaI

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

RadioIsotope Identifier (RIID)

Low resolution sodium iodide gamma detector for initial ***screening*** of radioactive materials, small neutron detector

Scintillation Gamma Detector (with Multi-channel Analyzer)



Low resolution detector for radioactive material "Screening"
R**adio**I**sotope **ID**entifier **(RIID)

How is a RIID used at an MPE?

PRD in Primary Inspection

RIID in Secondary Inspection

What Type of Instruments?

Radio**I**sotope **ID**entifinders (**RIID**)


Used to detect and identify radioactive materials

Sodium iodide detectors for gamma ray detection, He-3 for neutron detection

Compact and easy to operate with minimal training

Interfaces – LCD display, audio, flashing light and vibration alarms

Radioisotope Identifier Display

Display showing preliminary isotope identification

Screening with a RIID is the first step to identifying the radiation source and includes comparing results with cargo manifest and consulting experts for guidance

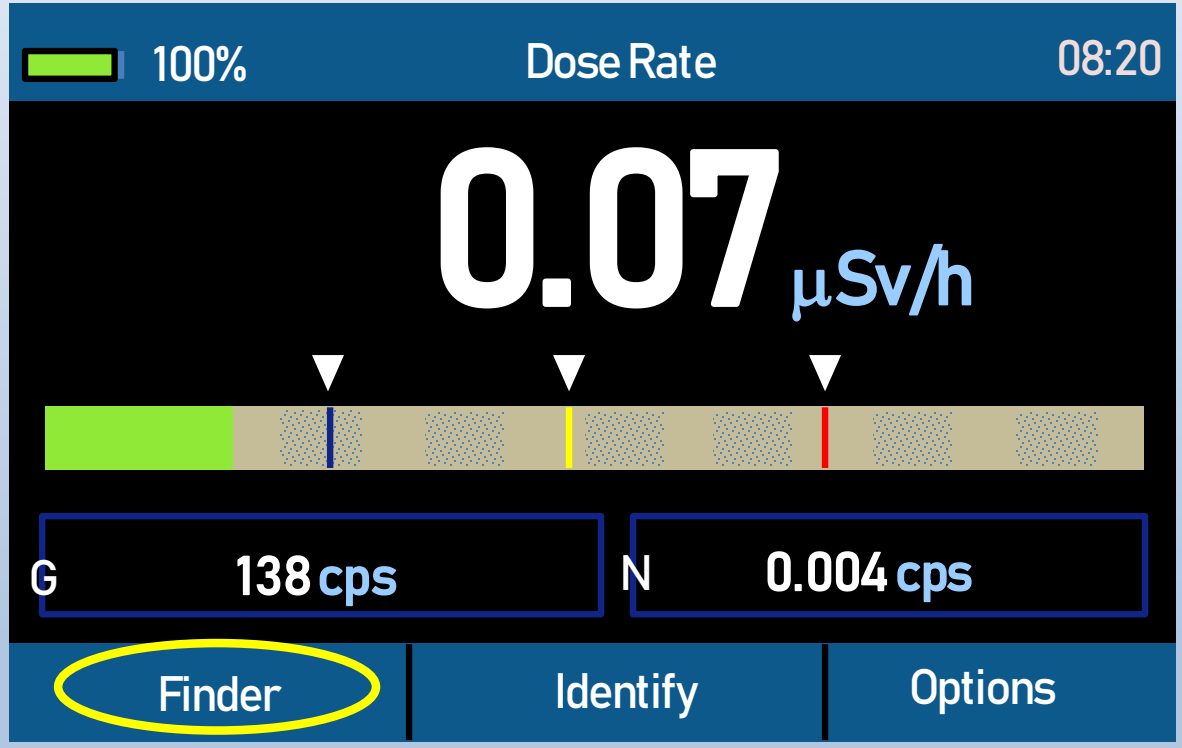
Four Step Process

Detect Source → **Acquire Spectrum** → **Library Lookup** → **Identify Radioisotope**

Three Detector System

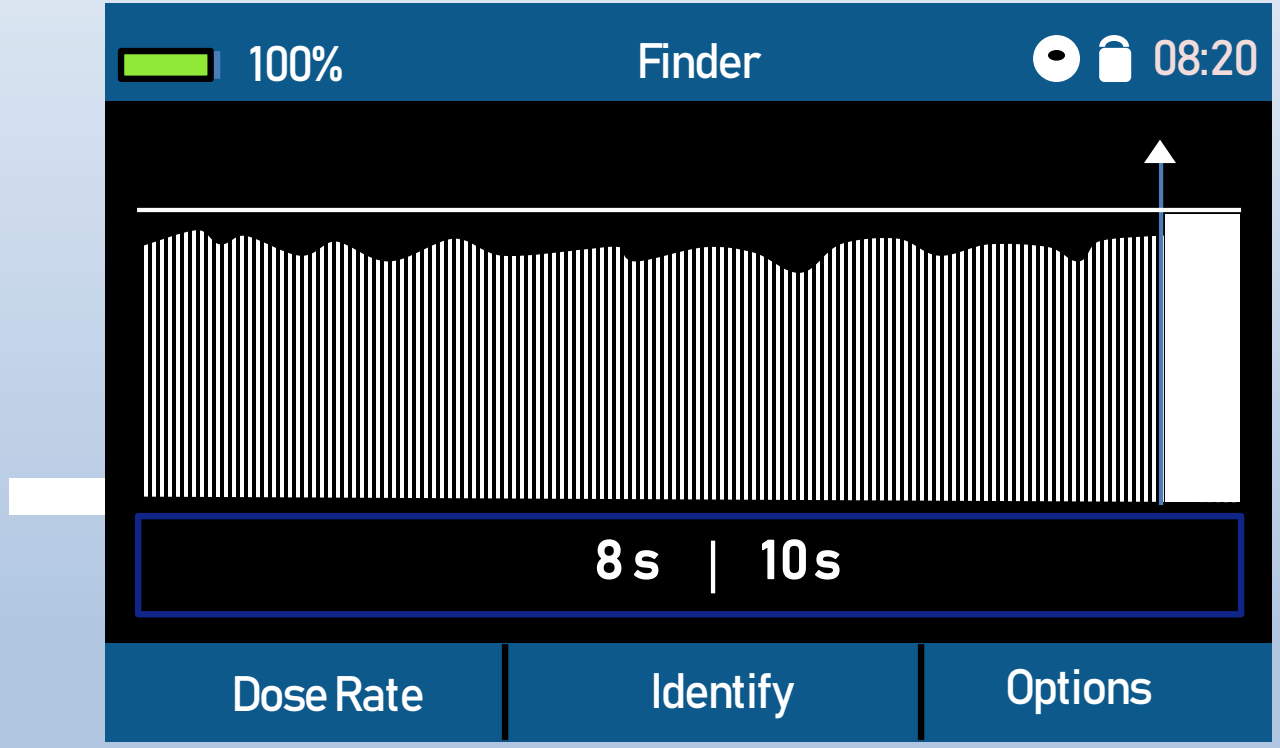
1 NaI Gamma Detector
(4.5 x 4.5 x 4.5 cm)
2 Geiger Muller Gamma Detector
3 LiF/ZnS Neutron Detector

Dose Rate Mode



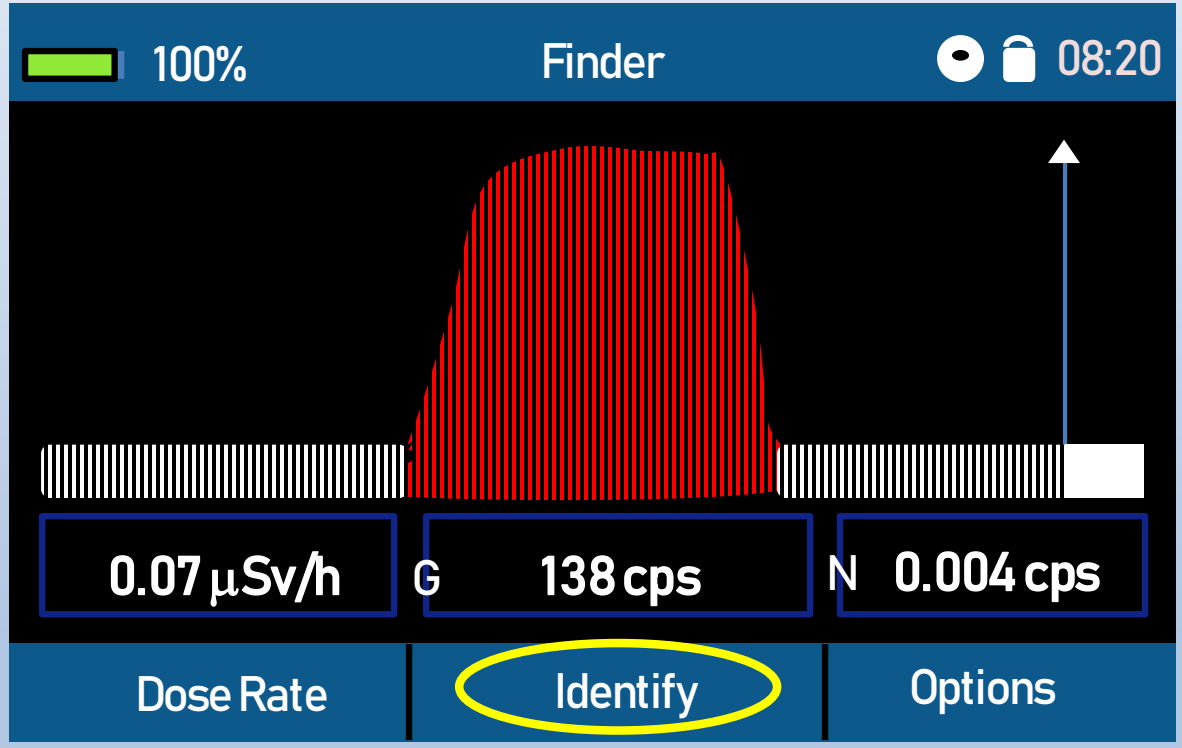
Finder Mode

Automatically collects 10 s of background count rate data and then ready to use
New data is compared to the background data threshold for alarms



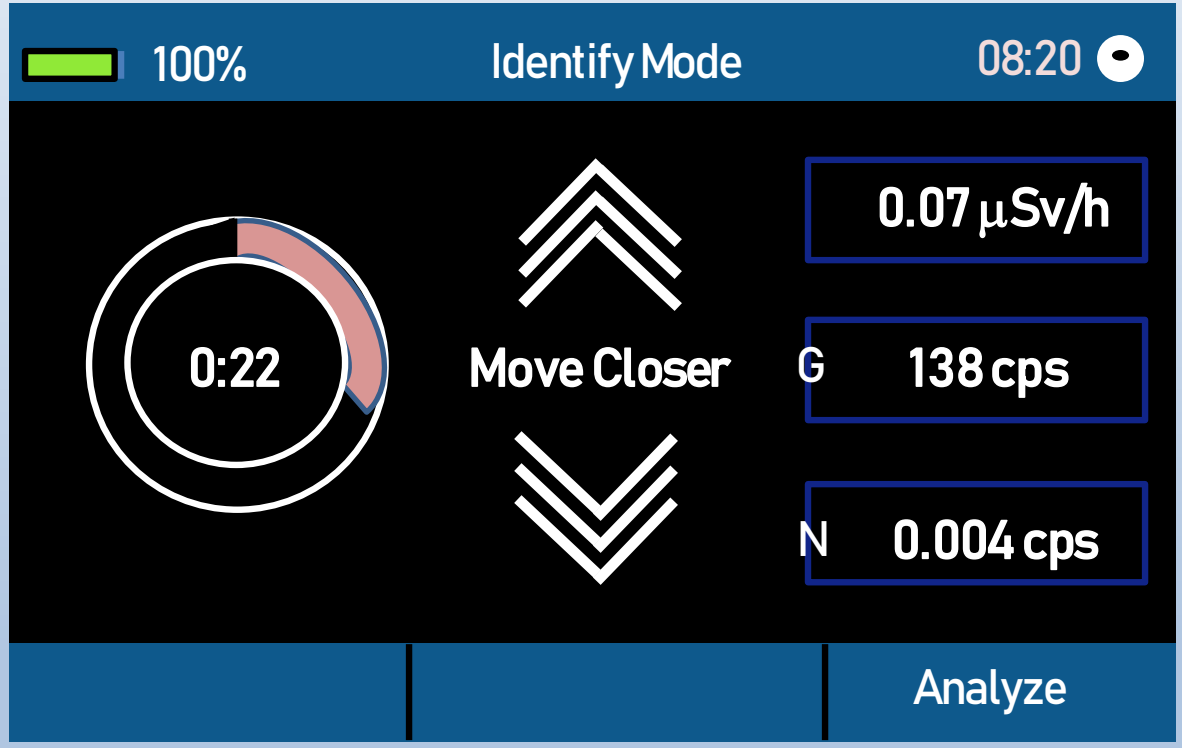
Finder Mode

Audible (tones), color change and vibration alarms when count rate exceeds thresholds

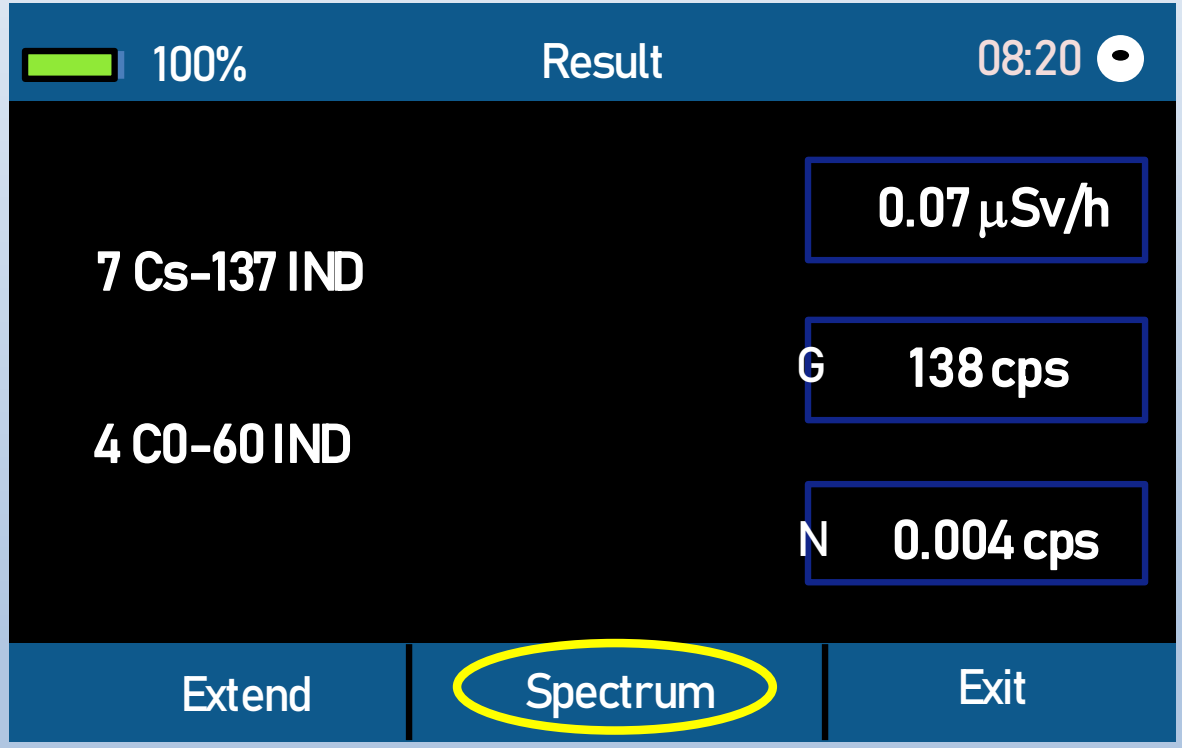


Identify Mode

Indicator arrows shows best distance for collecting spectral data



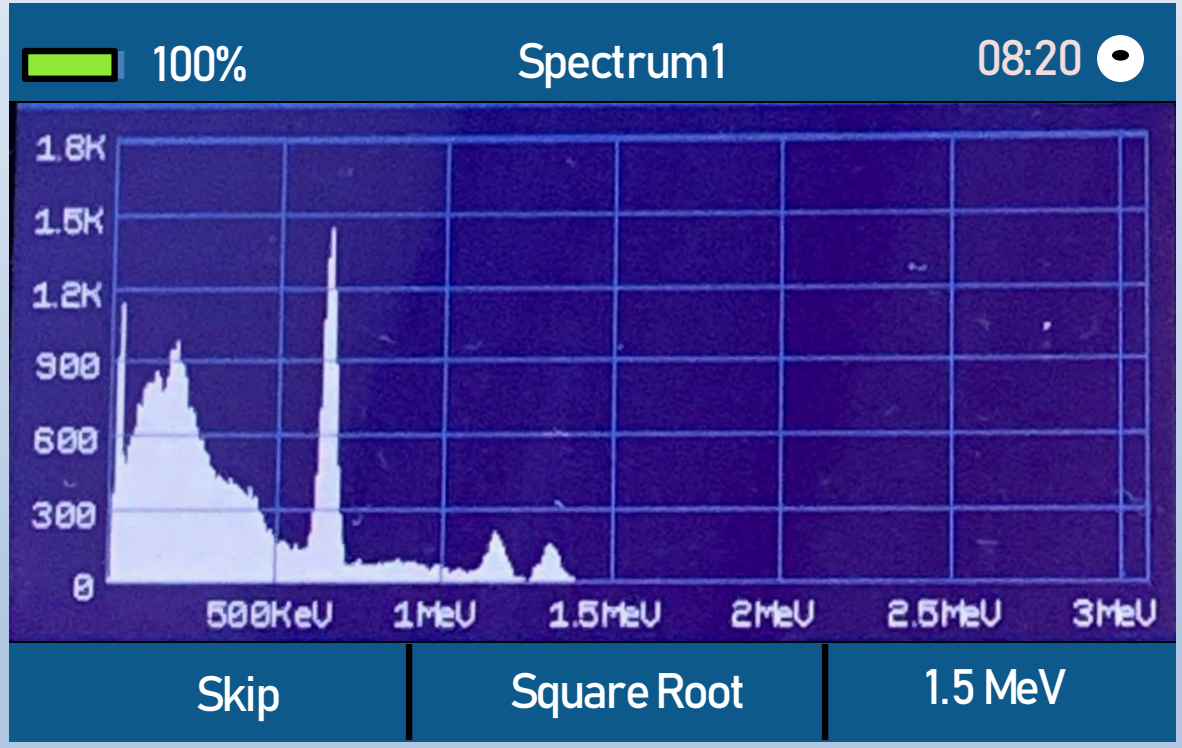
Identification Mode
for Analysis and Radioisotope ID



Confidence Level (1-10)	
10	very likely
1	unlikely

Med	Medical
Ind	Industrial
NORM	Naturally Occurring Radioactive Material
Nuc	Fissile Material

Identification Mode
Spectrum Review



Radioisotope Identifinder (RIID)

Radionuclide Identification (High Resolution RIID)

High resolution High Purity Germanium (HPGE) gamma detector ***for laboratory quality spectroscopy in the field*** and accurate radioactive material identification

How is an HPGe used at an MPE?

ID of Alarm on Cargo Truck

ID of Alarm on Suspect Package

What Type of Instruments?

High Resolution Radio**I**sotope **ID**entifinders (RIID)

Used to detect and identify radioactive materials

HPGe detectors for gamma ray detection, He-3 or LiF/ZnS for neutron detection

Compact and easy to operate with minimal training

Interfaces – LCD display, audio, flashing light and vibration alarms

Detector Components

Touch screen
and buttons

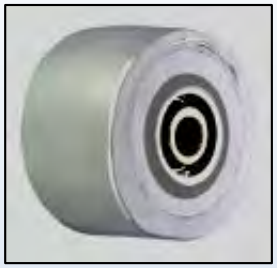
Removable
batteries
SD Card

GM detector

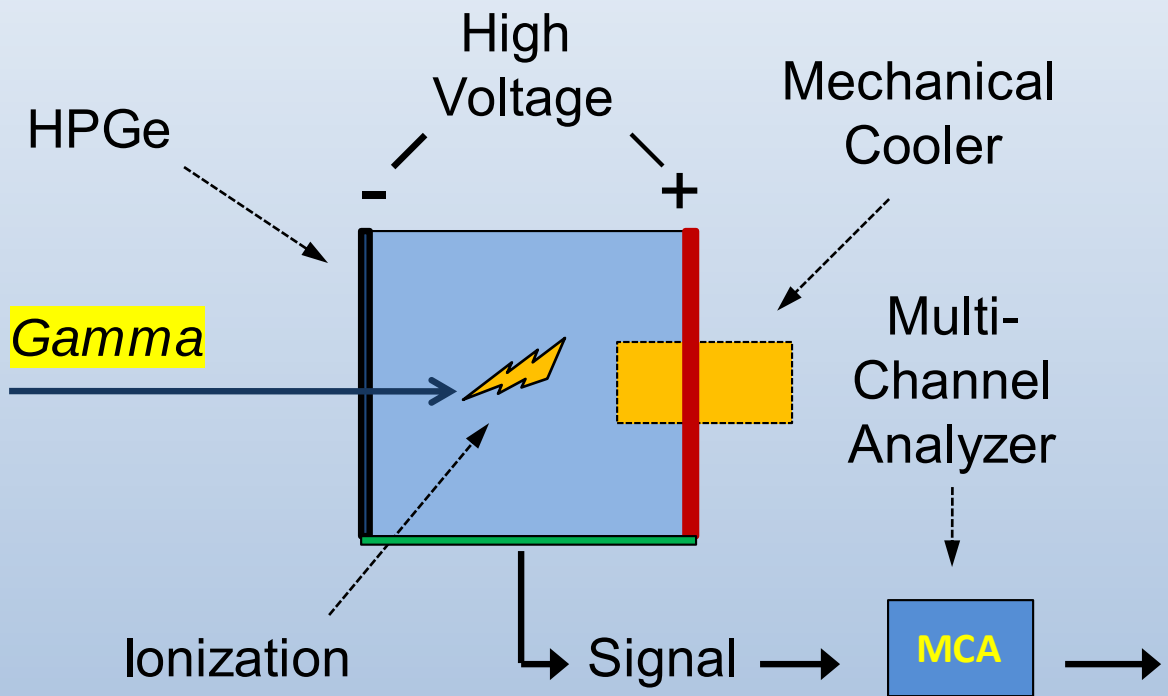
Neutron detector

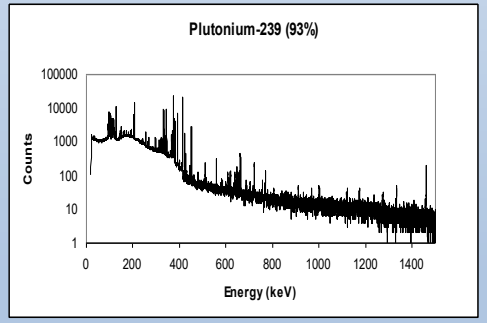
HPGe Gamma detector

Cooler



High Purity Germanium (HPGe) Gamma Detector



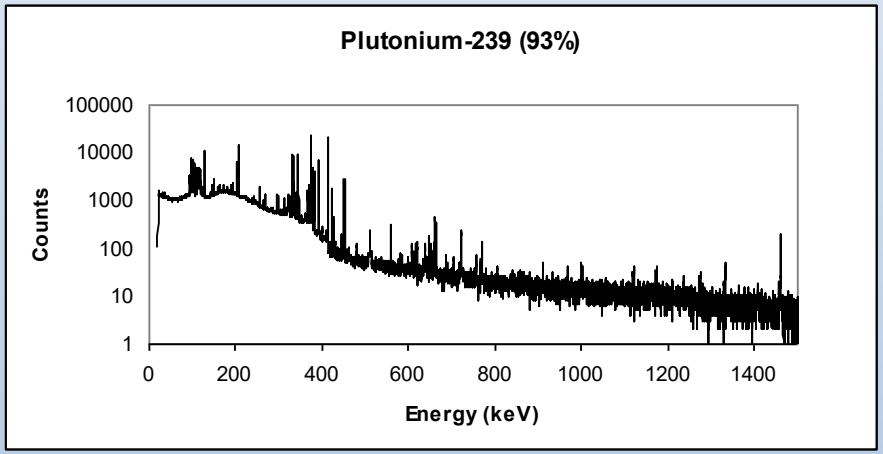


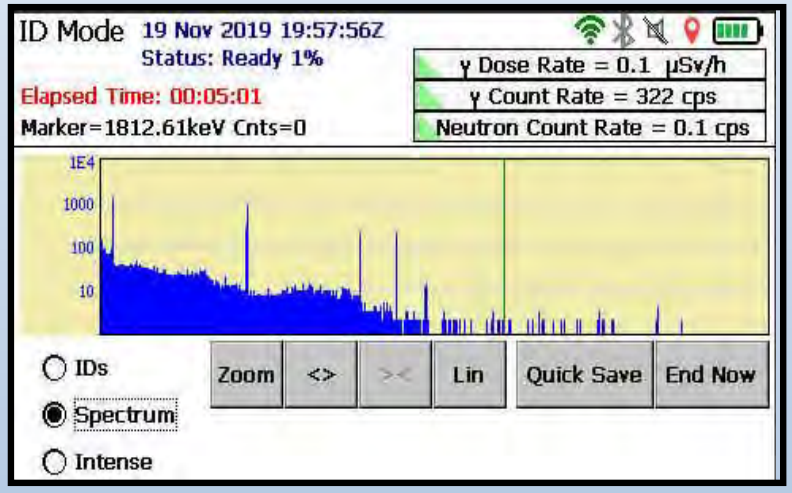
Spectrum

High resolution detector for radioactive material "Identification"

Radionuclide ID Display

Display showing gamma spectrum and count rates



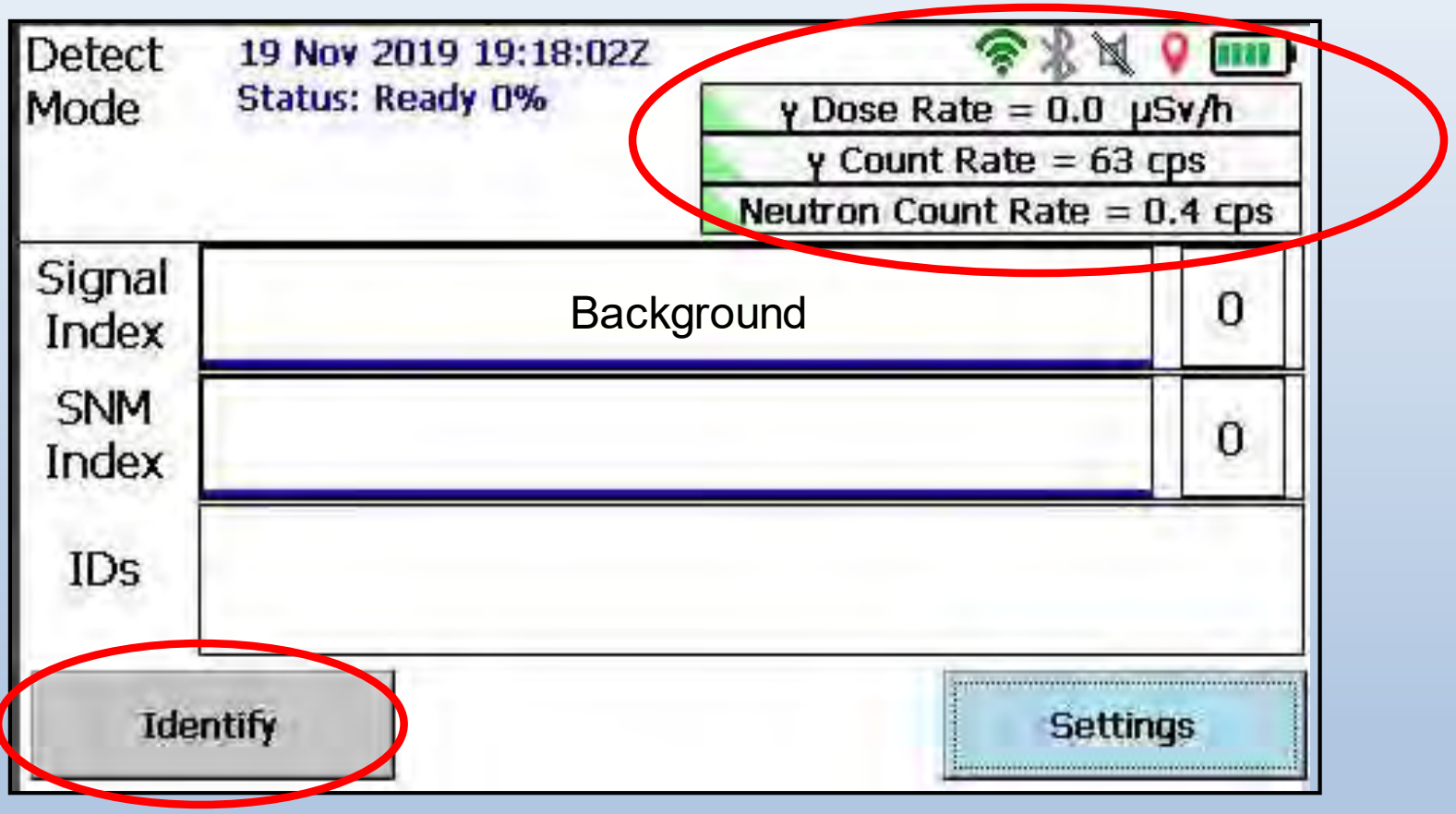


Every radioisotope has a unique spectral fingerprint

Multi-Step Process

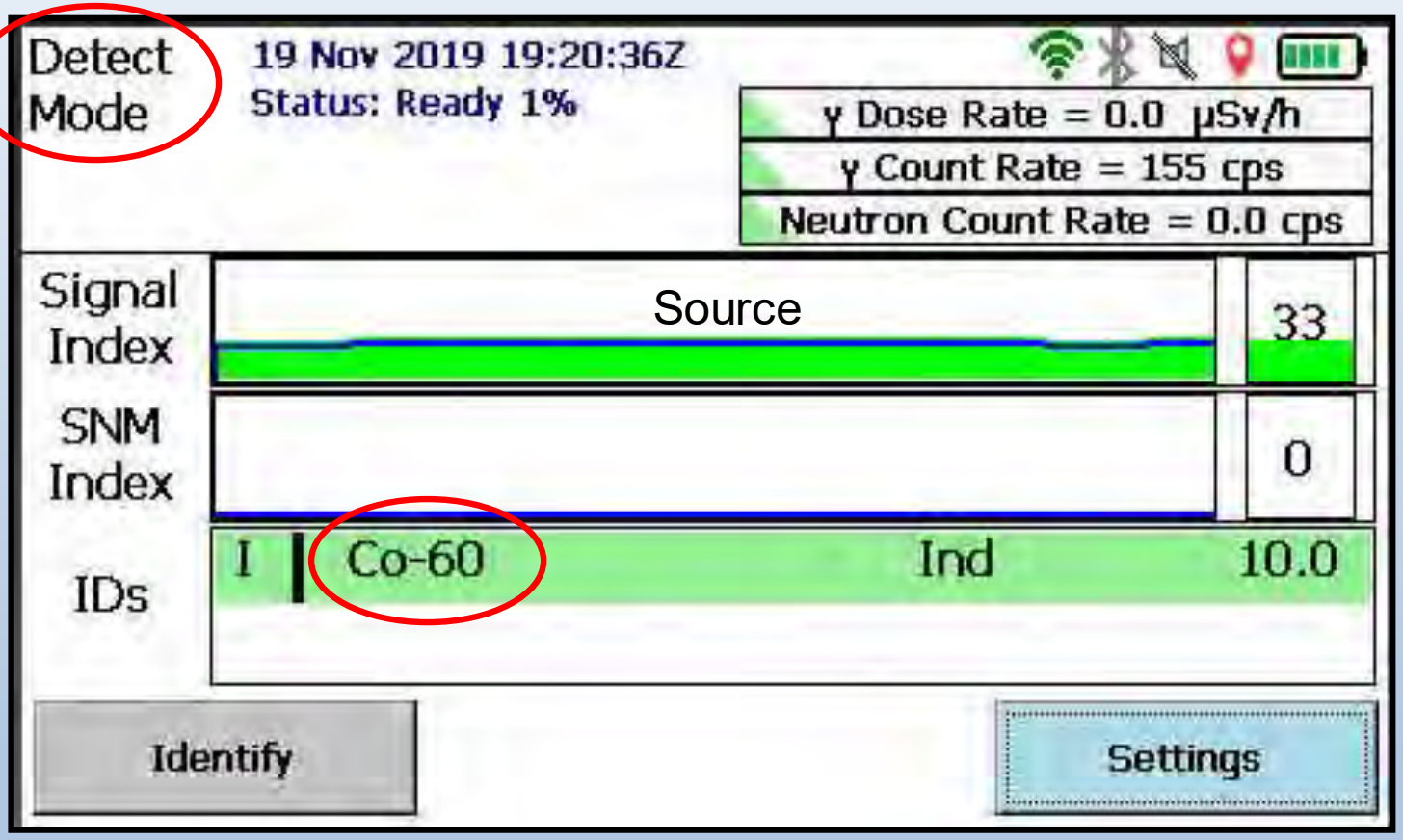
Detect Source → **Acquire Spectrum** → **Real-time Library Lookup** ⟷ ***Real-time Identify Radioisotope***

Survey Mode - Main Window



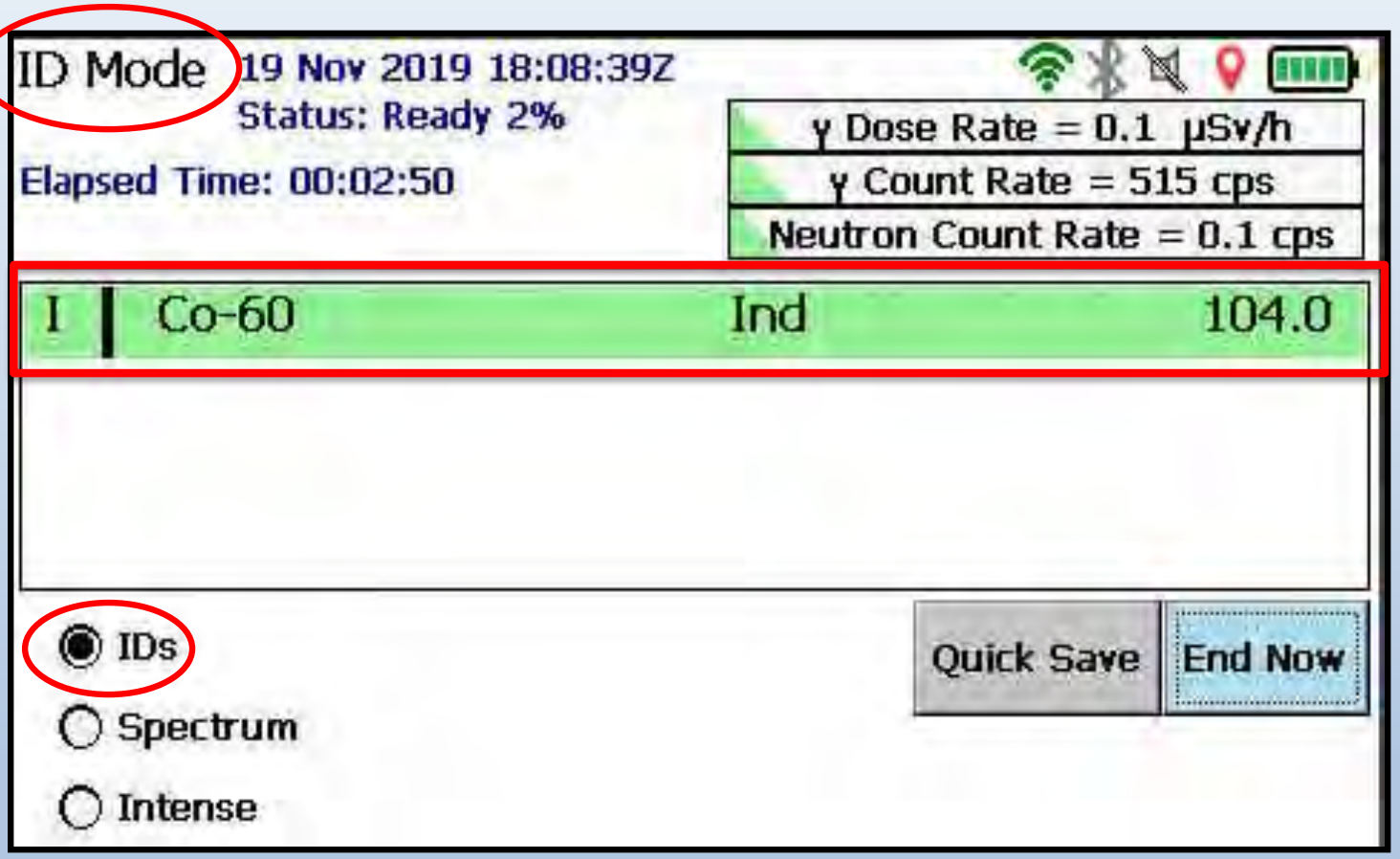
To collect a gamma spectrum, click on **Identify**

Detect Mode with Auto ID

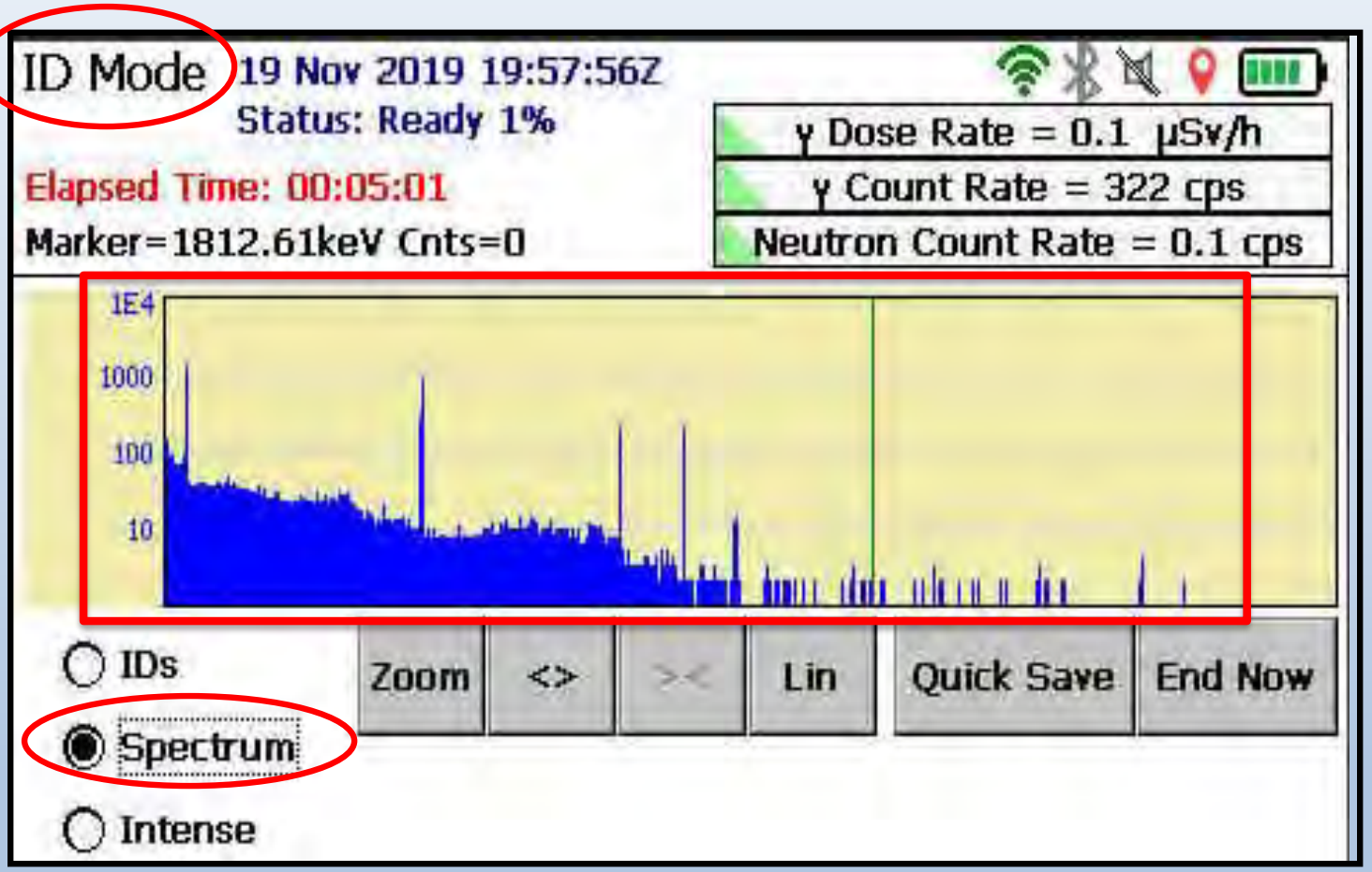


When elevated counts are detected, auto ID will start

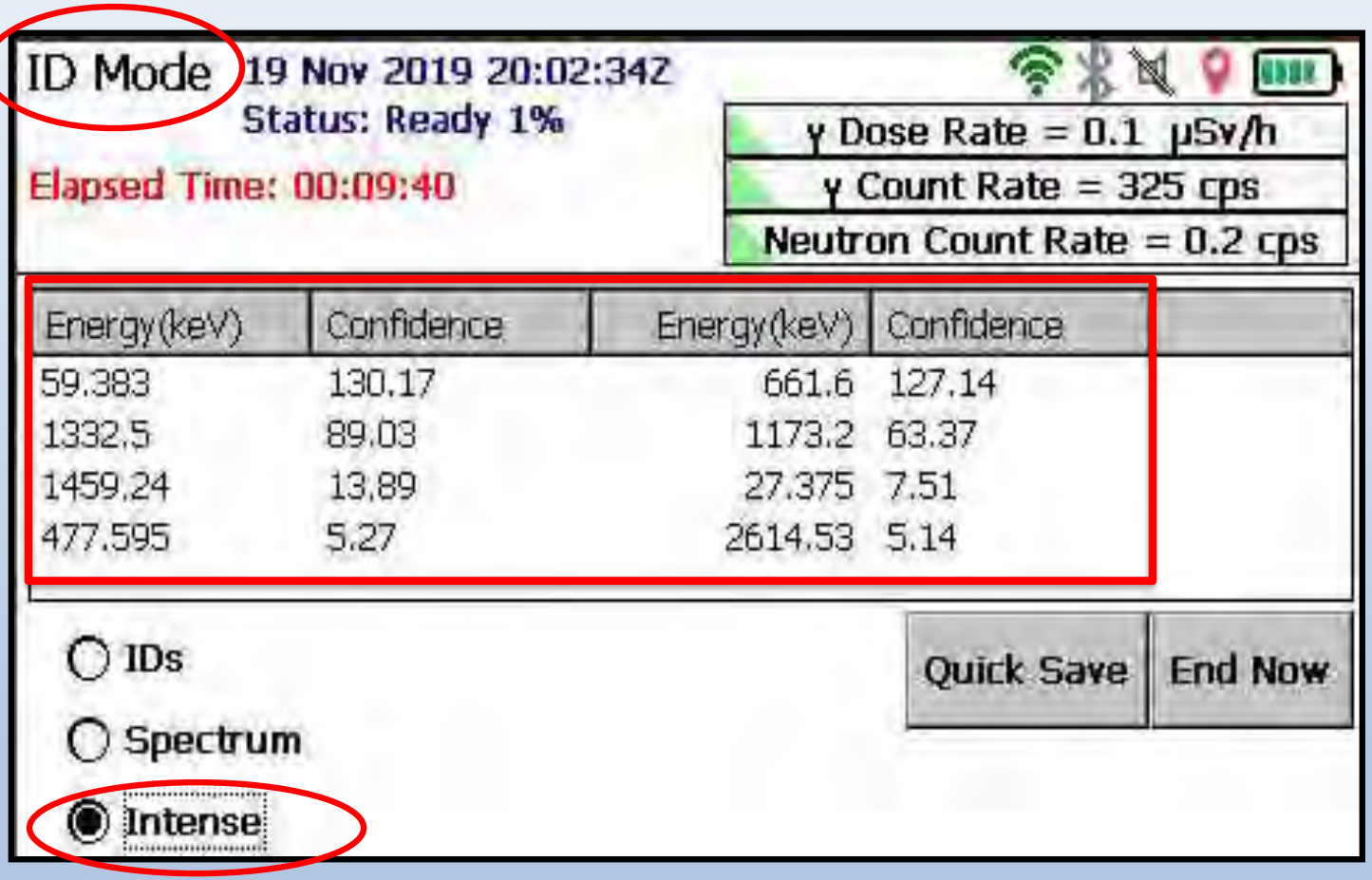
ID Mode


ID Mode
19 Nov 2019 18:08:39Z
Status: Ready 2%
Elapsed Time: 00:02:50
γ Dose Rate = 0.1 µSv/h
γ Count Rate = 515 cps
Neutron Count Rate = 0.1 cps
I
Co-60
Ind
104.0
IDs
Spectrum
Intense
Quick Save
End Now

ID Mode - Spectrum



ID Mode – Intense (*Intensity*)



High Purity Germanium

Phased Approach

Radiation Search

Wide Area Search

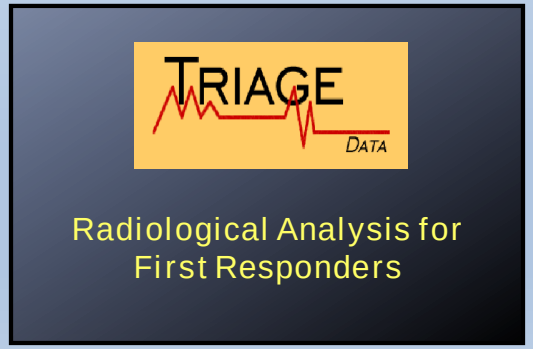
Small Area Search

Localization/Pinpointing

Radioisotope Identification

Screening

Identification



Data Analysis

Three Step Process for Radiological Response

Detection, identification, and recovery of a radiation source

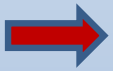
Step 1

Survey, Detection, Localization and Pinpointing

Radiation Pager

Radiation Backpack

SPARCS Mobile System

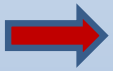


Step 2

Screening and Identification

Radioisotope Identifier (RIID)

High Resolution RIID



Step 3

Recovery

Tele-probe

Health Physics Kit

What Type of Instruments?

Health Physics Kit and Tele-probe for Safety

Used to provide personal protection and survey for contamination

Alpha and beta survey meters, dosimeters, extendable tele-probes

Compact and easy to operate, used by expert personnel

Interfaces – LCD display and audio

How is an HP Kit used at an MPE?

Survey for Contamination on a Suspect Package

Personal Protection

Tele-Probe Detector

Extendable long probe for measuring dose rates

FH-40 Tele-probe

Extendible up to 4 meters

Detectors

Proportional tube (internal)

Can be used with several probes

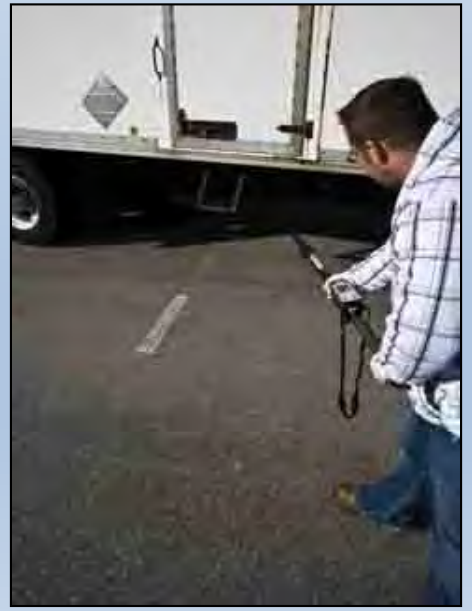
Unit Dimensions

0.4 kg

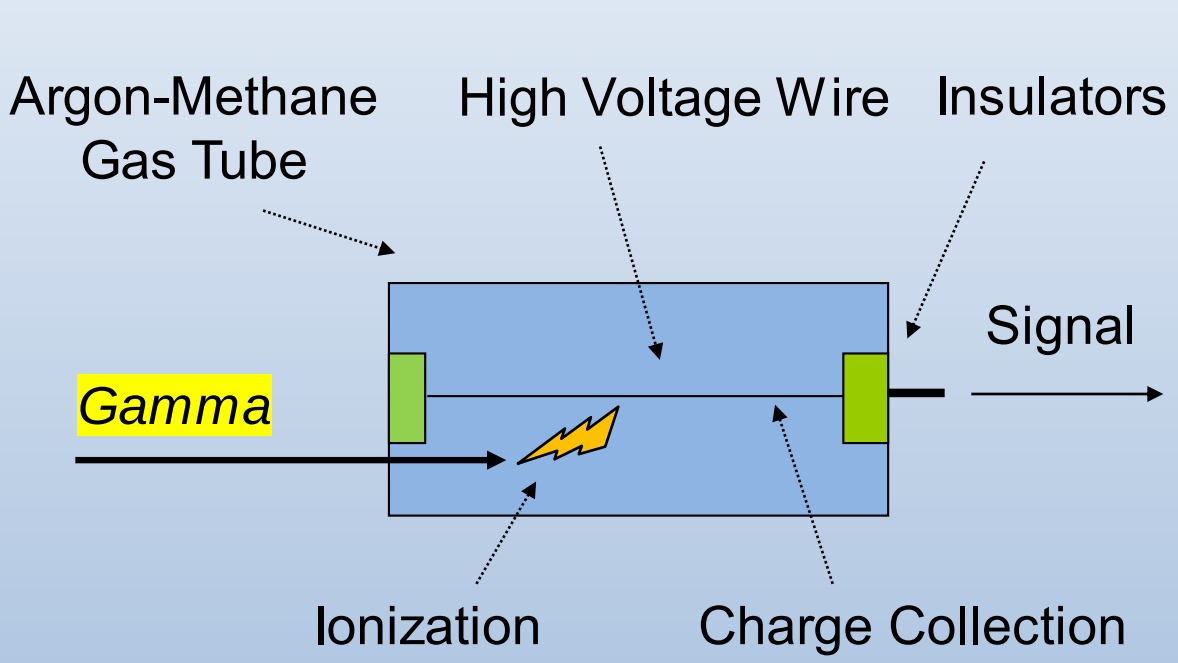
20 cm L x 7 cm W x 4 cm H

Uses

Measure dose rates



Geiger-Mueller Gamma Detector



Small "peanut size" detectors with high dose range for dose rate meters and alarming dosimeters

Health Physics Kit

Calibrated instrument for measuring dose rate and contamination

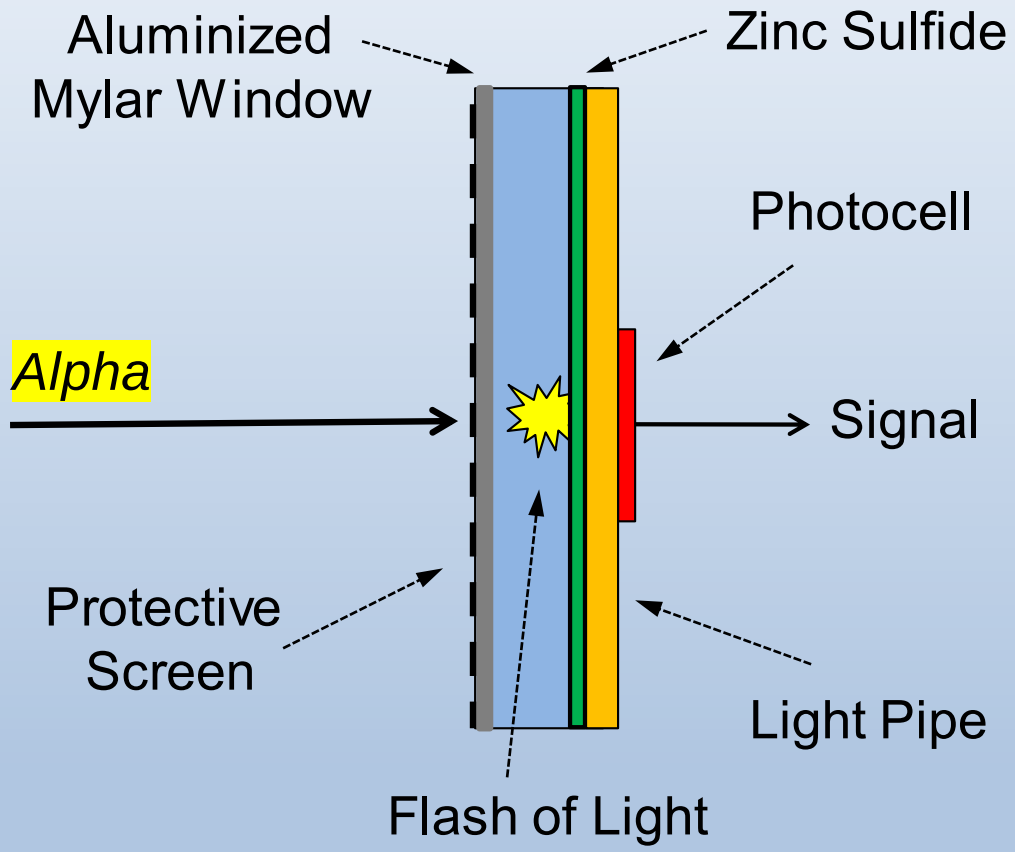
- **Internal Geiger-Muller detectors**
  - Two separate detectors
  - Low dose and high dose
  - Beta window on low range detector
- **Pancake probe (beta/gamma)**
  - Geiger-Muller detector
- **Alpha probe**
  - Zinc sulfide scintillation detector
  - Mylar window
  - 100 cm^2 surface

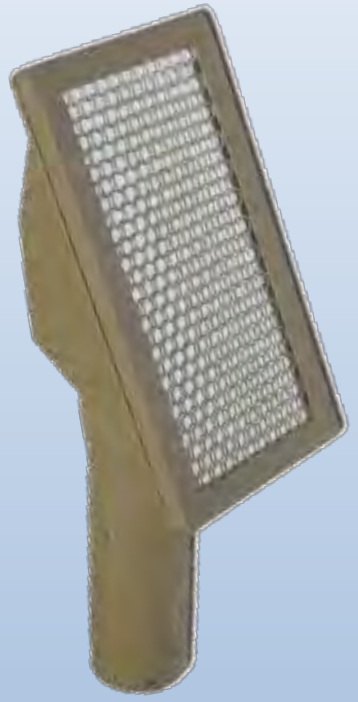
Health Physics Kit has Two Detector Probes

Alpha Probe

Beta Probe

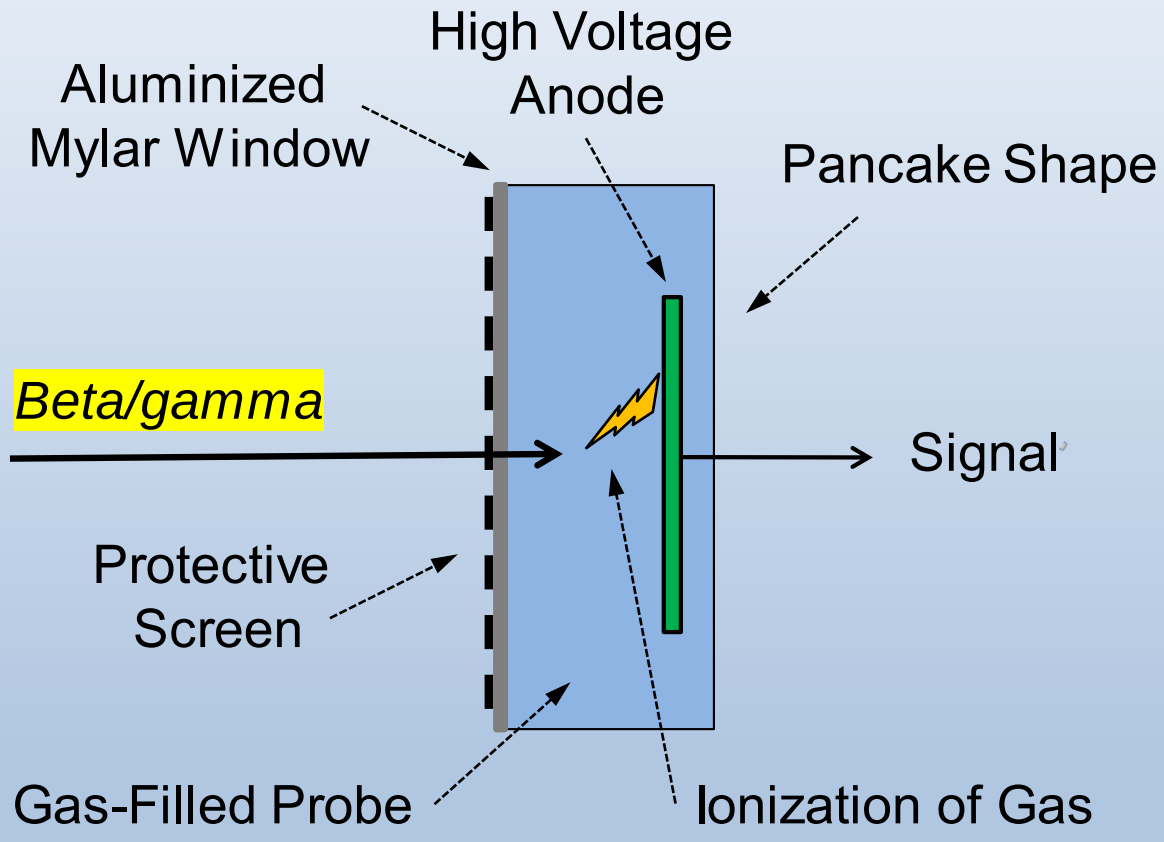
Alpha Scintillation Probe





Large surface area probe for surveying for alpha contamination

Beta/Gamma Pancake Probe



Pancake probe for surveying for beta/gamma contamination

Alpha Probe Detector

Beta Probe Detector

Three Step Process for Radiological Response

Detection, identification and recovery of a radiation source

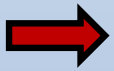
Step 1

Survey, Detection, Localization and Pinpointing

Radiation Pager

Radiation Backpack

SPARCS Mobile System

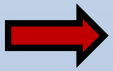


Step 2

Screening and Identification

Radioisotope Identifier (RIID)

High Resolution RIID



Step 3

Recovery

Tele-probe

Health Physics Kit

Summary

- Basic radiological response operations can be described in a Three Step Process:
  - **Detection** (Search and/or Survey)
  - **Identification** (of the Radioisotope)
  - **Recovery** (of the Source)
- Radiation detection instruments have been developed for each of these applications

Radiation detection equipment is relatively easy to operate but requires practical hands-on training to gain proficiency and confidence

Office of Counterterrorism and Counterproliferation

Nuclear Incident Policy and Cooperation

Radiation Detection Instrumentation Questions/Discussion

Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

Workshop Overview

Day 1 Major Public Events Overview and Nuclear Security Threats

Day 2 Radiation Detection and Emergency Response Equipment

Day 3 Nuclear Security Planning and Operations

Day 4 Alarm Interdiction and Adjudication and Source Recovery

Monday – Thursday

09:00-11:00 Washington, DC Time

Office of Counterterrorism and Counterproliferation
Nuclear Incident Policy and Cooperation

International Radiological/Nuclear Training for Emergency Response – Major Public Events Virtual Workshop

U.S. Department of Energy, National Nuclear Security Administration
Office of Nuclear Incident Policy and Cooperation

Date 2022
Washington, D.C., U.S.A.