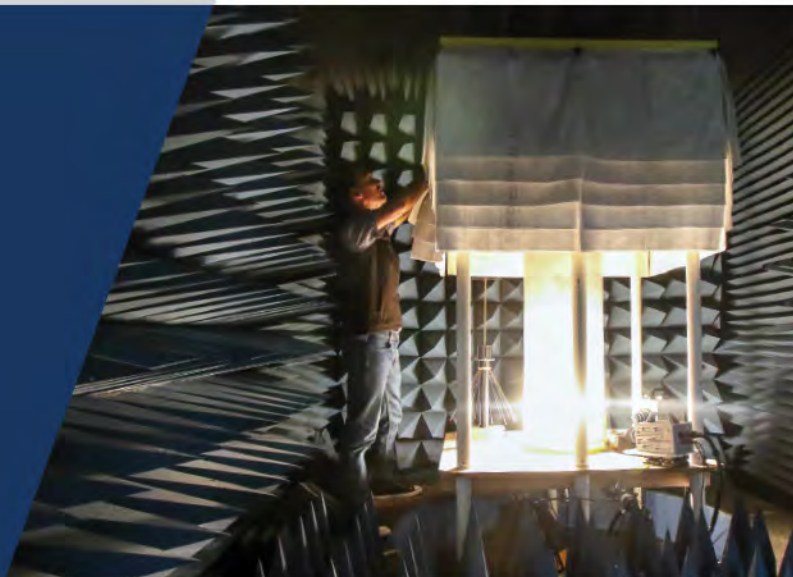




International Detection Equipment for Materials Out of Regulatory Control

Institute of Nuclear Materials Management 63rd Annual Meeting



Office of Nuclear Incident Policy and Cooperation

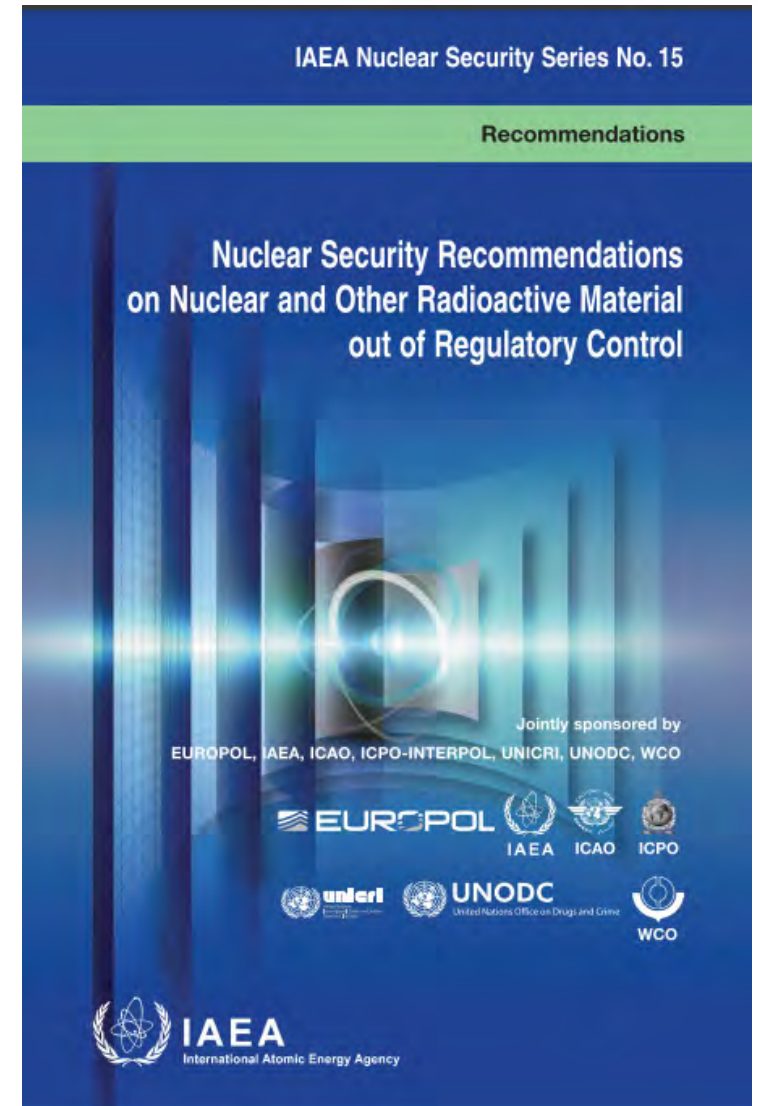
Sanjoy Mukhopadhyay, PhD

Sr. Principal Scientist

Remote Sensing Laboratory – Joint Base Andrews

July 26, 2022

- ▶ Introduction to the Office of Nuclear Incident Policy and Cooperation
- ▶ US National Assistance Capability (NAC) registered with the International Atomic Energy Agency (IAEA) Response and Assistance Network (RANET)
- ▶ International Aerial Measuring System
- ▶ International Consequence Management
- ▶ Radiation detection equipment and hands-on training



Nuclear Incident Policy and Cooperation

- ▶ The Office of Nuclear Incident Policy and Cooperation develops policy and provides capacity-building emergency preparedness training to counter and respond to radiological and nuclear incidents, accidents, and terror threats.
- ▶ Its experts provide nuclear and radiological technical support to domestic and foreign partners; operational support for major public events and emergencies; international nuclear and radiological incident modeling capabilities; and tabletop exercises.
- ▶ The Office provides long-term equipment loans to foreign partners, offers subject matter expertise to develop international guidance and standards with the IAEA, and coordinates with the IAEA's Incident and Emergency Center for international radiological or nuclear incident response.
- ▶ The Office conducts international exercises and counter nuclear smuggling scenario-based policy discussions.
- ▶ Additional international activities include workshops and training specifically designed to build foreign partners' emergency preparedness capacity. These events focus on responding to radiological emergencies, securing major public events, and countering radiological dispersal devices, or "dirty bombs."
- ▶ The Office also delivers radiological medical training for foreign first responders and partners with the North Atlantic Treaty Organization (NATO) and the US Department of Defense to hold training courses on nuclear and radiological incident response.

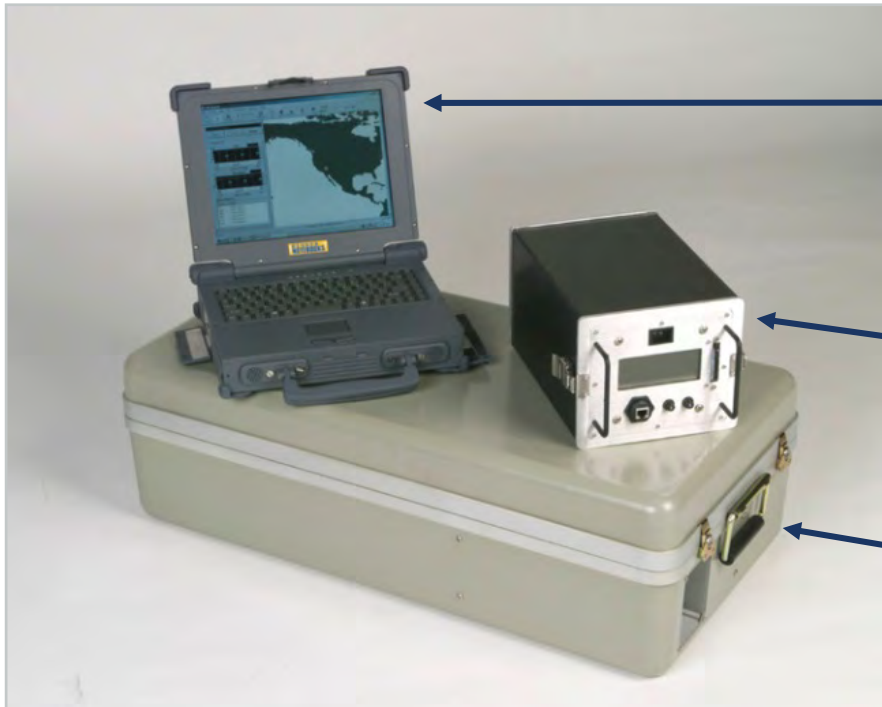
Spectral Advanced Radiological Computer System (SPARCS)

- ▶ Modular radiation detection system designed for use in any mobile platform (e.g., car, truck, boat, and aircraft)
- ▶ Two different detector configurations:
 - Aerial **SPARCS-A** and Mobile **SPARCS-M**
- ▶ Installation and ready to operate in 30 minutes
- ▶ Battery power 12–28 volts
- ▶ User-friendly graphical user interface



To date, world inventory includes 17 SPARCS-A and 24 SPARCS-M distributed to 12 countries/entities.

SPARCS Basic Components



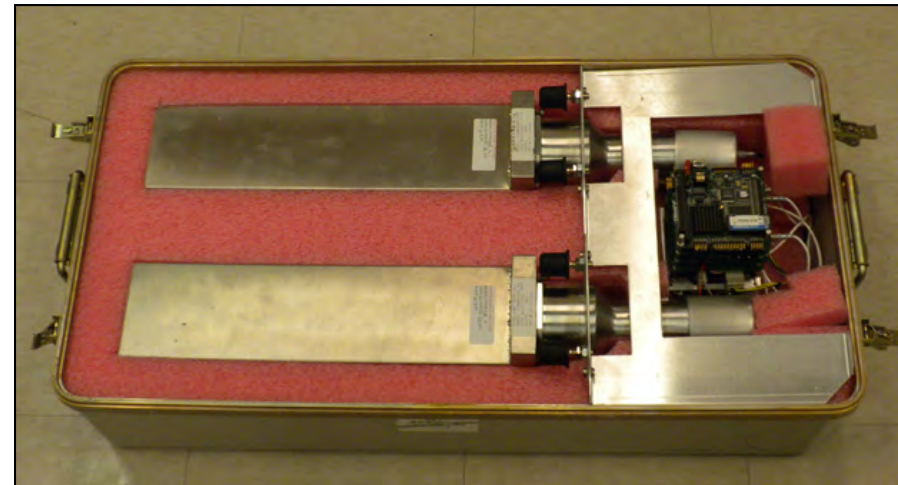
Cabin Display
(rugged notebook computer)

Acquisition and
Telemetry Unit (ATU)

Detector Pod



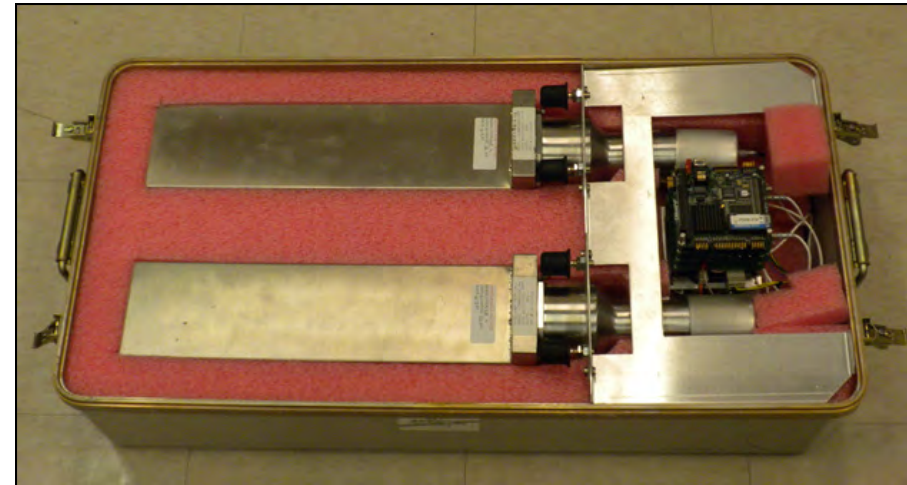
SPARCS-A



SPARCS-M

SPARCS-M Detector Pod

- ▶ Two NaI(Tl) gamma detectors
 - 2" x 4" x 16" (5 x 10 x 40 cm)
 - One pod
- ▶ Support electronics
 - HV power supplies
 - Preamplifiers
 - Multichannel analyzers
- ▶ Size
 - WDH: 16.5" x 32.5" x 10" (42 x 83 x 25 cm)
- ▶ Weight
 - 78 lb (35.4 kg)



Acquisition and Telemetry Unit (ATU)

ATU

- Records detector data
- Records GPS coordinates
- Stores data on CompactFlash card
- Provides data for laptop display
- Provides DC power for detector pod
- Size (WDH) 7.3" x 11.5" x 6.2"
(19 x 30 x 16 cm)
- Weight 10.5 lb (4.8 kg)



Front view

Power ON/OFF

CompactFlash card

Ethernet (RJ45) to computer

Ports

GPS antenna connector

Ethernet (RJ45) to computer (alternate)



Rear view

Serial port

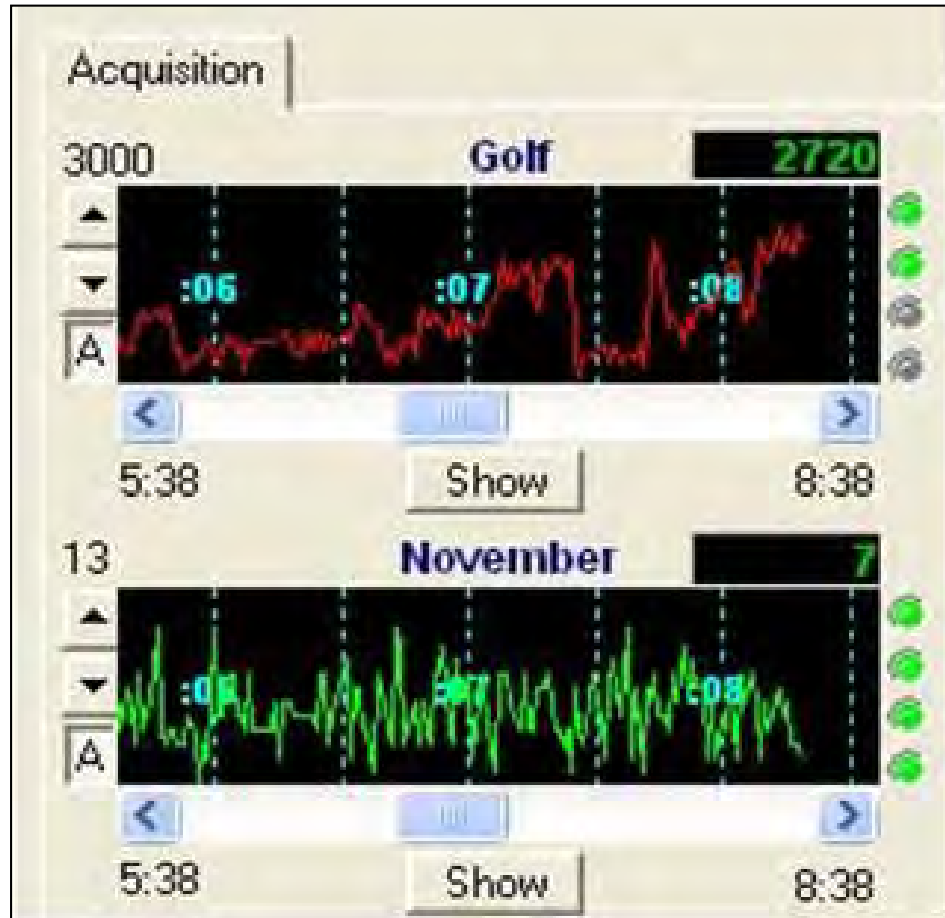
DC power input

Detector pod connector

Video output

Keyboard input

Count Rate Strip Charts/ALARM History



Strip Charts

Alarm History

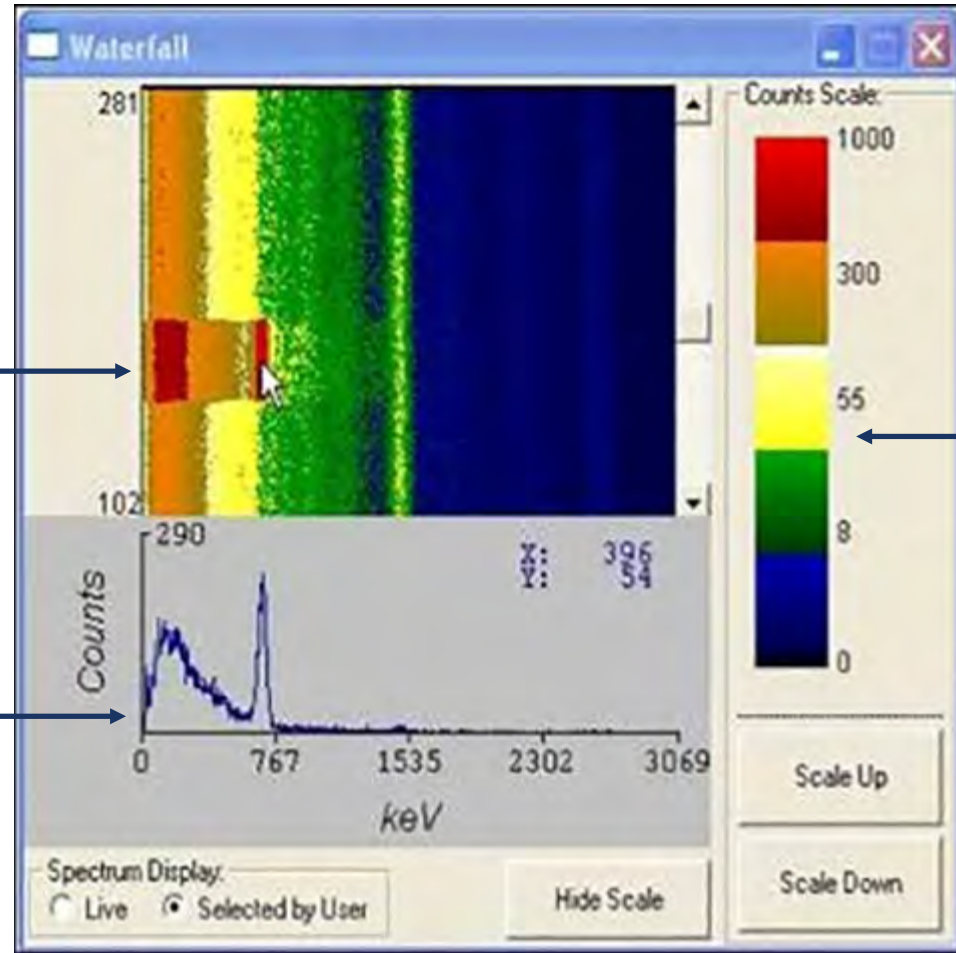
Event	Alarm	GPS Time
2186	Golf Alarm 4	21:13:34
2186	Ratio Alarm 4	21:13:34
2278	Golf Alarm 4	21:15:06
2496	Golf Alarm 4	21:20:44
2497	Golf Alarm 4	21:20:45
2558	Golf Alarm 4	21:21:46
2559	Golf Alarm 5	21:21:47
2560	Golf Alarm 4	21:21:48
2722	Golf Alarm 4	21:24:30
2723	Golf Alarm 4	21:24:31
2836	Golf Alarm 5	21:52:05
2836	Ratio Alarm 4	21:52:05
2837	Golf Alarm 6	21:52:06
2837	Ratio Alarm 4	21:52:06
2838	Golf Alarm 6	21:52:07
2838	Ratio Alarm 4	21:52:07

Alarm History

Waterfall Plot (Gamma Energy)

Visual indication of radiation source

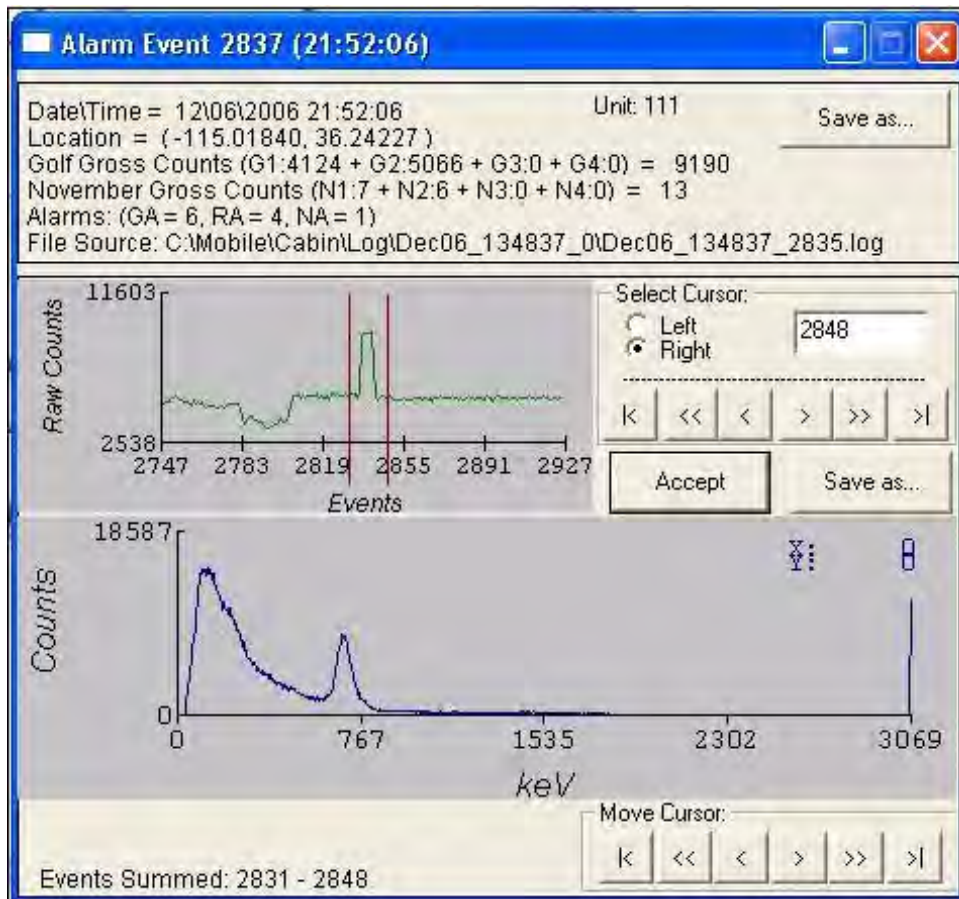
Gamma spectrum



Counts scale

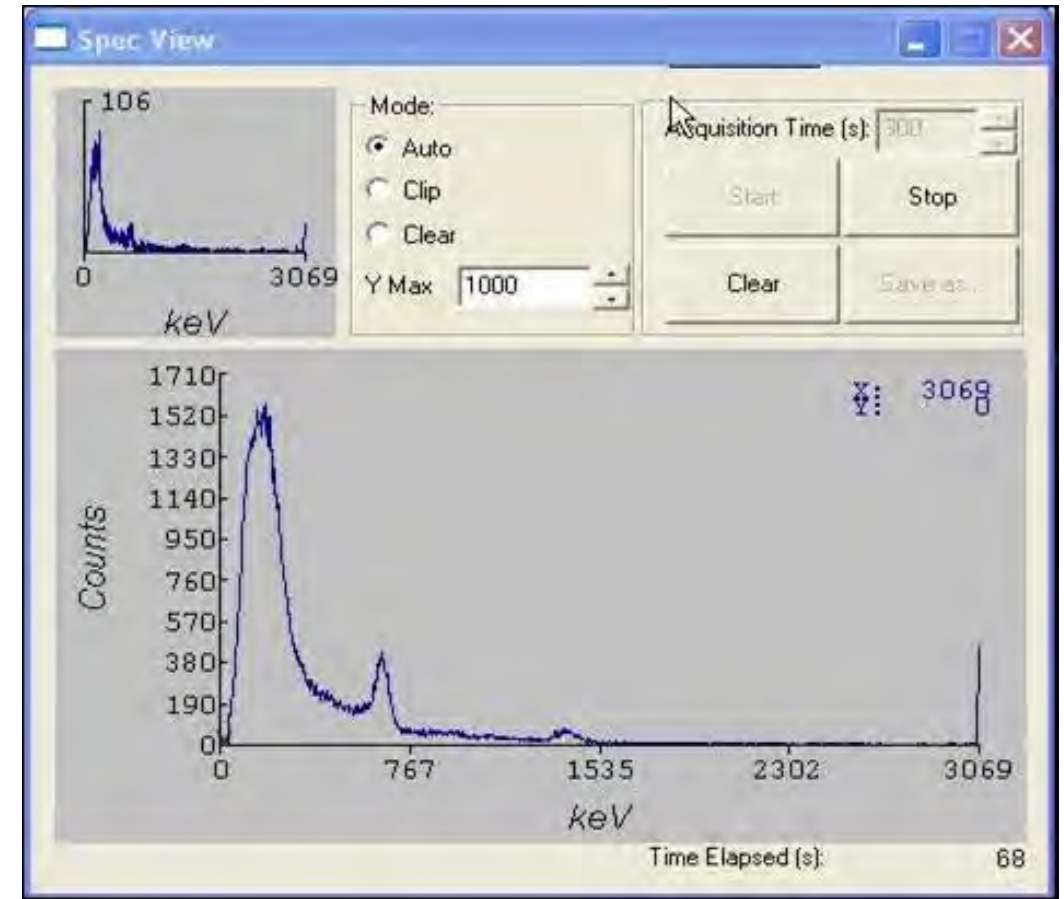
ALARM Event View

- Date/Time
- Counts
- Gamma spectrum
- GPS location
- Alarms



Spectral View

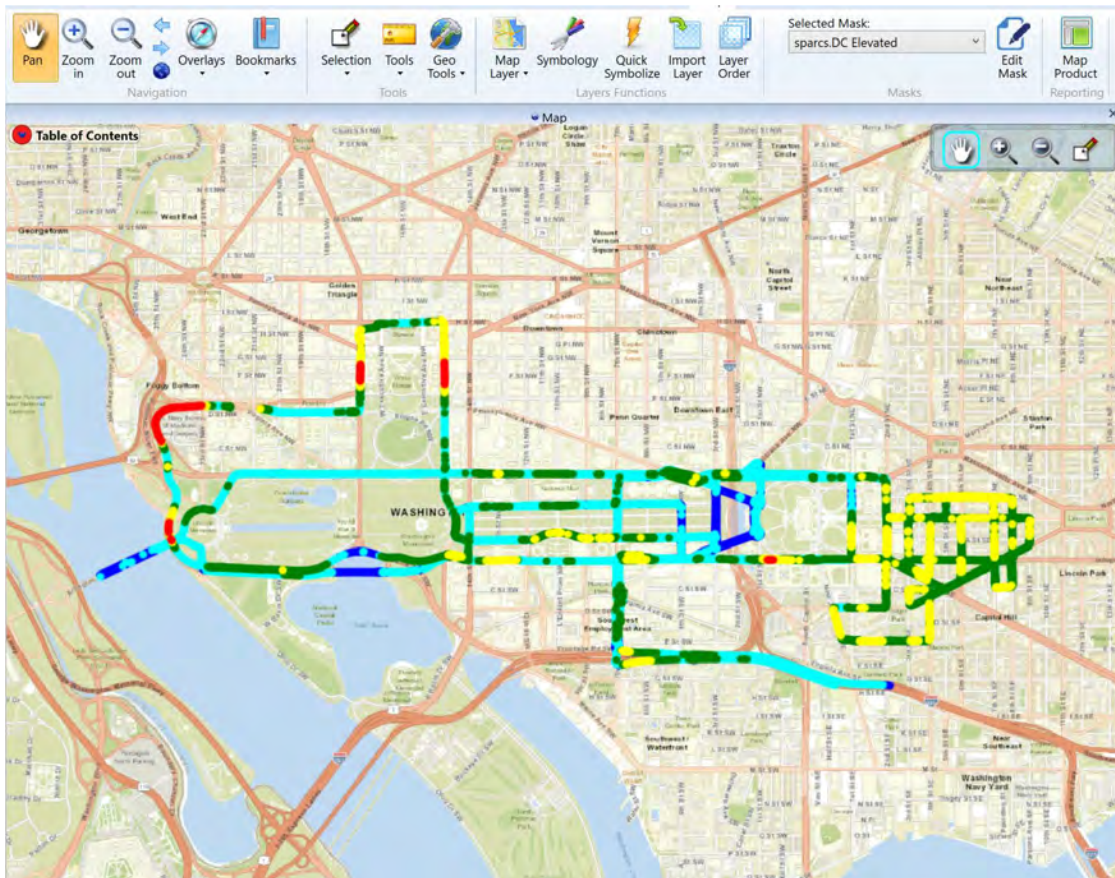
- View gamma spectrum
- Counts vs. energy in keV



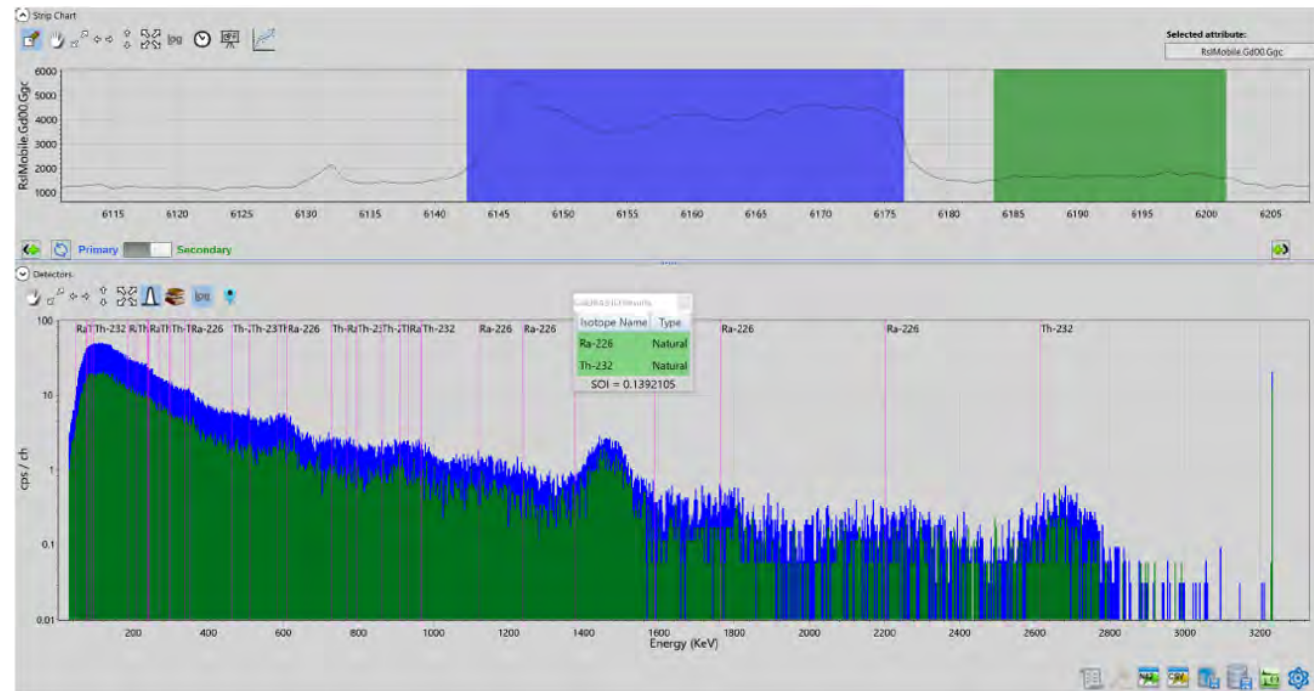
iAVID – International Advanced Visualization and Integration of Data

SPARCS data collection and analysis on iAVID

Mask on the elevated counts

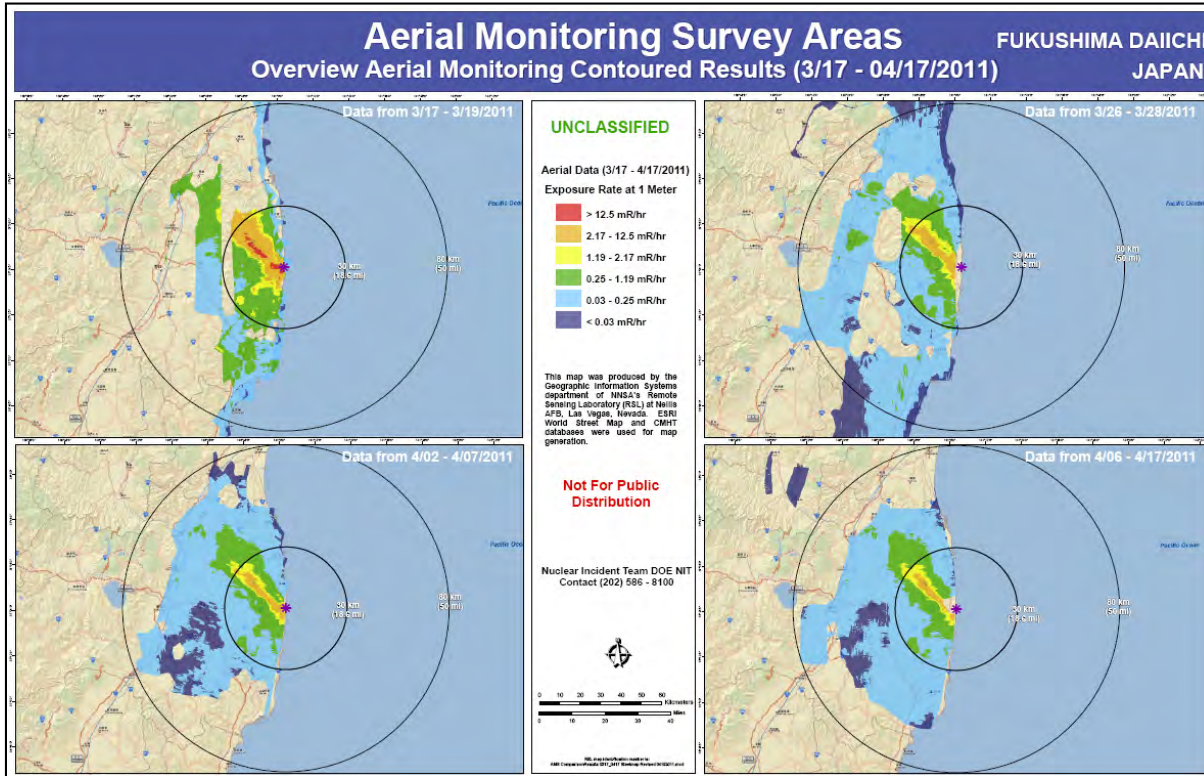


GADRAS evaluation of red zone – high counts area

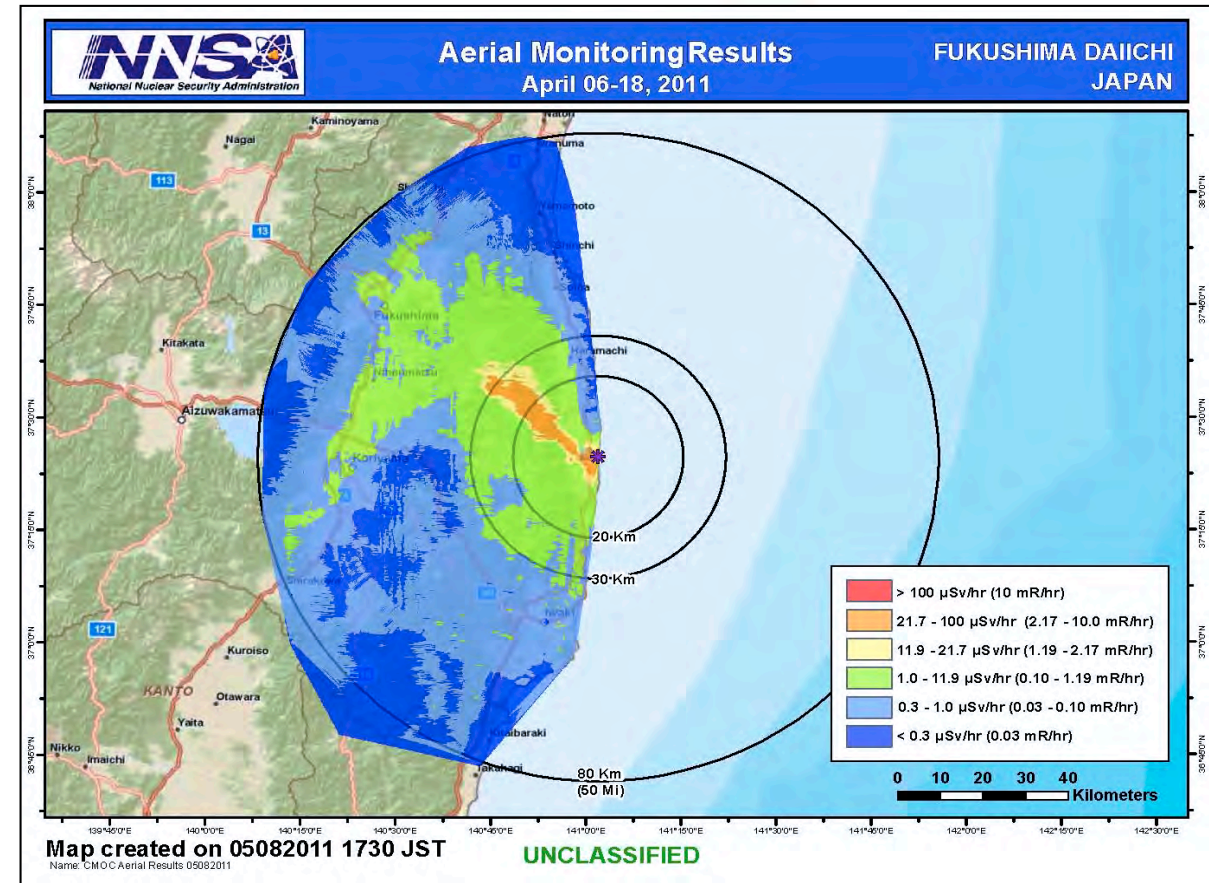


Elevated thorium and radium shown – statues and pavement

Fukushima Response



March 17–April 17, 2011



April 6–18, 2011

From March 16 to May 28, 2011, DOE conducted over 100 AMS flights and 525 flight hours over an area of 25,000 km² out to 80 km from Fukushima

SPARCS is a radiological data acquisition and analysis system designed for the nuclear or radiological emergency response mission.

- ▶ Modular system that records gamma radiation levels, spectral data, and GPS coordinates
- ▶ Operator display with key data and position tracking on a map
- ▶ Portable, lightweight, and durable—can be mounted on a variety of vehicles, including boats and aircrafts
- ▶ A wide array of applications—search, portal monitoring, pre-event baseline surveys, and emergency response
- ▶ Easy to install and operate

Human Portable (Backpack) Radiation Detectors

- ▶ Usually contain both gamma and neutron sensors
- ▶ Scintillator-based systems ruggedized for field operations
- ▶ Reach-back communication data telemetry with smartphones
- ▶ Capable of crude isotope identification

Examples of commercial off-the-shelf (COTS) backpack detector systems



COTS Backpack – Thermo Scientific PackEye



Battery life	30 hr (20 hr with PDA operation via Bluetooth)
Battery type	Rechargeable NiMH, power pack (7.2 V)
Description	FHT 1377 GN-2 PackEye Radiation Detection Backpack
Height	580 mm (22.8")
Depth	18 cm (7")
Radiation type	Gamma and neutron (gamma only available)
Weight	6 kg (16.5 lb)
Width	300 mm (11.8")
Alarms	Artificial gamma alarm: Typically better than 20% of natural background
Energy range	20 keV to 3 MeV
Temperature range	-20°C to +50°C

COTS Backpack – BNC (Berkeley Nucleonics Corp.) SAMpack 120 (RD-120)



Detection type: Gamma and neutron

Scintillation type: NaI and CeBr₃

Wi-Fi, Bluetooth, GPS, and USB

Weight <9 lb (4 kg)

Low power consumption and lithium ion; battery allows 24 hr operation

Clandestine mode with or without earphones
(e.g., vibration mode, color alert, real-time spectrum)

Automated detector calibration

Smartphone, ring tones, camera, etc.

COTS Backpack – Mirion Technologies SPIR-Pack



Nal(Tl) detector: 51 mm (2") diameter × 102 mm (4") length

Energy compensated GM tube for accurate high gamma dose rate from multiple radionuclides

Optional lightweight neutron detector: LiZnS. Detects primarily the gamma radiation and provides neutron source confirmation capabilities

Optional sensitive neutron detector: BZnS

Energy range

- 25 keV to 3 MeV (gamma)
- 0.0025 eV to 15 MeV (neutron)

Gamma dose range: 0.001 μSv/h up to 100 mSv/h (0.1 μR/h to 10 R/h)

Gamma sensitivity to ¹³⁷Cs: 3500 cps/(μSv/h) or 35 cps/(μR/h)

Continuous real-time nuclide identification

- Single, bare or shielded, and mixed isotopes
- Seven libraries containing 80 nuclides
- Identifies up to eight nuclides simultaneously
- Continuous energy stabilization using ambient background

COTS Backpack – RSI (Radiation Solutions, Inc.) RS-340



Gamma crystal type and size: 3" x 3" NaI(Tl) or 2" x 4" NaI(Tl)

Energy range: 12 keV to 3 MeV

Energy resolution: <7.5 %

MCA channels: 2048

Neutron detector type: ^3He (or alternative)

GPS: internal

Communication: BT4.0, Wi-Fi, cellular adaptability, Ethernet, USB data storage

Battery life: 10 hr

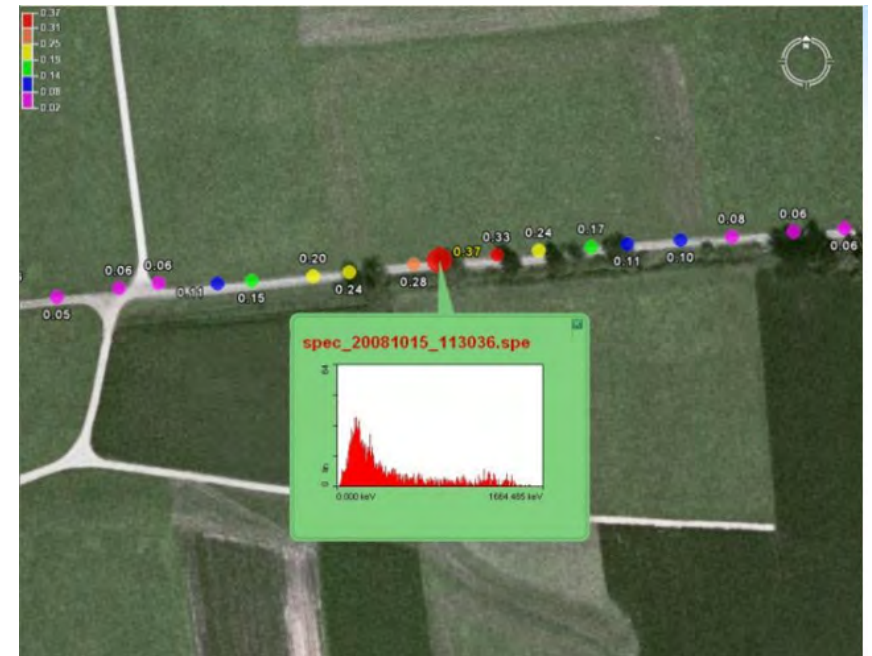
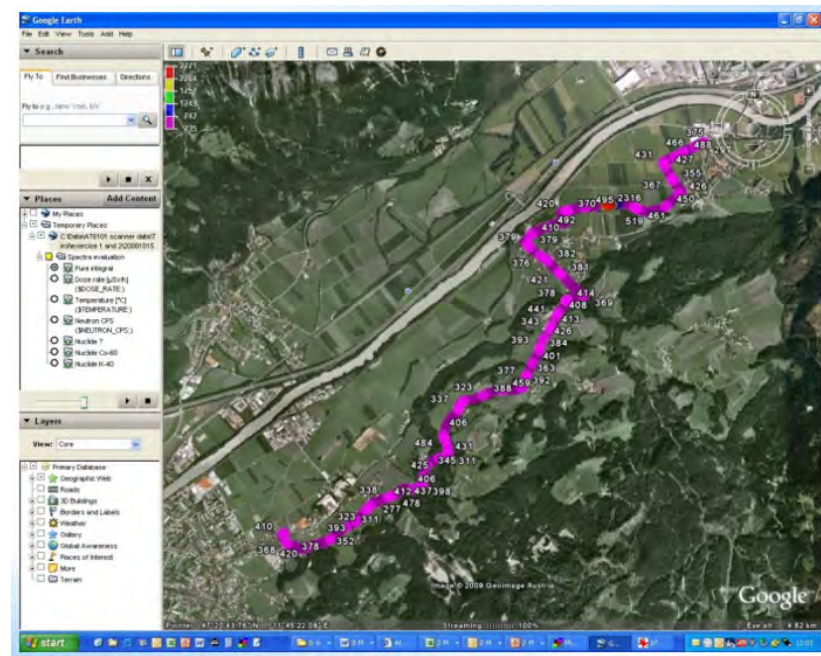
Operating temperature: -40°C to $+50^{\circ}\text{C}$ / -40°F to $+122^{\circ}\text{F}$

Stabilization: Automatic and continuous; no source required

COTS Backpack – Atomtex AT6101C



Batteries	<p>HPC and BT-DU3 adaptor</p> <p>Continuous operation time >15 hr</p> <p>Charge batteries once a month even if you do not use the backpack</p>
PDA	<p>Clean PDAs memory regularly</p> <p>To save battery power, shut down the PDA correctly</p> <p>Transfer data regularly to save the space in PDSA</p>
Stabilization	<p>At each startup, select YES when the request for stabilization pops up</p> <p>KCl sample should be located in the side pocket next to the gamma detector</p> <p>If required, perform manual stabilization (Menu – Spectrometer – Stabilize)</p>



COTS Backpack – Bruker Detection Corp. Sentry



Detector: 3" x 3" (7.6 x 7.6 cm) NaI(Tl)

Gamma energy resolution: $\leq 8\%$ at 662 keV

Gamma energy response range: 30 keV to 3 MeV

Isotope identification time: Nominally 2 seconds, designed to ANSI N42.53

Battery-powered operation: Over 8 hours with rechargeable batteries (universal chargers included)

Weight: Under 14 lb (6.4 kg)

Dimensions: Approximately 20" x 15" x 10" (51 x 38 x 24 cm)

Water and dust resistant

Operating temperature: -20°C to $+60^{\circ}\text{C}$

Humidity: $\leq 95\%$ non-condensing

COTS Backpack Systems Comparison

Backpack Model	Manufacturer	Detector Material & Size		Package Size	Ruggedized?	Dose Range	Weight
		Gamma	Neutron				
Guardian Predator	Nucsafe	PVT for gross counts NaI(Tl) for spectroscopic detection	⁶ Li glass fiber ⁶ Li solid state ¹⁰ B or ³ He tubes	16" x 24" x 6" (40.6 x 61 x 15.2 cm)	Yes	MIL standard	<30 lb (14 kg) ; <20 lb (9 kg)
FlexSpec	Bubble Technology Industries (BTI)	NaI:Tl 2" x 4" cylinder	³ He or optional non- ³ He	11.6" x 15.2" x 4.5"	Yes	500 R/h	22 lb
RadPack Max	Sensor Technology Engineering (STE)	CsI:Tl 1" x 4" cylinders 6 x 51 cc	³ He tubes 2" dia 7 x 44.3 in ³ (39.3 psi)	46 x 36 x 18 cm			8.6 kg
RS-350/RS-340	Radiation Solutions, Inc. (RSI)	NaI:Tl RS-350: 3" x 3", 2 ea. RS-340: 3" x 3", 1 ea.	³ He 2" dia x 9" long RS-350: 4 ea. RS-340: 2 ea.	RS-350: 20" x 12.5" x 8" RS-340: 19" x 12.25" x 6.5"		0.8 mSv/h with spectrum; 250 mSv/h with GM detector	RS-350: 15 to 19 lb RS-340: 8.5 to 9.5 lb
SPIR-Pack	Mirion Technologies	NaI:Tl 2" x 4" cylinder	¹⁰ BZnS:Ag	G: 30.3 x 25 x 46 cm (11.9" x 10" x 18.1") GN: 29 x 20 x 51.5 cm (11.4" x 7.9" x 20.3")		0.1 μR/h to 10 R/h	15 lb
SAMPack 120 (RD-120 LGN)	Berkeley Nucleonics Corp.	NaI:Tl 3" x 3"		10" x 5" x 6"		10 nR/h to 10 R/h	8 lb max (with NaI detector)
AT6101C	Atomtex	NaI:Tl 2.5" x 2.5"	³ He tubes	17.7" x 13" x 10"	Yes		15 lb
RanidPro200	EnviroNics	LaBr ₃ :Ce 1.5" x 1.5" NaI:Tl 2" x 2"	⁶ Li:ZnS(Ag)	44 x 34 x 19 cm (17" x 13" x 7")		0.01 to 100 μSv/h	4.7 kg with LaBr ₃ :Ce 5.9 kg with NaI:Tl

Radioisotope Identification Devices (RIIDs)

Typical Energy Resolutions of Different RIIDs Gamma-Ray Detector Types

Detector Type	Full Width at Half Maximum (662 keV)
NaI(Tl)	6%–8%
LaBr ₃	2%–4%
CeBr ₃	4%–5%
CZT	1%–2%
HPGe	<0.2%

Radioisotope Identification Devices (RIIDs)

- ▶ FLIR identiFINDER R400
- ▶ Detect, locate, measure, and identify radioactive sources
- ▶ Switching on/off
 - Dose rate mode
 - Finder mode
 - Identification mode
 - GPS location available



FLIR identiFINDER R400 – Different Types

R400 Name	Material and Dimensions	Neutron Detection	GM Counter
R400-NG	NaI(Tl) 2" x 1.4"	N	Y
R400-NGH	NaI(Tl) 2" x 1.4"	Y	Y
R400-ULCS-NG	NaI(Tl) 2" x 1.4"	N	Y
R400-ULCS-NGH	NaI(Tl) 2" x 1.4"	Y	Y
R400-ULK-NGH	NaI(Tl) 2" x 1.4"	Y	Y
R400-UW-ULCS-NGH	NaI(Tl) 2" x 1.4"	Y	Y
R400-LG	LaBr ₃ 1.2" x 1.2"	N	Y
R400-LGH	LaBr ₃ 1.2" x 1.2"	Y	Y

Switching on R400

- ▶ Press power button
- ▶ System self-check
- ▶ Display indicates instrument's status
- ▶ Ready for use when dose rate is displayed



Identification Mode

► Unclear results

- “UNK” unknown
- “Not in library”
- “Activity too low”

► Special identification results

- “Uranium” does not specify if source is natural, depleted, or enriched uranium
- Plutonium does not specify burn-up grade
- ^{241}Am is one of the daughter products of plutonium – ^{214}Am is possible indication of plutonium

Technical Specifications

- Dimensions (L × W × H): ≤3.7" × 10.6" × 3.2" (9.4 × 26.9 × 8.1 cm) – with battery
- Weight: ≤3.2 lb (≤1.5 kg)
- Temperature range: -4°F to 122°F (-20°C to 50°C)
- Scintillator dose rate range: 0 nSv/h–500 μSv/h (0 nrem/h–50 mrem/h)
- GM counter dose rate range: 100 μSv/h–10 mSv/h (10 mrem/h–1.0 rem/h)
- Energy range (gamma): 20 keV–3 MeV
- Resolution: 4.5% FWHM at 662 keV with LaBr₃ crystal (dimension: 1.2" × 1.2" [30 × 30 mm])
- Memory: More than 600,000 spectra onboard memory

Workshops and Training Courses

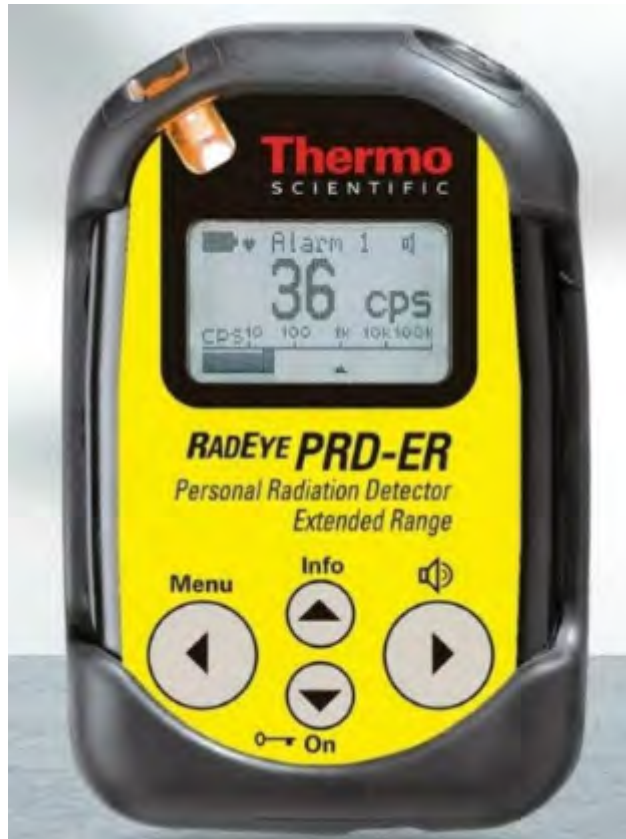
The technical workshops and training courses are designed to address all aspects of best practices in nuclear or radiological emergency, including the following:

- ▶ Radiation basics and health physics
- ▶ Emergency response planning and operational procedures
- ▶ Radiation search, detect, locate, and identify
- ▶ Aerial radiological search operations
- ▶ Alarm interdiction and adjudication
- ▶ Personal protective equipment
- ▶ Contamination surveys and assessment
- ▶ Source recovery operations
- ▶ Consequence management planning
- ▶ Medical response to radiation injuries



The events are designed for Competent Authority technical experts, senior security and law enforcement officers, emergency management, and other key federal agency officials.

Personal Radiation Detectors (PRDs)



Thermo Scientific RadEye
PRD/PRD-ER



Thermo Scientific RadEye
SPRD-ER



Polimaster PM1703GN

The instrument shall include the following requirements:

- ▶ A display that is easily readable over the required temperature range and under different lighting conditions
- ▶ Controls that are user-friendly for routine operation
- ▶ A menu structure that is simple and easy to follow
- ▶ The capability of operation if the user is wearing gloves
- ▶ A display that provides the user with an instantly recognizable indication of the fact that the magnitude of radiation present has increased

RadEye GN Specifications

Technical details of the Thermo Scientific RadEye GN Gamma Neutron Pager

Size	96 mm x 61 mm x 31 mm
Weight	160 g
Battery life time	> 300 h
Detection capability	Gamma count-rate from 30 keV to 1.3 MeV Energy compensated gamma dose rate from 45 keV to 1.3 MeV (H*(10)) from 1 μ Rem/h to 25 mRem/h (0,01 μ Sv/h to 250 μ Sv/h) Neutron count-rate from 0,1 to 1000 cps
Gamma efficiency	900 cps per μ Sv/h (Am-241); 130 cps per μ Sv/h (Cs-137); 60 cps per μ Sv/h (Co-60)
Neutron efficiency	4.3 cps/20,000 n/s Cf-252; shielded in 1 cm lead 25 cm in front of instrument with 30 cm x 30 cm x 15 cm PMMA phantom. Exceeds ANSI 42.32 and IEC 62401 alarm requirements
Order number	RadEye GN: #4250630

RadEye SPRD Specifications

Technical specification of the Thermo Scientific RadEye SPRD

Detector material:	CsI(Tl)-detector
Dose rate range:	0.01 $\mu\text{Sv/h}$... 250 $\mu\text{Sv/h}$ [1 $\mu\text{R/h}$... 25 mR/h]
Energy response:	40 ... 3000 keV
Measurement units:	cps, cpm, Sv/h, rem/h, R/h
Overload:	Tested up to 10 Sv/h [1000 R/h]
Protection rating:	IP 65
Battery type:	Rechargeable and non rechargeable batteries, 2 x AAA
Battery lifetime:	Approx. 170 h on alkaline batteries
Size:	104 mm x 67 mm x 41 mm [4.1" x 2.6" x 1.6"], with rubber shock protector
Weight:	190 g [0.4 lbs]
Number of channels:	1024



Radiation Pager by Sensor Technology Engineering (STE)



SPECIFICATIONS

Radiation Type	Gamma
Detector Type	Cesium iodide scintillator
Detector Size	5 cc
Sensitivity	2.2 cps per $\mu\text{R/h}$ at ^{137}Cs (662 keV)
Overrange Indication	Above 4 mR/h at ^{137}Cs (662 keV)
Integration Time	Multiple (<1, 2 seconds)
Size	9.3 x 5.6 x 2.3 cm
Weight	150 g with battery
Battery	1x AA lithium (Li-FeS ₂)
Battery Life (Operating)	3,500 hours
Environmental Protection	Per ANSI N42.32 (2016)
Water Ingress Protection	Waterproof
Temperature Range	-25°C to 50°C
Indicators	Visible, audible, vibration
Compliance	ANSI N42.32 (2016)
Bluetooth	Yes

Handheld Radiation Monitor (HRM) by STE



SPECIFICATION		Description
Radiation Type		Gamma, neutron
Gamma	Detector Type	Cesium iodide scintillator
	Detector Size	5 cc
	Sensitivity	2.2 cps per $\mu\text{R/h}$ at ^{137}Cs (662 keV)
Neutron	Detector Type	Helium-3 proportional counter
	Detector Size	1.81 in ³ (122 psi)
	Sensitivity	10.5 cps/nv
Integration Time		<1 second
Size		21.1 × 5.1 × 3.0 cm
Weight		369 g with battery
Battery		CR123A
Battery Life (Operating)		1 month
Environmental Protection		Shock, vibration, and drop resistant; waterproof to 66 ft
Indicators		Visible, audible, vibration
Data Streaming		Optional Bluetooth
Operational Availability		0.999

The NNSA Office of Nuclear Incident Policy and Cooperation develops policy and provides capacity-building emergency preparedness training to counter and respond to radiological and nuclear incidents, accidents, and terror threats. As part of this mission, the Office shares knowledge of nuclear and radiological threats with federal, state, local, and international partners by conducting training, exercises, and information exchanges.

- The Office provides equipment training reach-back support in preventive radiological/nuclear detection (PRND), consequence management, medical support to countries across the world
- The Office works closely with IAEA and has listed a large number of capabilities in NAC with RANET in both Field Assistance Team (FAT) and External Based Support (EBS)
- The Office provides state-of-the-art COTS and government off-the-shelf (GOTS) radiation detection equipment to foreign countries in the form of long-term loan

Questions?

Thank you for your attention