
How to choose a radioisotope identifier

A technical note for responders and operators: the instrument classes and the question each one answers, what the detector choice buys in the field, when a neutron channel is required, the standards to specify by number, and the response sequence from alarm to decision.

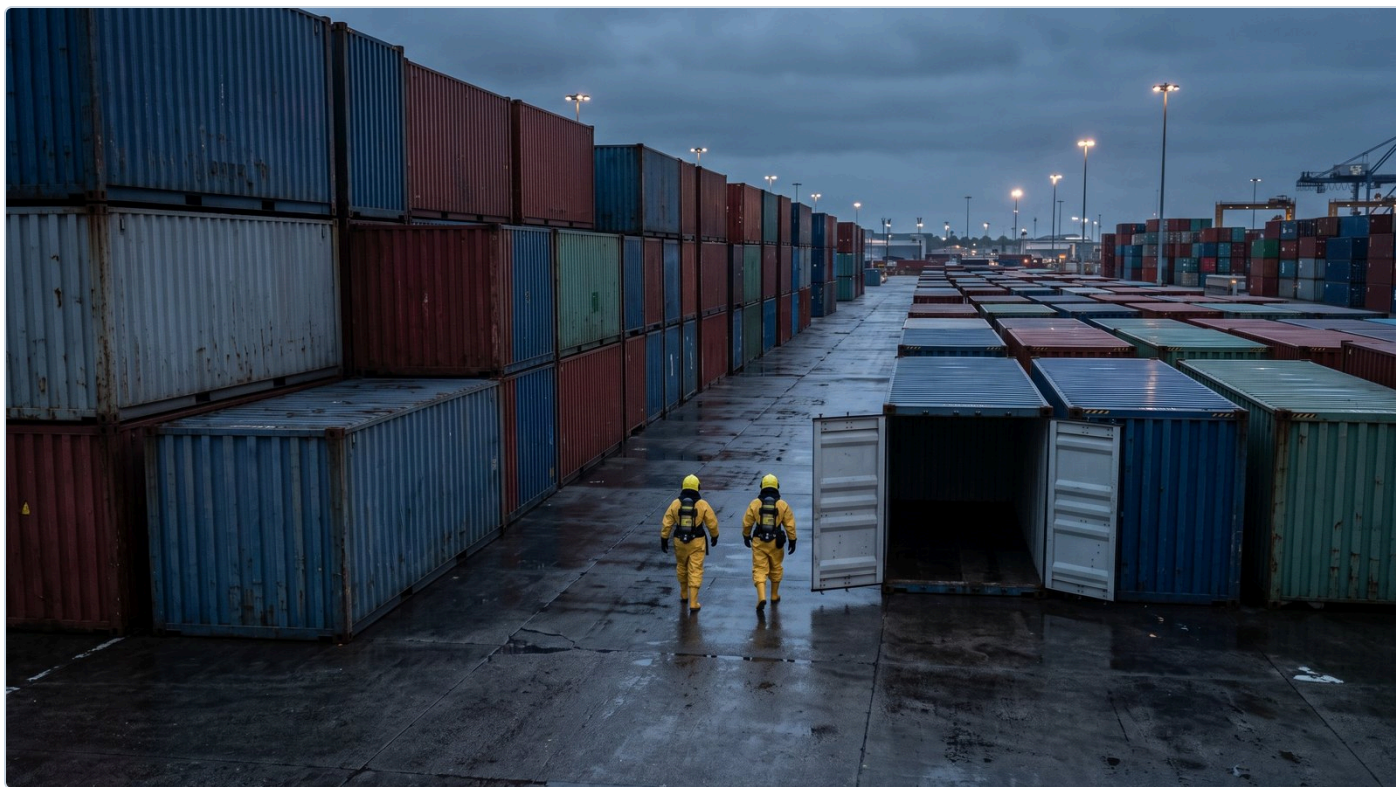
TECHNICAL NOTE · ISOTOPE ID

What am I looking at, and what do I do next

A detector on a belt has alarmed at a cargo door. A hazmat technician has a reading that will not clear. A boarding team has an elevated count in a hold. In each case the first instrument said only that radiation is present. The next decision, whether to stand down, hold the scene, or call for reachback and a response, depends on which isotope is producing it, and that is the question a radioisotope identifier answers.

A radioisotope identification device, or RIID, measures the energy spectrum of the gamma rays reaching its detector and matches the peaks against a library. It reports three things: an isotope, a category (special nuclear material, industrial, medical, or naturally occurring radioactive material), and a confidence. Those three outputs are what the operator acts on. Potassium-40 in a pallet of ceramic tile, technetium-99m in a patient who had a scan that morning, and a cesium-137 industrial gauge all set off a personal detector. They lead to three different next calls, and the identifier is what separates them.

This note is written for the people who make those calls: hazmat and fire officers, CBRN teams, and border and maritime interdiction units. It sets out the instrument classes and the question each one answers, what the detector choice buys, when a neutron channel is required, the standards to specify by number, and the response sequence from first count to decision. Every specification is taken from the current Berkeley Nucleonics datasheets. Figure 5 condenses the response sequence to one field card.



■ **ILLUSTRATION** **Figure 1.** Figure 1. A two-person entry team approaches a flagged container during secondary screening. The scene is illustrative; no real site, agency or instrument is depicted.

Five instrument classes, and the question each one answers

The ANSI N42 series defines a performance class for each kind of instrument a response program carries, and the IEC publishes a counterpart for most of them. Writing the class into a requisition by number is the shortest way to state what an instrument has to do. Figure 2 walks the choice; Table 1 lists the current line by class.

Personal radiation detector (PRD): ANSI N42.32, IEC 62401. Worn on the belt, always on, alarms on count rate. It answers one question: is radiation here, and is it rising as I move. It records no spectrum. The Model 951 nukeALERT is a gamma-only CsI pager with a 1 to 9 readout, watertight, with a two-year battery; it cues the identifier that follows.

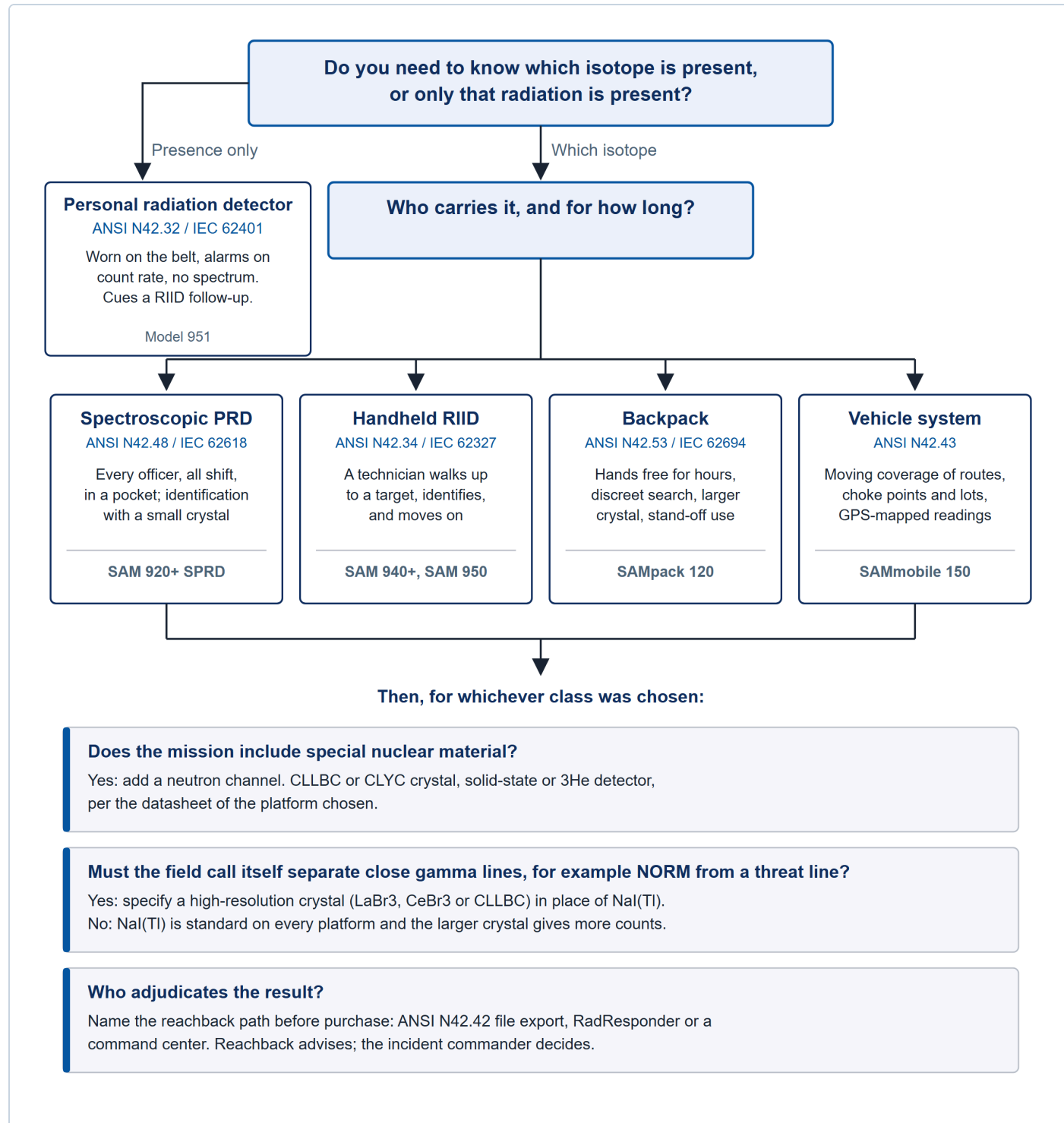
Spectroscopic PRD (SPRD): ANSI N42.48, IEC 62618. Pocket size, with a spectrum and an identification. The SAM 920+ SPRD weighs 340 g, uses a CsI(Tl) crystal or a CLLBC crystal that also counts neutrons, and is ANSI N42.48 compatible. It puts identification on every officer for a whole shift, at the resolution a small crystal allows.

Handheld RIID: ANSI N42.34, IEC 62327. The instrument a technician walks up with. The SAM 940+ (1.2 kg) carries a 2 by 2 inch NaI(Tl) crystal as standard, with CeBr₃, LaBr₃ and the dual-mode CLLBC and CLYC crystals as options. The SAM 950 (2.9 to 4.3 kg by detector) carries NaI(Tl) up to 3 by 3 inches, LaBr₃ or CeBr₃ at 1.5 by 1.5 inches, and a GM tube so the dose-rate reading continues after the scintillator saturates; it is a ruggedized unit built for gloved one-hand operation and can be sprayed for decontamination.

Backpack: ANSI N42.53, IEC 62694. Hours of hands-free, discreet search with a larger crystal. The SAMpack 120 carries a 3 by 3 inch or 2 by 4 by 8 inch NaI(Tl) crystal, or LaBr₃ or CeBr₃, and a two-detector version reports left or right of the wearer. It weighs 8 lb maximum with one NaI detector and 19 lb with the left/right pair, detaches from the harness for stand-off operation and mounts on a tripod.

Vehicle system: ANSI N42.43. Moving coverage of routes, choke points and lots. The SAMmobile 150 carries a 2 by 4 by 16 inch NaI(Tl) crystal, up to two per unit, in a 20 kg shock-mounted package, and plots GPS-tagged readings on a map with the source shown left or right of the vehicle.

One instrument in the same kit does a different job. A survey meter with a pancake GM probe, such as the Model 907, measures dose rate and surface contamination in alpha, beta and gamma. It tells you how much, not what, and it is the instrument for the contamination check once the identifier has answered the identity question.



■ **SCHEMATIC Figure 2.** Figure 2. Selection flow. The first question separates detection from identification and the second sets the platform; three questions that follow set the neutron channel, the crystal and the reachback path. Standards are the ANSI N42 performance classes with their IEC counterparts.

Table 1. The current line by class, from the datasheets. Resolution is full width at half maximum (FWHM) at 662 keV, and a smaller figure separates closer lines.

Table 1.

Model and class	Gamma detector and resolution at 662 keV	Neutron	Dose-rate range	Mass	Protection, temperature, battery	Data and reachback
Model 951 nukeALERT PRD; no standard listed	CsI scintillator, gamma only; count rate, no spectrum	None	Not listed	6.4 oz (181 g)	Watertight, 3 ft drop; -23 to 50 °C; 2 AA, two years or more	1 to 9 readout; no data output listed
SAM 920+ SPRD SPRD; ANSI N42.48 compatible	CsI(Tl) under 8.5%, or CLLBC under 4%; PIN diode for high dose rate	With the CLLBC crystal	Under 100 nSv/h to 1 mSv/h (scintillator); 1 to 10 mSv/h (PIN)	340 g	IP65; -20 to 50 °C; Li-ion, 6 h run, 16 h sleep	ANSI N42.42 or CSV one-touch reach-back; Wi-Fi, BLE 5.0, GPS, 8 MP camera
SAM 940+ Handheld RIID; ANSI N42.34 compatible	2 by 2 in NaI(Tl) under 7%; CeBr3 under 5%; LaBr3 under 4% (2 by 2 or 2 by 1 in)	Optional 1.5 by 1.5 or 2 by 2 in CLLBC (under 3.5%) or CLYC (under 5%); external 3He probe	10 nSv/h to 100 mSv/h	1.2 kg	IP65; -20 to 50 °C; Li-ion over 7 h, AA backup pack	One-click reachback to RadResponder or a command center; Wi-Fi, Bluetooth, USB, GPS, 8 MP camera
SAM 950 Handheld RIID; ANSI compliant library, ANSI N42.42-2012 reachback	NaI(Tl) 1.5 by 1.5, 2 by 2 or 3 by 3 in under 8%; LaBr3 1.5 by 1.5 in under 3%; CeBr3 1.5 by 1.5 in under 4%; GM tube	Optional solid state (4 cm ² , 20% thermal efficiency, gamma rejection 1 in 10 ⁷) or 3He	0 to 10 mR/h on NaI; GM tube to 10 R/h	2.9 kg (1.5 by 1.5), 3.2 kg (2 by 2), 4.3 kg (3 by 3)	IP65, sprayable for decontamination; -20 to 50 °C; Li-ion over 8 h	ANSI N42.42-2012 or CSV by email list or Wi-Fi (RadResponder); Bluetooth, USB, GPS, 13 MP camera; identification typically 2 to 10 s
SAMpack 120 (RD-120) Backpack; designed to meet or exceed ANSI N42.34 (2006)	3 by 3 in or 2 by 4 by 8 in NaI(Tl); LaBr3 1.5 by 1.5 in (2%); CeBr3 1.5 by 1.5 or 2 by 2 in (3%); GM tube	Optional solid state or 3He	10 nR/h to 10 R/h	8 lb max with one NaI detector; 19 lb max with the left/right pair	IP65, 1 m drop; -20 to 50 °C; Li-ion over 8 h, AA swappable pack	XML per ANSI N42.42; cellular, Wi-Fi, Bluetooth, GPS; left/right directionality; detaches for stand-off use, tripod mount
SAMmobile 150 (RD-150) Vehicle; identification according to ANSI N42.34	2 by 4 by 16 in NaI(Tl) standard, 4 by 4 by 16 in optional, up to two per unit; about 8%; GM tube	Optional solid state, tileable to 20 detectors	0 to 10 mR/h on NaI; 10 mR/h to 10 R/h on GM	20 kg (44 lb) system	IP65; -15 to 50 °C; Li-ion over 8 h	ANSI N42.42 via tablet or smartphone; Bluetooth; GPS mapping with left/right of vehicle

Reading an identification: isotope, category, confidence

Every identifier in Table 1 reports an isotope, a category and a confidence. Confidence is the instrument's statement of how well the measured peaks fit the library entry. It is not a probability that the material is safe. The SAM 950 datasheet gives a typical identification time of 2 to 10 seconds; a longer acquisition, held still at a fixed distance, puts more counts into each peak, and the confidence follows the counts.

Berkeley Nucleonics' recorded webinar on this subject (linked at the end of this note) makes three points that hold up and are repeated here as written guidance. The identification changes who is called: a medical or NORM result is a hazmat disposition, while a special nuclear material result brings in a state or federal agency. A neutron count alongside a uranium or plutonium identification is an independent confirmation that the gamma match on its own cannot give. And a library is a mission choice: adding every isotope the software knows raises the chance of a wrong match, so the library is edited with a specialist and a health physicist and kept to the isotopes the post expects.

Read the result against the category, and act on the category:

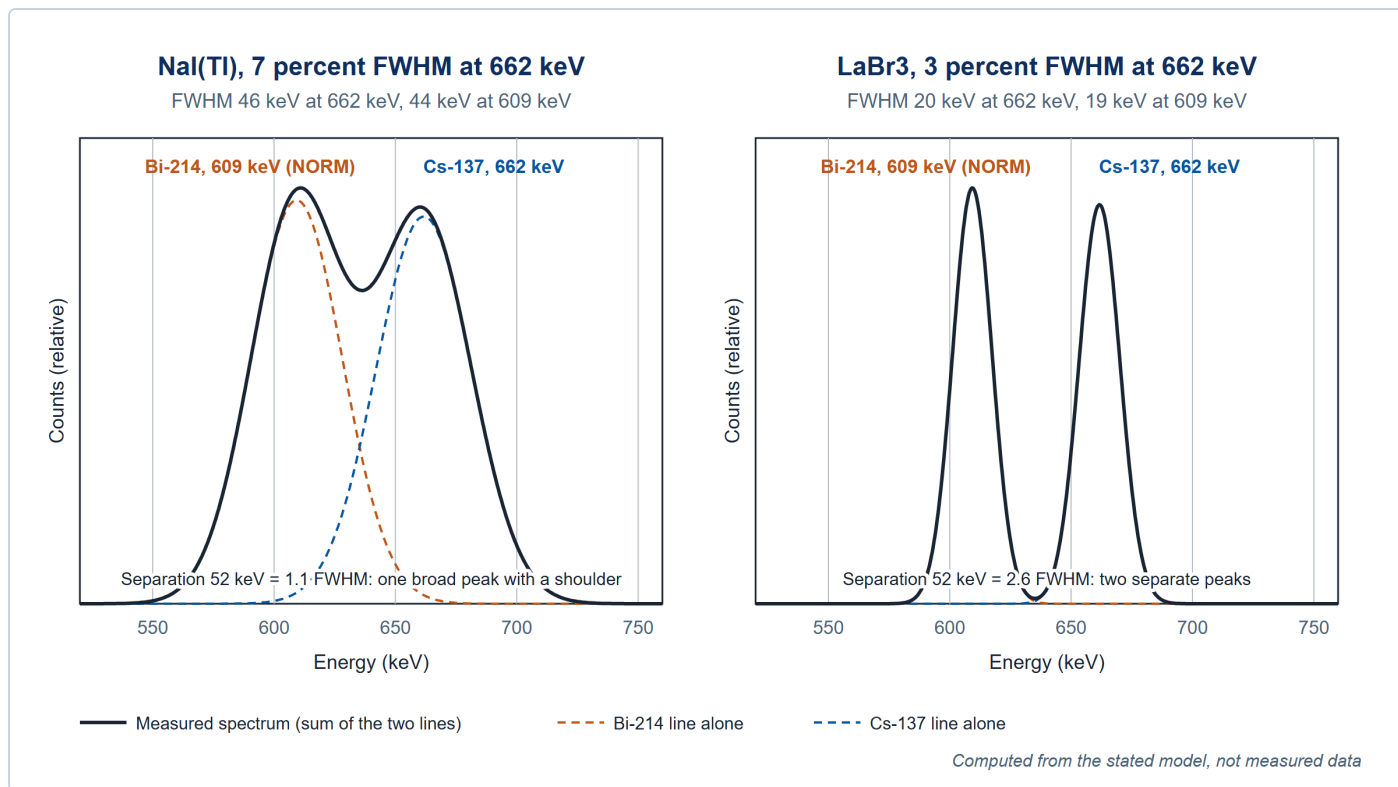
- **NORM**, steady, matching the object in front of you (tile, fertilizer, granite, potash, scrap): record and disposition under agency procedure.
- **Medical**, matching a person who reports a recent procedure: document and release under agency procedure; the incident commander or screening supervisor makes the release call.
- **Industrial**: a source that should be licensed and shielded. Hold the scene and notify the state radiation control program.
- **Special nuclear material**, any neutron count above background, or an unknown or low-confidence result that does not improve on a second acquisition: a reachback event. Hold position, send the spectrum, and wait for the adjudication.

A spectrum can contain more than one isotope, and a NORM or medical match does not clear a scene with a second, unexplained peak. Any result the operator cannot reconcile with what is in front of them goes to reachback. Reachback analysts advise; the incident commander decides.

Detector material: what resolution buys in the field

The scintillator crystal sets how cleanly the instrument separates one gamma line from another. Resolution is quoted as full width at half maximum at the 662 keV line of cesium-137, as a percentage of that energy; 1 percent is 6.6 keV. Across the current datasheets NaI(Tl) is specified under 7 to 8 percent, CsI(Tl) under 8.5 percent, CeBr₃ under 4 to 5 percent, LaBr₃ under 2 to 4 percent, CLLBC under 3.5 to 4 percent and CLYC under 5 percent, the figure depending on the platform (Table 1). NaI(Tl) is the standard crystal on every platform in the line; the others are options, offered in smaller sizes.

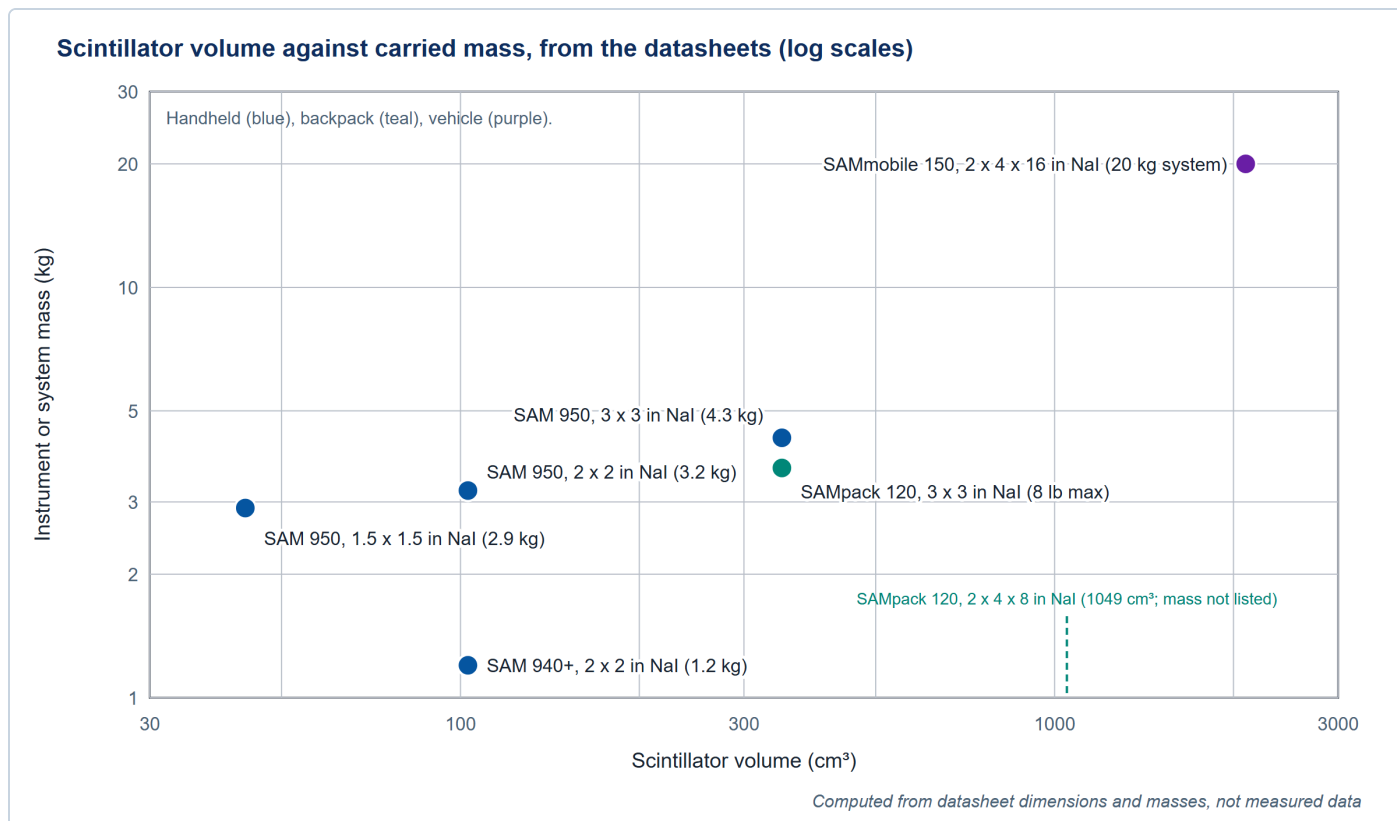
Figure 3 shows what the number means on the display. Bismuth-214, a daughter of radium-226 and therefore present in granite, tile, fertilizer and other NORM loads, has a line at 609 keV. Cesium-137 is at 662 keV, 52 keV away. At 7 percent, FWHM at 662 keV is 46 keV and the separation is 1.1 FWHM: the pair appears as one broad peak with a shoulder, and the identification algorithm works on that shape. At 3 percent, FWHM is 20 keV, the separation is 2.6 FWHM, and the display shows two peaks. The lesson holds for any instrument: two lines closer together than the FWHM at their energy merge into one peak on the display, whatever the software does afterwards.



■ **DERIVED** **Figure 3.** Figure 3. Two lines 52 keV apart, Bi-214 at 609 keV (a radium daughter, NORM) and Cs-137 at 662 keV, modeled at 7 percent and 3 percent FWHM with equal peak areas. At 46 keV FWHM the pair is one broad peak with a shoulder; at 20 keV FWHM it is two separate peaks. Computed from the stated model, not measured data.

Specify a high-resolution crystal when the field call itself has to separate a NORM line from a threat line and the release decision is made on scene: secondary screening of cargo that is routinely NORM, and any post where the operator's call releases a shipment without waiting for reachback. Where the spectrum goes to reachback before release, NaI(Tl) in the largest size the operator can carry is the better buy, because a short acquisition serves the analyst best with counts.

Crystal size is the other half of the choice. For a point source at a fixed distance and a fixed count time, the counts in the full-energy peak rise with the area of the crystal facing the source and, up to a thickness of a few centimeters at 662 keV, with its thickness. A larger crystal reaches the same confidence sooner, or reaches it at a greater distance for the same source. Figure 4 puts the sizes in the line against the mass the datasheets list. On the SAM 950, moving from a 2 by 2 inch to a 3 by 3 inch NaI(Tl) crystal multiplies the crystal volume by 3.4 (103 to 347 cm³) and the frontal area by 2.25, for 1.1 kg more in the hand (3.2 to 4.3 kg). The same crystal rides in the SAMpack 120 at 8 lb maximum, and the vehicle system carries 2,100 cm³ at 20 kg. Choose the platform by who carries it, then the largest crystal the platform allows.



■ **DERIVED** **Figure 4.** Figure 4. Scintillator volume against the mass the datasheets list for each configuration, on log scales. Three times the crystal volume costs about 1.1 kg on the SAM 950; the same 3 by 3 inch crystal rides in a backpack at 8 lb; the vehicle system carries 2,100 cm³ at 20 kg. Volumes computed from the datasheet crystal dimensions, not measured data.

The neutron channel: when it is required

Some materials in the special nuclear material category emit neutrons as well as gamma rays. A neutron count is an independent signature: it does not depend on a library match, and NORM and medical isotopes do not produce it. Specify a neutron channel whenever the mission includes interdiction of special nuclear material: maritime boarding and inbound cargo, border crossings, secondary screening at ports of entry, event security, and safeguards work.

Every identifier in Table 1 offers one. The SAM 920+ SPRD counts neutrons with its CLLBC crystal. The SAM 940+ takes a CLLBC or CLYC crystal, or an external ^3He probe. The SAM 950, SAMpack 120 and SAMmobile 150 take a solid-state neutron detector or ^3He ; on the SAM 950 and SAMmobile 150 the solid-state detector is specified at 4 cm² active area, 20 percent thermal-neutron efficiency and a gamma rejection of 1 in 10^7 , and the SAMmobile 150 tiles up to 20 of them.

The operating rule is short. Any neutron count above the instrument's background alarm is a reachback event, whether or not the gamma channel identified anything; a neutron alarm with no gamma identification is not a false alarm to be cleared on scene. The companion note Neutron Detection Explained covers the detector types.

Library, standards and reachback

Library. The libraries in the line are organized by category: special nuclear material, industrial, medical and NORM, with an ANSI set and a user-defined list. The SAM 950 ships ANSI, ANSI+ 2015, medical, industrial and user-defined libraries; the SAMpack 120 library expands to 393 isotopes from Kocher's radioactive decay data tables. A larger library is not a better library for a given post. Agree the mission list with a Berkeley Nucleonics specialist and your health physicist, and change it under procedure control.

Standards to specify by number. Write the class into the requisition and ask for the test report for the configuration ordered.

Table 2.

Instrument class	ANSI	IEC	Current models
Personal radiation detector	ANSI N42.32	IEC 62401	Model 951
Spectroscopic personal radiation detector	ANSI N42.48	IEC 62618	SAM 920+ SPRD
Handheld radionuclide identifier	ANSI N42.34	IEC 62327	SAM 940+, SAM 950
Backpack radiation detection system	ANSI N42.53	IEC 62694	SAMpack 120
Mobile and transportable system	ANSI N42.43		SAMmobile 150
Data format for spectra and reports	ANSI N42.42		All identifiers in the line
Responder competencies, radiological	NFPA 470 (2022)		Governs the procedure, not the instrument

Each datasheet states compliance in its own words (Table 1 quotes them): compatible, compliant library, designed to meet or exceed, according to; the Model 951 datasheet lists no standard. Where a program requires a tested-to claim against a specific edition, say so in the requisition.

Reachback. Reachback sends the spectrum to an analyst who can confirm or overturn the field call, usually within minutes. The SAM 920+ SPRD, SAM 950, SAMpack 120 and SAMmobile 150 export event data in the ANSI N42.42 format, and the SAM 940+ sends its event report by one-click reachback; the GPS position travels with the file, and so does a photo where the platform has a camera. The SAM 940+, SAM 950 and SAMmobile 150 connect to RadResponder, the FEMA network for radiation monitoring data; the SAM 950 also sends by email distribution list. Name the reachback destination before purchase, and name the adjudicator: reachback and the health physicist advise, and the incident commander or the screening supervisor decides. The instrument does not.

From alarm to decision

The sequence below is written for the operator holding the instrument. Where NFPA 470 or your agency's procedure differs, follow the procedure. Figure 5 is the same sequence as a one-page card.

1. **Stop.** Note the reading, the time, the place and what is in front of you. Do not move closer to improve the number.
2. **Increase distance if told to.** The SAM 940+ and SAM 920+ SPRD show four dose-rate alarm levels: Move Forward, In Range, Move Back and Danger. On Move Back or Danger, and whenever the identification channel saturates (about 10 mR/h on NaI; the SAM 950 GM tube continues the dose-rate reading to 10 R/h), increase distance until the reading clears and tell the incident commander. Your agency and its radiation safety officer set the turn-back dose rate, not the instrument.
3. **Identify.** Hold still at a fixed distance and run the identification for the full acquisition. Repeat once if confidence is low. Note the neutron count.
4. **Read the category** and apply the four actions in the previous section.
5. **Send.** Send the event file with the photo and the GPS position to reachback through RadResponder, the agency email list or the command center, and say in plain words what you saw.
6. **Hand off the decision.** Reachback and the health physicist advise. The incident commander decides.
7. **Record.** The event log on each instrument keeps the spectrum, the result, the location and the attached media. Export it at the end of the shift.

Field card: from alarm to decision

Radioisotope identifier response sequence. Defer to NFPA 470 and your agency's procedures where they differ.

1

Alarm

Stop. Note the reading, the time, the place and what is in front of you.
Do not move closer to improve the number.

2

Distance

If the display shows Move Back or Danger, or the identification channel saturates (about 10 mR/h on NaI), increase distance until it clears and tell the incident commander. Your agency sets the turn-back dose rate.

3

Identify

Hold still at a fixed distance and run the identification for the full acquisition. Repeat once if confidence is low. Note the neutron count.

4

Read

NORM, steady, matches the object: record and disposition.
Medical, matches a person: document; release per agency procedure.
Industrial: hold the scene; notify the state radiation control program.
SNM, any neutron count above background, or unknown after a second count: a reachback event. Hold position and send the file.

5

Send

Send the ANSI N42.42 file with photo and GPS position to reachback (RadResponder, email list or command center) and say what you saw.

6

Decide

Reachback and the health physicist advise. The incident commander decides. The instrument does not.

What the result means

Isotope: the library match. Category: SNM, industrial, medical or NORM.
Confidence: how well the measured peaks fit the library entry. It is not a safety rating.
Neutron count: an independent signature that a gamma library match cannot give.

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■ **SCHEMATIC** **Figure 5.** Figure 5. The one-page field card: six steps from alarm to decision, with the category readings that trigger each action. Defer to NFPA 470 and agency procedure where they differ.

Limitations

- An identifier measures gamma rays from the object in front of it. It does not measure surface contamination; use a survey meter with a pancake probe for that check.

- Confidence is a fit quality, not a safety rating. A low-confidence or unknown result that does not improve on a second acquisition goes to reachback.
- A gamma-only configuration has no neutron signature. Where the mission includes special nuclear material, specify the neutron channel.
- Background varies with location and with the material in the scene. The instruments hold their energy calibration on the natural potassium-40 line without a check source; the calibration interval and the daily check-source response are set by your radiation safety officer.
- Identification stops where the scintillator saturates. On the SAM 950 the NaI(Tl) channel reads to 10 mR/h and the GM tube reads dose rate to 10 R/h; above the scintillator range the instrument meters, it does not identify.
- Battery is the operational limit on a long detail: over 7 hours for the SAM 940+, over 8 hours for the SAM 950, SAMpack 120 and SAMmobile 150, and a 6 hour maximum run for the SAM 920+ SPRD. Carry the AA backup pack where the platform offers one. Operating temperature is -20 to 50 °C for the handhelds, the SPRD and the backpack and -15 to 50 °C for the SAMmobile 150.

Selection checklist

Table 2. Nine decisions, in the order they are made. Each one narrows the field, and together they name a configuration.

Table 3.

Decision	What to settle
Detection or identification	Presence only: a PRD (ANSI N42.32). Which isotope: an SPRD, handheld, backpack or vehicle identifier.
Who carries it, and how long	Every officer, all shift: SPRD (N42.48). A technician who walks up to a target: handheld RIID (N42.34). Hands free for hours: backpack (N42.53). Moving coverage: vehicle (N42.43).
Neutron channel	Required where the mission includes special nuclear material. CLLBC or CLYC crystal, solid-state or 3He detector, by platform.
Crystal material	NaI(Tl) as standard. LaBr ₃ , CeBr ₃ or CLLBC where the field call itself must separate close lines before release.
Crystal size	The largest the platform allows. Figure 4 gives the volume and mass of each configuration.
High dose rate	A GM channel where the instrument may be carried toward a source: SAM 950 (to 10 R/h), SAMpack 120, SAMmobile 150.
Library	Mission list agreed with a specialist and the health physicist; edited under procedure control.
Reachback	ANSI N42.42 export; RadResponder, email list or command center named; the adjudicator named.
Environment	IP65 across the identifiers; drop rating, operating temperature and decontamination (the SAM 950 is sprayable) against the deployment.

On configurations

every identifier in the line is ordered by detector, crystal size and neutron option. The answer to a mission is usually a platform plus options, not a different product, and a short scoping call settles it faster than a specification comparison.

Definitions

- **RIID.** Radioisotope identification device: records a gamma spectrum and reports an isotope, a category and a confidence.
- **FWHM.** Full width at half maximum of a peak, quoted at 662 keV as a percentage of that energy. Smaller is sharper.

- **NORM.** Naturally occurring radioactive material: potassium-40 and the uranium and thorium decay chains, in tile, granite, fertilizer, potash and scrap.
- **Reachback.** Remote expert analysis of a spectrum sent from the field; it advises the decision authority.
- **ANSI N42.42.** The data format that lets a spectrum from any compliant instrument be read by any compliant analysis service.

Further reading

- ANSI N42.32, N42.34, N42.42, N42.43, N42.48 and N42.53 (IEEE); IEC 62327, 62401, 62618 and 62694; NFPA 470 (2022), Hazardous Materials and Weapons of Mass Destruction Standard for Responders.
- Companion notes: NaI vs LaBr3 vs CeBr3 Detectors and Neutron Detection Explained.
- Datasheets: SAM 920+ SPRD, SAM 940+, SAM 950, SAMpack 120, SAMmobile 150, Model 951, Model 907.
- Recorded webinar: The Guide to Choosing Your Isotope Identifier.

Talk to a BNC specialist

The fastest path to the right configuration is a short conversation about the mission. A Berkeley Nucleonics specialist can map an operational picture to a platform, a crystal and an option set before the requisition is written. Reach the team at info@berkeleynucleonics.com or **800-234-7858**, or browse the Isotope ID & Radiation Detection documentation index.

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Technical Note

Isotope Id