First Responder RDD/IND Protocols

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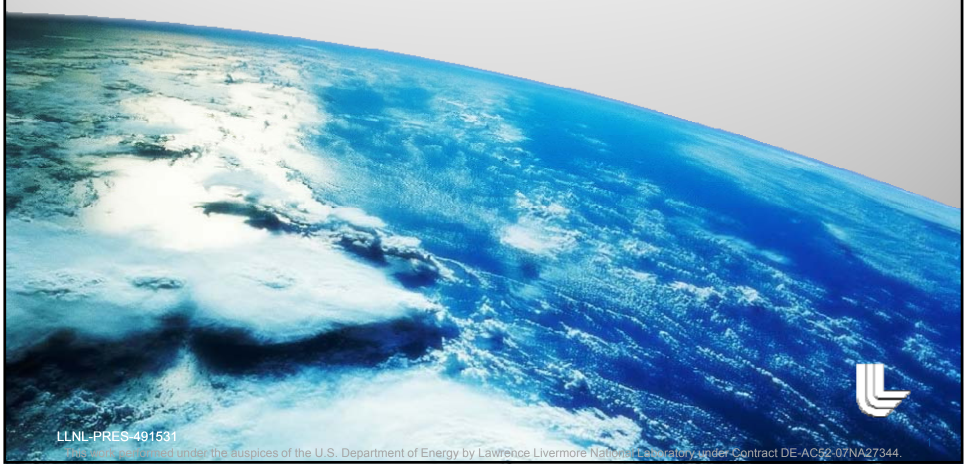

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Radioactive Material Production, Transportation, and Use

- The creation, shipping, and use of radioactive material is **highly regulated** (IAEA, NRC, DOT, etc.).
- High Activity Sources can **only** be produced by sophisticated methods (e.g. reactors & accelerators).
- High activity sources can only be obtained after special licensing to ensure their <u>safe use</u> and their <u>security</u>.
- Similar regulations exist in other countries were radioactive material is produced or used.

High Activity Radioactive Material

Fuel Assembly

Sr-90 RTG at Burnt Mountain, Alaska

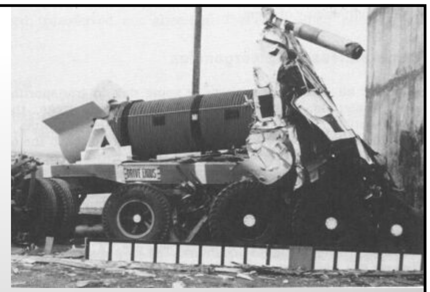
- Spent Nuclear Fuel & High Level Waste
- Radioisotope Thermoelectric Generators (RTG)
- Medical & Radiographic sources

CDC Emergency Preparedness & Response Radionuclides

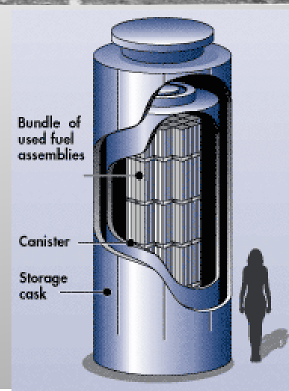
Radionuclide	Half Life (years)	Radiation	Information
Uranium	billions of years	α, + progeny	Natural uranium is comprised of several different isotopes. When enriched in the isotope of U-235, it's used to power nuclear reactor or nuclear weapons.
Americium-241	430 y	α	Am-241 is used for neutron generation (AmBe), in industrial devices that measure density and thickness, and in smoke detectors in small amounts.
Plutonium-238	88 y	α	Radionuclide thermoelectric generators and heat sources (primarily for space applications)
Cesium-137	30.2 y	β	Blood irradiators, tumor treatment through external exposure. Also used for industrial radiography.
Strontium-90	29 y	β	Radionuclide thermoelectric generators, industrial gauges and to treat bone tumors.
Cobalt-60	5.3 y	β	Tumor treatment through external exposure. Also used for industrial radiography.
Polonium-210	0.4 (140 d)	α	Anti-static devices and lightning detectors. Involved in U.K. Poisoning incident.
Irridium-192	0.2 (74 d)	β	Implants or "seeds" for treatment of cancer. Also used for industrial radiography.
Iodine-131	0.02 (8 d)	β	I-131 is used in medicine to diagnose and treat cancers of the thyroid gland. Also a concern for nuclear power plant accidents

Source: http://emergency.cdc.gov/radiation/

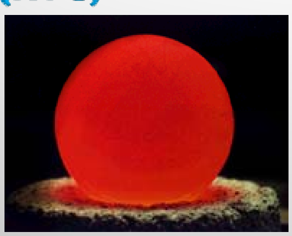
Spent Fuel



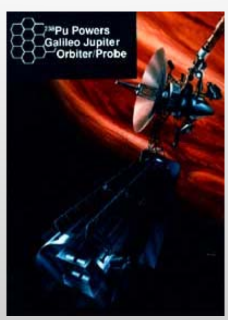
- Currently stored "onsite" at locations throughout the country.
- Spent Fuel containers extremely rugged and made to withstand extreme accident conditions.
- For thirty years, > 5,000 highly-radioactive fuel assemblies have been shipped without radiation release (despite several accidents).
- Security measures are taken.



Radioisotope Thermoelectric Generators (RTG)



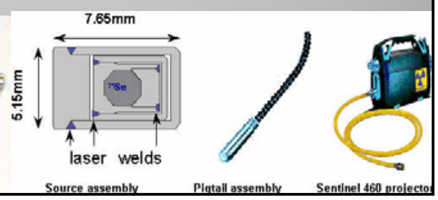
Self heated Plutonium 238



- **The heat generated by the radioactive decay is used to generate electricity**
- **Used when maintenance free power is need for decades (satellites, ocean bottom, and arctic applications)**
- **RTGs most often made from Sr-90 (0.46 kW/kg) or Pu-238 (0.54 kW/kg).**

Portable Radiography Sources

- "Top strength" industrial radiography sources can burn fingers and cause radiation sickness within a few minutes.
- Effects drop off dramatically with distance. Outside of 3 meters, acute effects rare even after hours of exposure.
- Sources are constructed to meet rigorous testing standards. A typical source is encapsulated in two (2) TIG welded Stainless Steel Capsules.
- Source Material itself is often metal (Cobalt or Iridium) or embedded on non-soluble ceramics or "microspheres" to prevent inhalation of radioactive material if the source encapsulation is breached.

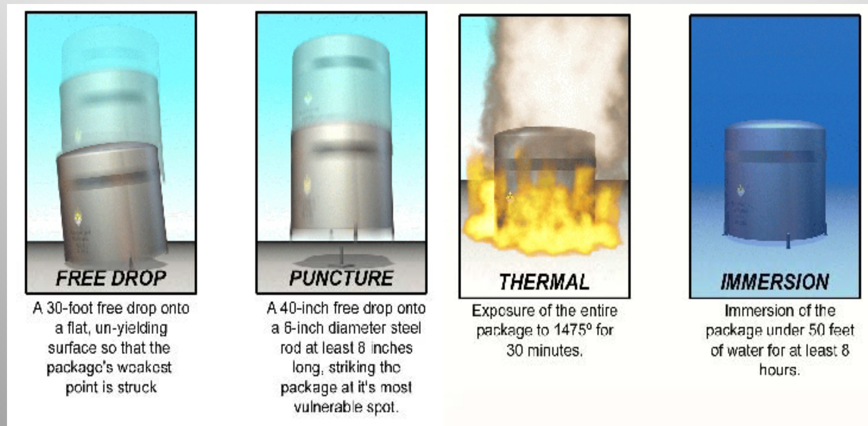


Facility Based Irradiators

- These sources can have 10 to 100 times more radioactivity than radiography sources
- Found in food irradiators, medical sterilizers, etc.
- The shielded enclosures that hold the sources weigh more than a ton.
- Difficult to remove source from the facility or equipment.

High Activity Source Transportation

Containers that ship high activity sources are meant to withstand very punishing accident conditions.

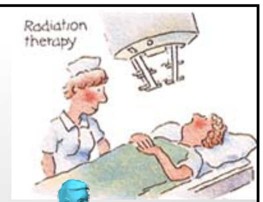


Conclusion:

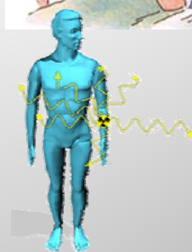
Radioactive Material Production, Transportation, and Use

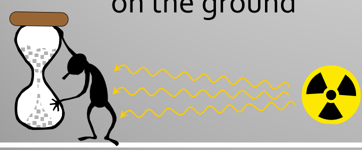
- High Activity Radioactive Material is highly regulated.
- Industrial Sources are very robust and made not to leak.
- When dangerous quantities are shipped, the material is in a container capable of withstanding harsh accident conditions.
- Very high activity industrial/medical sources are facility based and difficult to remove.

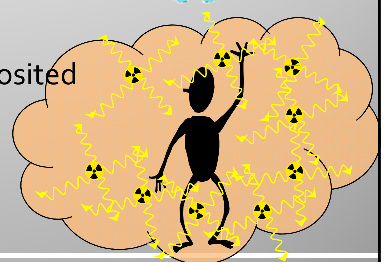
External Exposures



- Focused radiation or localized contamination can result in radiation effect to specific areas on the body
- Whole body exposure can result from:
  - A passing radioactive cloud or smoke
  - A large, distant point source
  - Exposure from contamination deposited on the ground

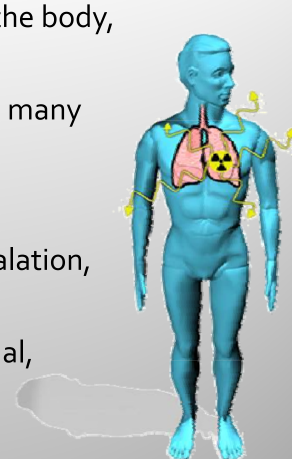






Internal Exposures

- Once radioactive material is deposited in the body, it can expose the person from within.
- The magnitude of the dose will depend on many factors:
  - How much material was deposited,
  - How it got into the body (ingestion, inhalation, absorption, or injection)
  - Chemical form of the radioactive material,
  - the radiation it produces,
  - How quickly it decays, and
  - How quickly the body eliminates the material



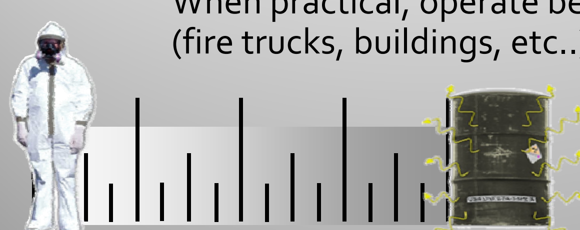
Response to a Radiological Incident ~ Contamination ~

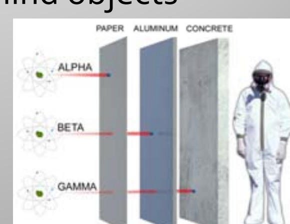
- Monitor and isolate contaminated area
- Evacuate and "gross decon" victims (removal of outer clothing is an effective gross decontamination method)
- Avoid breathing in radioactive material
  - Shelter in place (close windows, turn off heating and A/C)
  - Evacuate, when safe to do so
  - Wear respiratory protection

- Radioactive material will not be uniformly distributed. Radiation "Hot Spots" near the source of the event will be a hazard.

Response to a Radiological Incident ~ Radiation ~

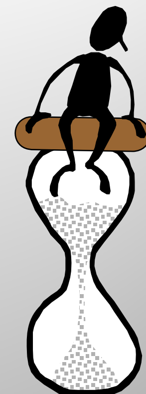
- Time: Limit the time spent in an areas of high radiation
- Distance: Exposure decreases dramatically as you increase your distance from the source.
- Shielding: Radiation is blocked by mass. When practical, operate behind objects (fire trucks, buildings, etc..)





Internal Exposures

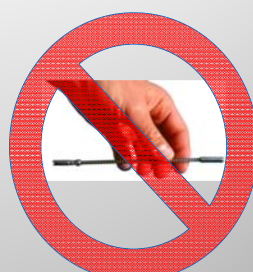
- Dose from internal depositions are usually expressed by **summing dose that will be received over the next 50 years from a one time internal deposition**.
  - Referred to as Committed Effective Dose Equivalent (CEDE).
  - This dose calculation/estimate takes into account factors on the previous slide.
  - Even with a large CEDE, there may or may not be acute effects from the exposure.



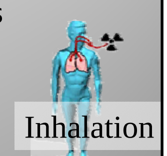
Do not use internal doses to predict acute exposure effects like nausea and vomiting.

Types of Exposure & Health Effects

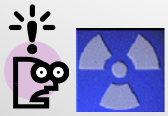
- **Acute Dose**
  - Large radiation dose in a short period of time
  - Large doses may result in observable health effects
    - Early: Nausea & vomiting
    - Hair loss, Fatigue, & medical complications
    - Burns and wounds heal slowly
  - Examples: Medical Exposures and accidental exposure to sealed sources



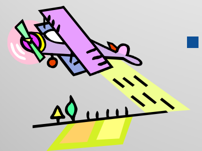
- **Chronic Dose**
  - Radiation dose received over a long period of time
  - Body more easily repairs damage from chronic doses
  - Does not usually result in observable effects
  - Examples: Background Radiation and Internal Deposition



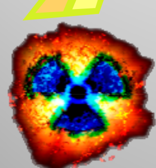
How Might High Activity Radioactive Material be Misused?



- Expose people to an external source of radiation.



- Disperse radioactive material using conventional means.



- Explosively Disperse radioactive material [a "Dirty Bomb"].

- Create a Nuclear Weapon (this requires special nuclear material)

WHAT IS A 'DIRTY BOMB'?

- A "Dirty Bomb" is conventional explosives combined with radioactive material with the intention of spreading the radioactive material over a relatively large area.
- This is **NOT** a nuclear explosion, the radioactive material does not enhance the explosion.
- Very few deaths would be expected from acute radiological exposure (the greatest hazard would likely be from the effects of the conventional explosives).
- The contamination will hamper emergency response efforts and can delay hospital treatment.
- Widespread contamination can deny the use of facilities and areas and have a significant psychological impact on the exposed population.

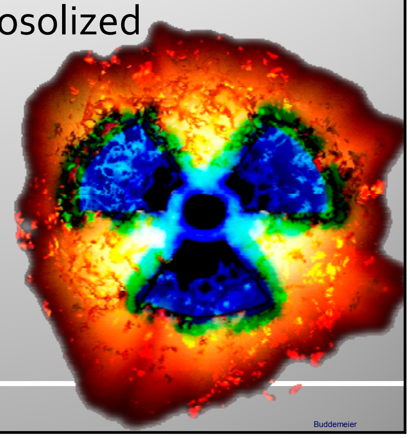
A Case Study: Goiania, Brazil 1987

- The 1.4 kiloCi (1,400 Ci) Cs-137 medical teletherapy source was breached by scrap metal recyclers.
- Everyone was impressed by "the glowing blue stones." Children & adults played with them.
- Serious radiological accident recognized 10 days later when Acute Radiation Syndrome symptoms where recognized by hospital staff.
- 112,000 people (10 % of Goiania's population) were surveyed at an Olympic Stadium. Significant psycho-social impacts.
- 4 deaths, 28 skin injuries, 50 internal depositions, significant contamination: 85 residences (41 demo-ed)

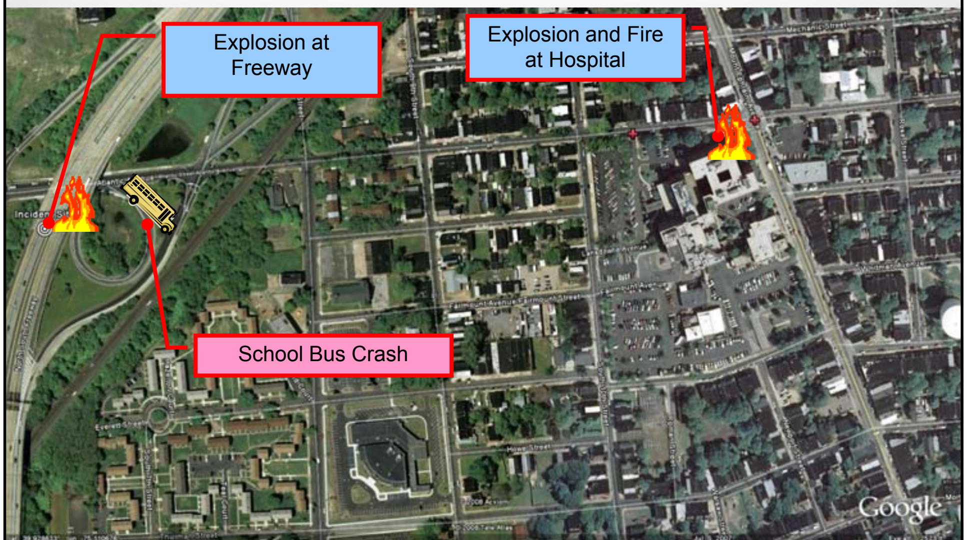


Example: Brazil's 1.37 kCi (1,370 Ci) Cs-137 Source Made Into a "Dirty Bomb"

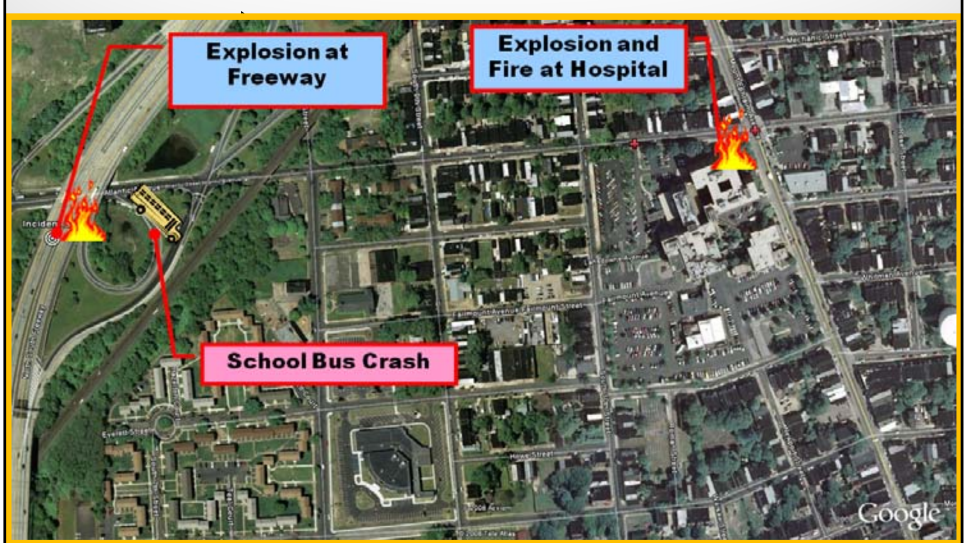
- Using Fictional "North Pointe" Example
- This model assumes "worse case" in that:
  - The source was 100% aerosolized (unrealistic)
  - Small explosive (~ 1 stick of dynamite)



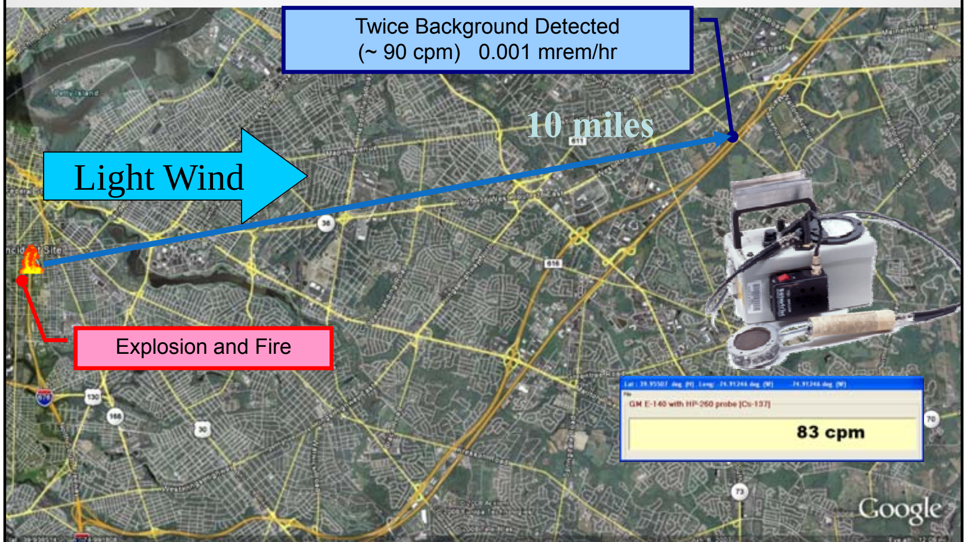
Trouble In North Pointe…

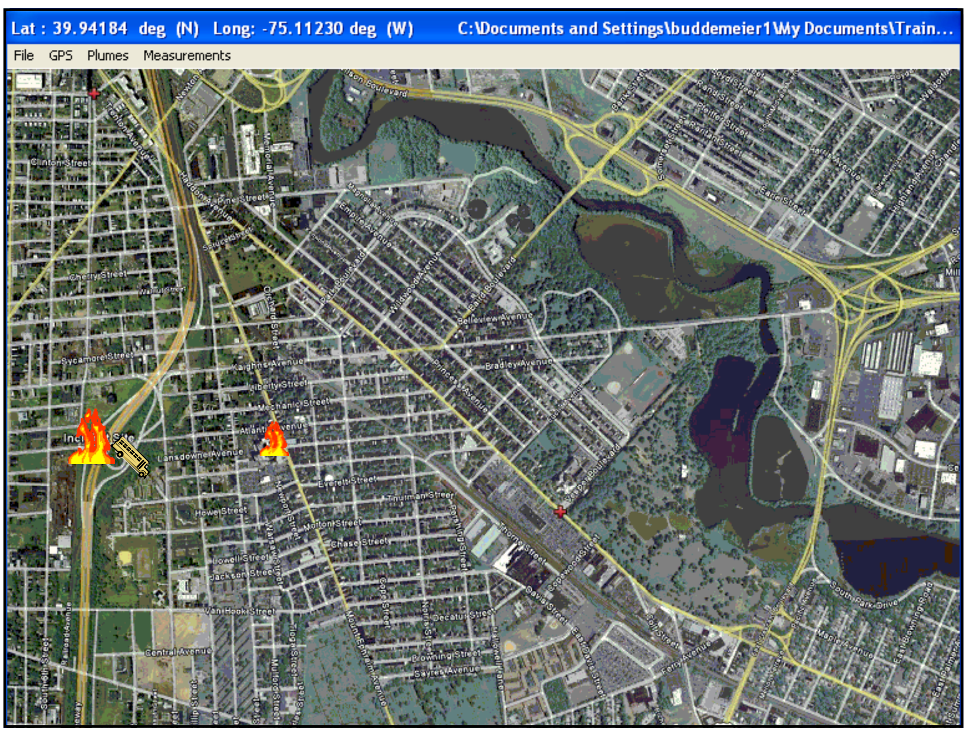


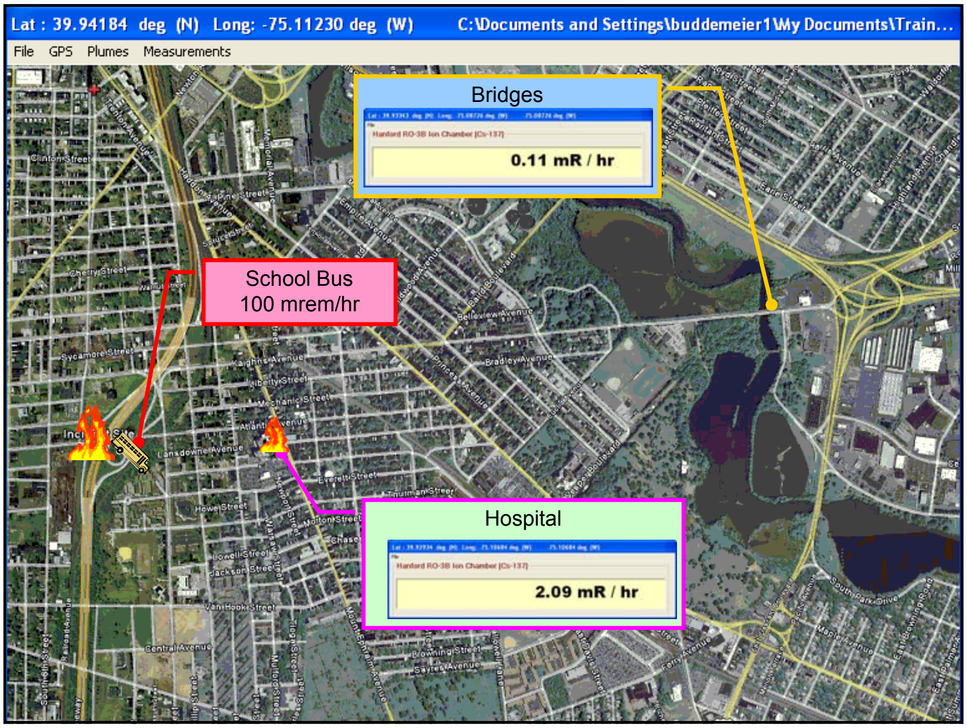
Long Range Effects



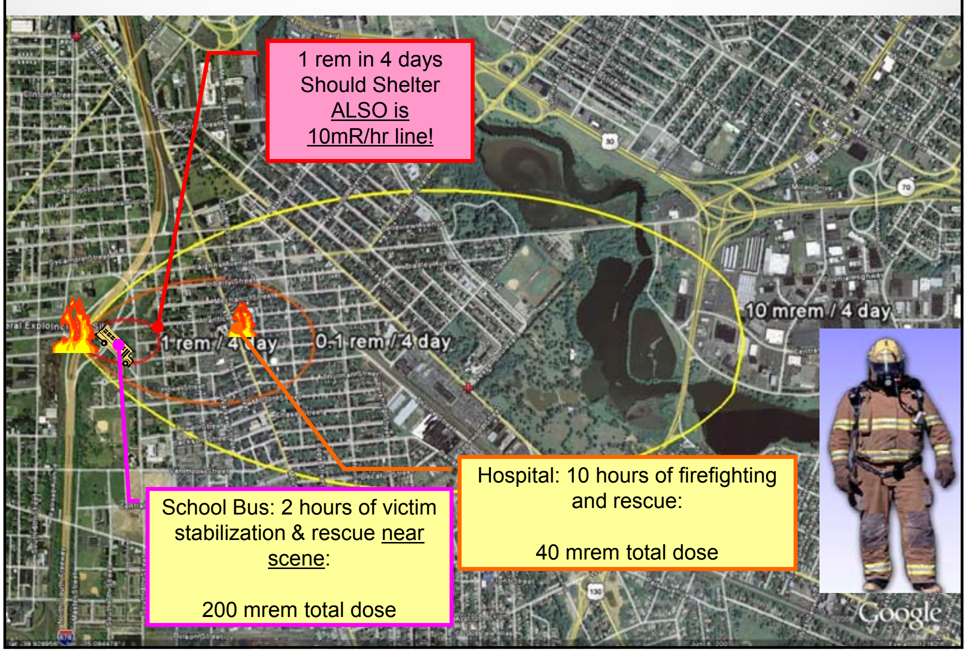
Detectable Ground Contamination Can Be Found Miles Downwind







Useful Points of Reference



Putting It in Perspective

- Although easily measured for miles,
- Shelter area may only be a few blocks, and
- Responders unlikely to get high exposures

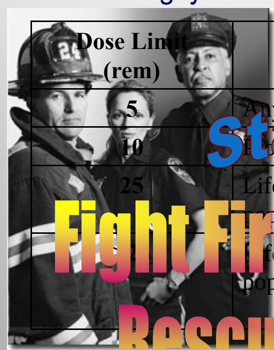
Conclusion:

Misuse of Radioactive Material

- High activity sources can cause health effects, but only to those in close proximity.
- Acute health effects from distributed radioactive material unlikely without prolonged, high-concentration exposure.
- Radiation or contamination will hinder response efforts.
- Denial of facilities and areas will have a major cost effect
- Public anxiety and it's effects may be the primary lasting health effect.

Some Federal Guidelines Do Exist…

But what does it mean to
these guys?



Dose Limit (rem)	Activity being performed	Limitations or conditions
5	Any	None
10	Protecting valuable property	None
25	Life saving or protection of large populations	None
	Life saving or protection of large populations	Persons fully aware of the risks involved use this limit only on a voluntary basis.

Stay Times?

Turn Back Dose?

Fight Fires…

Decontaminate?

Rescue Victims…

…or wait for the Experts?

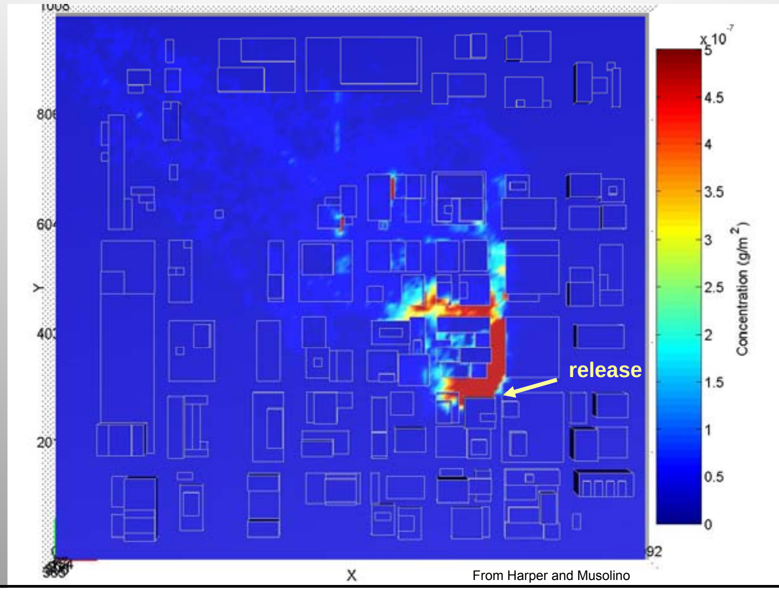
*Taken from Table 2-2 of EPA 400-R-92-001 *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents.*

Current Guidance is Inconsistent and Hard to Implement.

Turn-Back dose rate (lifesaving)	**200 R/hr**
Turn-Back dose	**10 rem**
Personnel Decontamination trigger level (beta, gamma β,γ)	**2 times background**
Personnel Decontamination trigger level (alpha α)	**Any constant, continuous clicks**
Personnel Equipment reuse contamination level (beta, gamma β,γ)	**1 mR/hr on contact (above this decontaminate the equipment prior to reuse.)**

Gamma Ray Dose Rate			Stay Time to Receive This Dose					
ate / hr	Rate / min	Rate / sec	1 rem	5 rem	10 rem	25 rem	100 rem	500 rem
5 mR/hr	83 μR/min	1.4 μR/min	200 hrs	6 weeks	12 weeks	30 weeks	2 years	
00 mR/hr	1.7 mR/min	27 μR/sec	10 hrs	50 hrs	100 hrs	250 hrs	6 weeks	30 weeks
1R/hr	17 mR/min	270 μR/sec	1 hr	5 hrs	10 hrs	25 hrs	100 hrs	500 hrs
10 R/hr	170 mR/min	2.7 mR/sec	6 minutes	30 minutes	1 hr	2.5 hrs	10 hrs	50 hrs
00 R/hr	1.7 R/min	27 mR/sec	36 seconds	3 minutes	6 minutes	15 minutes	1 hrs	5 hrs
00 R/hr	8.3 R/min	140 mR/sec	7 seconds	36 seconds	72 seconds	3 minutes	12 minutes	1 hrs

How Do We Define “Onsite”?



Who’s Got the Right PPE?

What is the Appropriate DECON?

How Do You Handle the Injured?

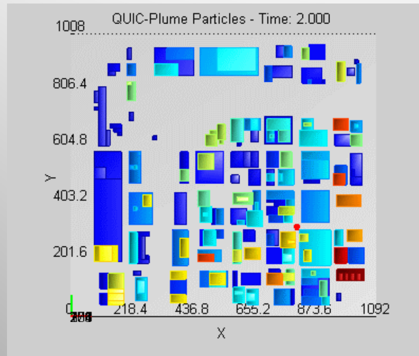
What is the Right Equipment?

Solutions are Community Specific

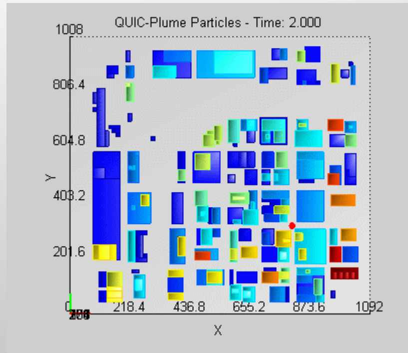
- Every community balances the "risk / benefit" equation differently and has different needs.
- Most important to have a **scaleable approach.**
- Planning is often more important than the plan itself.
- A sound scientific basis is important

Particle Size is Important

Transport & Dispersion



5 micron particles



250 micron particles

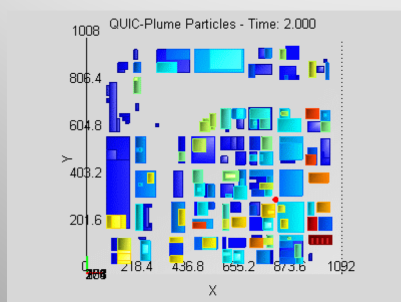
QUIC model (different particle sizes) From Mike Brown (LANL)

250 micron particles disappear due to gravitational settling and deposition.

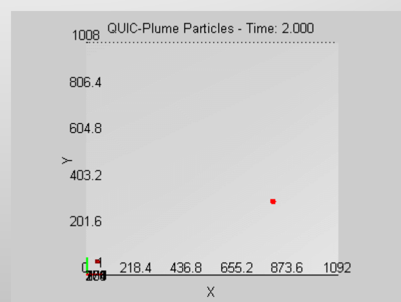
Particle Interactions with Urban Environment

Comparison of dispersion of 5µm particles

Impact of buildings on transport and dispersion



QUIC model w/ buildings

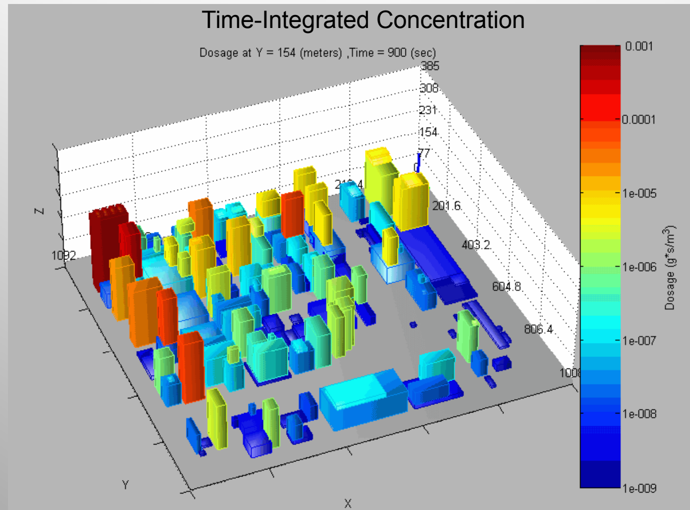


QUIC model w/out buildings

QUIC model (with and without buildings) From Mike Brown (LANL)

Not just a problem on the Ground

x-z
slice



QUIC model From Mike Brown (LANL)

From Harper and Musolino

Initial Findings, Explosive RDD

REALISTIC RADIOLOGICAL DISPERSAL DEVICE HAZARD BOUNDARIES AND RAMIFICATIONS FOR EARLY CONSEQUENCE MANAGEMENT DECISIONS

- Primary concern is external exposure from the material deposited on the ground (a.k.a. groundshine)
- **Inhalation dose is a very minor concern** *except to those* *<u>outdoors</u>* *and* *<u>near the explosion</u>*. Responders will usually arrive after most the radiotoxic smoke has dissipated

ERG Equivalent for RDD

- Area of highest concern limited to 500 m (worse case)
- Within 500m, Primary inhalation hazard is gone within 10 minutes (prior to arrival of most responders)
- For likely scenarios, primary concerns of the early first responder are:
  - Protection from groundshine,
  - Provide guidance on how to handle contamination, &
  - Assess inhalation concern
- Although inhalation exposure not the primary focus, respiratory protection still advised

As Measurements are Made...

- **Hazard Detection, Identification, & Control**
  Establish control zones consistent with NCRP and CRCPD

2 mrem/hour	Outer Exclusion Zone	Outer boundary for small incidents. No legal restrictions outside this area.
10 mrem/hour or Contamination above ßγ 1,000 Bq/cm² α 100 Bq/cm²	Hot Zone	Proceed for Emergency Operations (life saving, fire fighting, etc.). Shelter/Evacuate public, isolate area, and minimize responder time spent in the area.
10,000 mrem/hour (10 R/h)	High Radiation Hazard Zone	Proceed for time sensitive, mission critical emergency operations such as life saving
200,000 mrem/hour (200 R/h)	"Turn Back" Level	At this dose rate, the likelihood of successful rescue of victims is potentially outweighed by dose effects to the responders

Defining Outer Boundary & Exits/Triage/Monitoring Points

As additional resources arrive,* establish Hot Zone boundary and triage evacuees:

a) Boundaries should be established based on urban landscape features (e.g., streets, parks, etc..). In the urban environment, turbulent wind conditions will make warm zone boundaries very irregular.

b) Establish exit points, monitor to ensure < 10 mR/h

c) If possible monitor at the exits to identify (triage) highly contaminated individuals

d) If mass self-evacuation
- Do not detain people in the contaminated area
- Establish evacuation routes to channel self-evacuees away from Hot Zone

***** The time sensitive, critical response operations (e.g., life saving, fire fighting) in the Hot Zone take precedent over warm zone activities.**

Shelter / Evacuation Considerations

Smoke and Dust from an explosive RDD may be contaminated. Immediately after a suspicious event, effort should be made to avoid breathing smoke and dust by seeking shelter and through respiratory protection, even ad-hoc protection.

- Sheltering is effective:
  - Respirable aerosol penetrates single residence buildings, even so...
  - Inhalation dose to those inside is a small fraction of outside dose
  - Larger buildings have more aerosol removal mechanisms than smaller buildings
- Effectiveness of turning off HVAC of modern high rise building needs further evaluation, buildings at risk should develop individualized emergency shelter in place (SIP) protocols.
- Ad-hoc Respirator: A dry cloth over the nose and mouth can reduce internal dose by 90%

Inhalation not a significant hazard after 10-30 minutes

Quotes from Harper and Musolino, "Realistic Radiological Dispersal Device Hazard Boundaries and Ramifications for Early Consequence Management Decisions"

Shelter / Evacuation Recommendations For and Outdoor, Urban "Dirty Bomb"

The best way to avoid or reduce exposure is to shelter, this means:

- If you are inside and your building is intact, stay inside.
- If you are outside, or in a significantly damaged or "smoky" building, move immediately in to the nearest robust, intact structure or out of the area if the event is small and there is a clear path out.

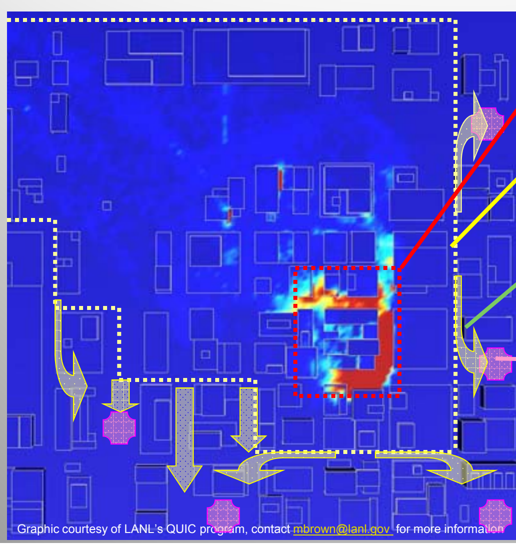
Evacuation is most effective if it can be accomplished *before* the radiological contamination arrives at the point of concern. For a no notice dispersal, this is generally not practical because;

- Those outdoors and in buildings near the event will not have time before the contaminates (smoke/particulate plume) reach them, and
- The radiological nature of the event may not be recognized until after responders arrive.

Immediate evacuation also carries a high degree of risk because:

- In the initial confusion of the event, evacuees may inadvertently evacuate into more heavily contaminated areas, and
- Immediate evacuation tends to be rushed, increasing breathing rates (and therefore internal exposure to airborne contaminates) and the possibility of accidents (either running or driving erratically).

Use Natural boundaries for Warm Zone, Exits, and Monitoring sites



- Dangerous Radiation Zone (>10R/h)
- Hot Zone Boundary based on natural breaks & < 10mR/h
- Evacuees directed to triage & monitoring sites
- Triage & Monitoring sites; identify & manage highly contaminated

Medical Triage

a) ***Medical emergencies (life threatening injury) take precedent over radiological monitoring or decontamination***

b) Some may need medical assessment because of their exposure or radioactive material inhalation, A priority for decontamination and medical follow up are:

- People with high levels of contamination on their clothes
- People with wounds exhibiting high levels of radiation
- People with upper body contamination (this is an indicator they were outside and close to the explosion)

c) If the source is not ^{137}Cs, ^{60}Co, or ^{90}Sr, high doses and acute radiation effects are not possible with explosive RDD

First Responder PPE

a) Uniform

b) Goggles

c) Half-face APR

d) Gloves

Level A and B protection are <u>ineffective</u> against a primary dose concern; groundshine radiation. Using level A or B may actually <u>increase a responders dose</u> as it limits functionality and communication which will increases their working time in the radiation field.

Public Decontamination Considerations

- **Contaminated Public, 2 Possibilities:**
  - A few individuals close (within few hundred meters) to the release may require prompt decontamination for their safety and safety of others. These highly contaminated individuals also warrant medical follow-up.
  - Majority of those contaminated do not need decontamination on an urgent basis and are **not** a danger to themselves or others.
- **Radiological Decontamination requirements far less difficult than chemical or biological decontamination:**
  - Removal of outer layer of clothing
  - Gentle washing with soap & warm water on exposed skin & hair
  - Decon staff needs only minor respiratory protection

Decontamination: Scaleable Approach

- For **Small Events**:
  - Full wet decontamination techniques can reduce anxiety of the victim and clean-up costs from cross-contamination
- However, as the **number of victims grow large**, decontamination capacity can be quickly overwhelmed, Consider:
  - Screening to identify decontamination priorities
  - Dry decontamination techniques
  - Self decontamination
  - Pre-established reception centers throughout a community with supplies rapid set-up can facilitate decontamination of population

Decontamination Priorities

"Initial personnel monitoring and decontamination efforts at the scene should primarily focus on preventing acute radiation effects to the affected individual. Cross contamination issues are a secondary concern."
~ NCRP 2005

- Screening: Individuals with spot contamination greater than 2.2×10^6 dpm (37,000 Bq)* should be a priority for decontamination
- Post decontamination monitoring should look for 2.2×10^5 dpm (3,700 Bq) spot contamination

*This spot contamination can cause Acute Exudative Radiodermatitis if not removed within 36 hours. (FEMA-REP-22)

Twice Background Not Realistic… and Impossible to Measure

Instrument/ Detector Combination	Fixed Contamination (0.1 µCi Threshold) — 2.2×10^5 dpm (3,700 Bq): Probe Speed (inches/s)	Height Of Probe (inches)	Path Width (inches)	Time Needed to Monitor an Adult[b] (minutes)	Loose-Plus-Fixed Contamination (1.0 µCi Threshold) — 2.2×10^6 dpm (37,000 Bq): Probe Speed (inches/s)	Height of Probe (inches)	Path Width (Inches)	Time Needed to Monitor an Adult[b] (minutes)
CD V-700 with side window detector	4	0.25 to 0.5	0.6[c]	19	6	1 to 2	2	3.9
CD V-718 with end window detector	3	0.5 to 1	1	16	6	1 to 4	3	2.6
All tested instruments with pancake detector except the Victoreen 190	6	1 to 3	2	3.9	24	2 to 6	7	0.28
Victoreen 190 with pancake detector	6	1 to 4	3[c]	2.6	24	2 to 6	8[c]	0.24

"Background Information on Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents" dated October 3, 2002. FEMA REP-22

What is the Right Equipment?

Mission	Alarming Dosimeters & Personal Emergency Radiation Detectors (PERDs)[1]	Non-alarming Personal Emergency Radiation Detectors (PERDs)[1]	Survey Meter[2]	PRND Detection Systems[3]	Contamination monitors[4]	Dosimeters	Aerial System	Portal Monitor	Sensor Networks	Medical Instrumentation[5]
Confirmation of Nuclear Yield	●	○	●	○	—	—	●	○	○	—
Yield Estimation	—	○	●	—	—	○	●	—	●	—
Dangerous Fallout Zone Activities (use instruments that can function in exposure rates up to 1,000 R/hour)										
Location of Ground Zero	—	—	—	—	—	—	●	—	○	—
Worker Dose Assessment	○	○	—	—	—	●	—	—	—	—
Worker Safety for DFZ Missions	●	○	○	—	—	—	—	—	—	—
Survey of Dangerous Fallout Zone	●	—	●	—	—	—	●	—	○	—
Establishing Evacuation Routes	●	—	●	—	—	—	●	—	○	—
Hot Zone Activities (use instruments that can function in exposure rates up to 10 R/hour)										
Worker Dose Assessment	○	○	—	—	—	●	—	—	—	—
Worker Safety for Hot Zone Missions[7]	●	○	○	—	—	—	—	—	—	—
Survey of Hot Zone	●	—	●	—	—	—	●	—	○	—
Establishing Evacuation Routes	●	—	●	—	—	—	●	—	○	—
Activities Outside of Hot Zone (use instruments that can function in exposure rates up to 0.01 R/hour)										
Worker Dose Assessment	○	○	—	—	—	●	—	—	—	—
Worker Safety Outside Hot Zone	●	○	○	○	○	—	—	—	—	—
Locating Hot Zone Boundary	●	—	●	○	○	—	●	—	○	—
Monitoring Medical Care Locations	●	—	●	○	●	—	—	○	—	○
Monitoring at Shelters (Radiation Levels)	○	—	●	○	●	—	—	○	—	—
External Contamination Detection (Personnel)	○	—	○	○	●	—	—	○	—	○
Internal Contamination Detection (Personnel)	—	—	○	○	○	—	—	—	—	●
Equipment[8] & Facility[9] Contamination Monitoring	○	—	○	○	●	—	○	—	—	—

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Equipment Characteristics

There are three primary characteristics to consider when selecting Instruments

Sensitivity.

- ⇨ Sensitive detectors can measure very low levels of radiation.

Selectivity.

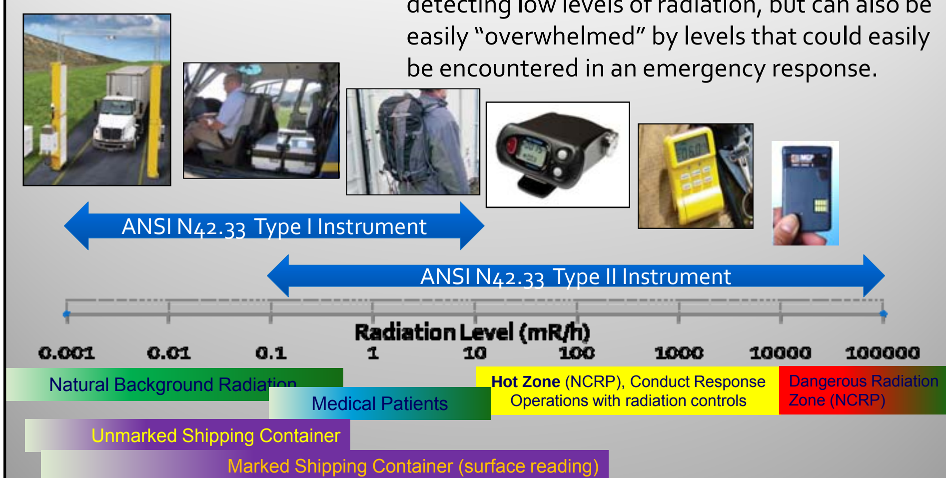
- ⇨ There are different types of Radiation, the type of radiation and it's energy "signature" can help distinguish common natural, medical, or commercial sources from potential threats.

Portability.

- ⇨ Portability can be a critical element depending on how the detection system is being used.

Sensitivity

- As a general rule, equipment sensitivity is proportional to size: larger detectors are more sensitive.
- Highly sensitive instruments may be helpful for detecting low levels of radiation, but can also be easily "overwhelmed" by levels that could easily be encountered in an emergency response.



Selectivity

Homeland Defense Equipment Reuse Program

Instrument Selection

COMMONLY USED CONTAMINATION SURVEY INSTRUMENT PROBE SELECTION

DETECTION ABILITY: NONE SOME GOOD

PROBE	AVE. BACKGROUND	ALPHA	BETA	GAMMA
Mica window	50 – 100 CPM	SOME	GOOD	SOME
Mylar® window	20 – 50 CPM	NONE	SOME	SOME
Sodium Iodide w/window	500 – 1000 CPM	NONE	SOME	GOOD
	20 – 50 CPM	NONE	SOME	SOME
Slide Open	20 – 50 CPM	NONE	SOME	SOME
	0 – 5 CPM	GOOD	NONE	NONE

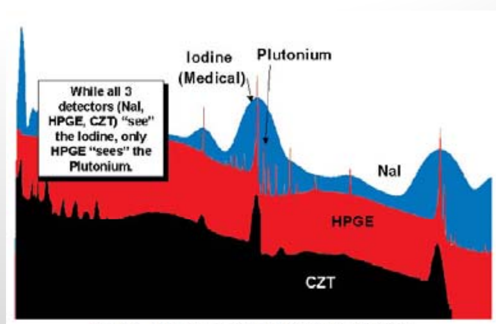


Figure 2. HPGe in comparison to NaI and CZT detectors.

- Alpha and Beta radiation require thin window detectors
- Gamma spectroscopy systems (RIIDs) use the energy "signature" to identify the radionuclide, however most hand-held RIIDs have poor resolution and can incorrectly identify complex signatures.

Detection Equipment Portability

- **Human-portable** – equipment that is small enough to be carried easily by a single person either as a handheld device or in a backpack.
- **Mobile** - vehicle mounted detection systems. These systems contain the largest detectors of all five types, and are therefore the most sensitive
- **Aerial** - detection equipment is carried by a helicopter. It is used for operations in large areas that are not easily covered with other mobile systems
- **Re-locatable** - detection equipment that can be moved from place to place. It differs from mobile types in the sense that it can be temporarily fixed to a certain area, but has the ability to be moved if needed
- **Fixed** – these are (typically) portal radiation monitors. This type of equipment is usually applied to choke points used by pedestrian, vehicle, and commercial traffic

Tools: *Electronic Dosimeters*

The Pros

- Alarms in hazardous situations.
- Can identify a significant radiological event.
- Records dose.
- Long battery life.
- Small Size.
- Simple operation and often very rugged

The Cons

- Not necessarily sensitive enough to detect low levels of radiation.
- Won't detect alpha or low energy beta radiation

Tools: *Electronic Dosimeters*

Description:

About the size of a pager, these electronic devices track the total radiation dose received by the wearer. They often use low power silicon chips or small Geiger-Müller (GM) tubes to measure dose. Most have the ability to alarm at certain dose rates or total dose. Although these devices are not sensitive enough to necessarily find fugitive radioactive material, they can quickly detect significant events and **protect the wearer from overexposure**.

Application:

Well suited for emergency responders who may need to quickly enter a scene, these devices can help ensure responder safety by alerting them to potentially hazardous radiation levels without any user activation or operation. The units can also alert the wearer when unusual radiation levels are present, though they may not be sensitive enough to find low levels, i.e., $< 5\ \mu Sv/hr$ (< 0.5 mrem/hr).

Examples:

Canberra Industries: http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/ANUDR13.pdf, http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/Dosicard.pdf
Far West Technology, Inc: http://www.fwt.com/hpi/hpi_4083ds.htm
MGP Instruments: http://www.mgpi.com/html/en/produits/masque.cfm?le_num_prod=87
POLIMASTER, Ltd.: http://www.polimaster.com/en/products/dosimeters.htm
Science Applications International Corporation (SAIC): http://www.saic.com/products/security/pd3i/pd3i.html
Siemens Environmental Systems - UK: http://www.siemens.co.uk/env-sys/uk/electronic_dosimetry/epd.shtml
Thermo Electron Corp: http://www.thermormp.co.uk/rmp/index.html

This does not represent an endorsement

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Tools: *Personal Radiation Detectors (PRDs)*

Pros

- Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material.
- Good battery life
- Small Size
- Simple operation

Cons

- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
- Does not accurately measure (or work in) high dose rates which would be of concern to emergency responders performing rescue operations.
- Won't detect alpha or low energy beta contamination (other than by any associated dose field)
- Expensive ($800 – $2,000)

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Tools: *Personal Radiation Detectors (PRDs)*

Description: Often called “Radiation Pagers,” and similar in appearance to the electronic dosimeters, these units have the very different function of finding low levels of radiation using very sensitive crystal or plastic scintillators. Although good for finding contraband radioactive material, these units do not have the range necessary for personnel protection (i.e., high dose rates).

Application: Well suited for law enforcement or inspectors, these devices can alert the wearer to any unusual radiation in their proximity. These devices are best used when there is an opportunity for a measured response, as most alerts will occur from legitimate commercial, medical, or natural radioactive material. Training and protocols need to be provided to properly resolve any alarms.

Examples:

POLIMASTER, Ltd: http://www.polimaster.com/en/products/ratemeters.htm
Sensor Technology Engineering, Inc http://www.nttc.edu/ertProgram/radpagers.asp
T$_A$TECHNICAL ASSOCIATES: http://www.tech-associates.com/dept/sales/product-info/dsi-2.html

This does not represent an endorsement

Tools: *Simplified Contamination Survey Instruments*

Pros

- “Open window” GM for alpha and beta contamination.
- Most have Good Sensitivity.
- Digital models can have set alarm levels
- Small Size
- Simple operation
- Rugged, simple technology.

Cons

- Sensitive enough alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
- Many models can not be used in high dose rates which would be of concern to emergency responders performing rescue operations (>0.1 Sv/hr | >10R/hr).
- Low accuracy (i.e., uses pancake GM for dose measurement)

Tools: *Simplified* *Contamination* *Survey Instruments*

Description:

These simplified meters use thin window (GM) detectors to measure alpha & beta surface contamination as well as dose rates. Although often ***more sensitive than the electronic dosimeter***, these devices are not as sensitive as the radiation proximity alert systems. Although they have a ***higher range than the personal radiation proximity alert systems***, many models will still not function well in the emergency response dose rate ranges (0.1 Sv/hr or 0.1 Sv). Their simplified operation is designed for the occasional user.

Application:

Well suited for emergency responders and hospital staff who may need to quickly determine if radioactive ***contamination*** is present. The units can also alert the wearer when unusual radiation levels are present. Training must be provided on their use as successful contamination monitoring requires specific techniques.

Examples:

Canberra Industries: http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/radiagem4.pdf
T_ATECHNICAL ASSOCIATES http://www.tech-associates.com/dept/sales/product-info/tbm-3.html
Berkeley Nucleonics Corp: http://www.berkeleynucleonics.com/PalmRAD/
Health Physics Instruments: http://www.fwt.com/hpi/hpi_4020ds.htm
Radiation Alert Instruments: http://www.seintl.com/mon5.htm, http://www.seintl.com/dig50.htm, http://www.seintl.com/inspect.htm, http://www.seintl.com/insp_exp.htm

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Tools: *Isotope Identification Equipment (Gamma Spectroscopy)*

Pros

- Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material.
- Often tracks dose rates and total dose of user while on.
- Can identify many common isotopes

Cons

- Although fairly good at identifying common isotopes with simple spectra, these units can not identify all possible isotopes of concern and can also mis-identify isotopes.
- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation (though the analysis capability can often help resolve this)
- Expensive ($8,000 - $12,000)
- Won't detect alpha or low energy beta contamination.
- Requires extensive training or support to use properly

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Tools: *Isotope Identification Equipment (Gamma Spectroscopy)*

Description: These expensive and sophisticated units use the different gamma ray “signatures” given off by the radioactive material to identify the originating isotope(s). Proper identification of the isotope is important for determining the appropriate response actions. Although the analysis being performed is complicated, these units offer a simple interface to help non technical users make a measurement. Many of the units have modes of operations similar to the proximity alert and electronic dosimeters.

Application: Best suited for experienced users or well trained and practiced responders, these units will help identify the radioactive material involved at a scene or in contraband. Good for follow-on radiological emergency response teams or inspectors.

Examples:

Berkeley Nucleonics Corp http://www.berkeleynucleonics.com/radiation/rindex.htm
Bicron/Thermo Electron: http://www.thermormp.co.uk/us/rmp/
Exploranium Radiation Detection Systems: http://www.exploranium.com/gr135pg1.htm
Perkin Elmer (Ortec): http://www.ortec-online.com/safeguards.htm
Quantrad Sensor: http://www.quantradsensor.com/
Radiation Alert: http://www.seintl.com/ursa.htm
XRF Corporation: http://www.xrfcorp.com/products/ics.html

This does not represent an endorsement

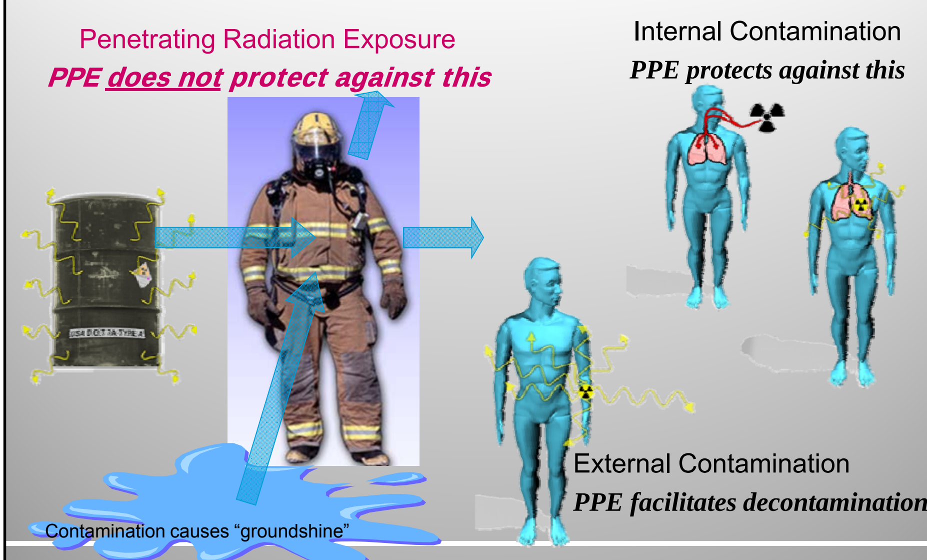
First Responder Training Objectives

- **Keep the messages simple!** Focus on what you want them to remember a year later.
- At the <u>awareness level</u> this should be;
  - Medical emergencies take precedent over radiological monitoring,
  - Used correctly, their instruments and protocols ensure their safety, and
  - The difference between contamination and radiation.

The overall objective when training first responders is to <u>increase their confidence</u> and <u>lower their anxiety</u> about effective radiological emergency response

Questions

Exposure & Contamination



References

- National and International regulations, recommendations, and guides evaluated:
  - OSHA Regulations
  - DHS Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND)," Federal Register, Vol. 71, No. 1, Notices, January 3 (2006)
  - "Handbook for Responding to a Radiological Dispersal Device – First Responder's Guide – The First 12 Hours," Conference of Radiation Control Program Directors, September (2006).
  - U.S. Federal Emergency Management Agency, "Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents," FEMA-REP-22, Washington, DC (2002).
  - International Atomic Energy Agency, "Development of an Extended Framework for Emergency Response Criteria," TECDOC-1432 (2005).
  - National Council on Radiation Protection and Measurements, "NCRP Commentary No. 19: Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism," Bethesda, Maryland, December (2005).
  - Other professional society and research recommendations.

References

The devices pictured and web pages referenced in this presentation were chosen as examples and in no way represent an endorsement of any manufacturer or product.

Compendium of Weapons of Mass Destruction Training produced by the federal government" [online]. Available at http://www.fema.gov/compendium/index.jsp

The Department of Energy, Transportation Emergency Preparedness Program (TEPP) [information available online] http://www.em.doe.gov/otem/program.html

A Practical Guide To Incident Response, ARSCE 2002; WPM-A.4 James G. Barnes, CHP Rocketdyne/Boeing

The Department of Energy's "Partners in Emergency Response" Publication. [information available online] http://www.doeal.gov/opa/Freedom.htm

The Department of Energy, Emergency Operations Training Academy (EOTA), Computer Based Training (CBT) for the response to Weapons of Mass Destruction CDs can be copied and have been distributed to each state's FEMA representative who can be found at www.fema.gov/fema/statedr.shtm or by contacting DOE's Emergency Operation Training Academy at www.eota.doe.gov or call (505) 845-5170 ext.172

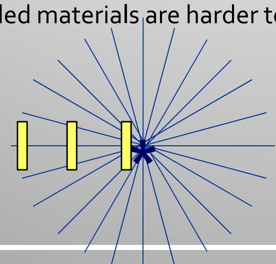
Equipment Supplement: Radiation Detection Equipment for the PRND Mission

Detecting Weak Sources of Radiation

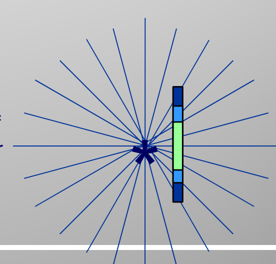
Time, Distance, and Shielding also apply to the probability of detection, though the principal is reversed

- **Maximize the time** the detection equipment is close to the source to increase the probability of detection.
- **Minimize the distance** between the detector and a suspected source of radiation to increase the probability of detection.
- **Reduce shielding** between the detector and the source. Remember, shielded materials are harder to detect.

Effect of Detector Distance from Source; $1/r^2$ drop



Effect of Detector Size



Human Portable Detection Equipment

Human-portable equipment is carried easily by a single person. This category include:

- **Personal Radiation Detectors (PRD)**
- **Backpack detectors**
- **Radioisotope Identification Devices (RIID)**
- **Advanced Radioisotope Identification Devices (ARIID)**

Equipment Selection Issues

- **Targeted Material** – determines the kind of radiation detection equipment needed (gamma or gamma and neutron)
- **Operation Type**
  - **Static operation -** stays in place, detecting objects as they approach the vicinity (at choke points or fixed sites)
  - **Mobile operation** – can be conducted in different places (sweeps), ***Covert vs. Overt***
- **Source Identification**
  - **Detect radiation only**
  - **Detect and identify radioisotopes**
- **Detection Period**
  - **Constant** – operation which is conducted continuously
  - **Intermittent** – operation conducted at certain intervals
  - **Event specific** – detection conducted at significant events

TYPES OF PRND EQUIPMENT

(USE OF PRODUCT IMAGES DOES NOT INDICATE AN ENDORSEMENT)

Personal Radiation Detectors (PRDs)

Description: Often called "Radiation Pagers," and similar in appearance to the electronic dosimeters, these units have the function of finding low levels of radiation using very sensitive crystal or plastic scintillators. Although good for finding contraband radioactive material, these units do not have the range necessary for personnel protection (i.e., high dose rates) or distant detection.

Application: Well suited for law enforcement or inspectors, these devices can alert the wearer to any unusual radiation in their proximity. These devices are best used when there is an opportunity for a measured response, as most alerts will occur from legitimate commercial, medical, or natural radioactive material. Training and protocols need to be provided to properly resolve any alarms.

Personal Radiation Detectors (PRDs)

Pros

- Very sensitive. Alerts the user of any significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material
- Good battery life
- Small Size

Cons

- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
- Does not accurately measure (or work in) high dose rates, due to signal overload, which would be of concern to emergency responders performing rescue operations.
- Won't detect alpha or low energy beta contamination (other than by any associated exposure field)
- Relatively Expensive ($800 – $2,000)

Personal Radiation Detectors (PRD)

- examples

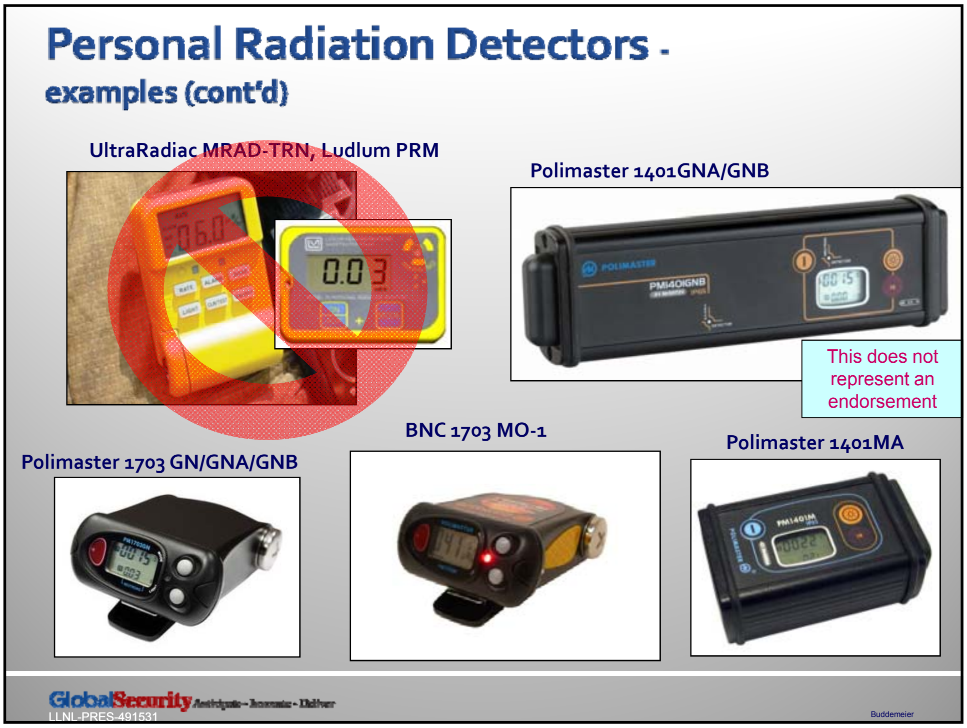
BNC nukeAlert 951

Thermo Scientific RadEye

BNC 1703MB/GNB

STE Handheld

Laurus Mini rad-D


Personal Radiation Detectors -
examples (cont'd)
UltraRadiac MRAD-TRN, Ludlum PRM
Polimaster 1401GNA/GNB
This does not represent an endorsement
BNC 1703 MO-1
Polimaster 1703 GN/GNA/GNB
Polimaster 1401MA
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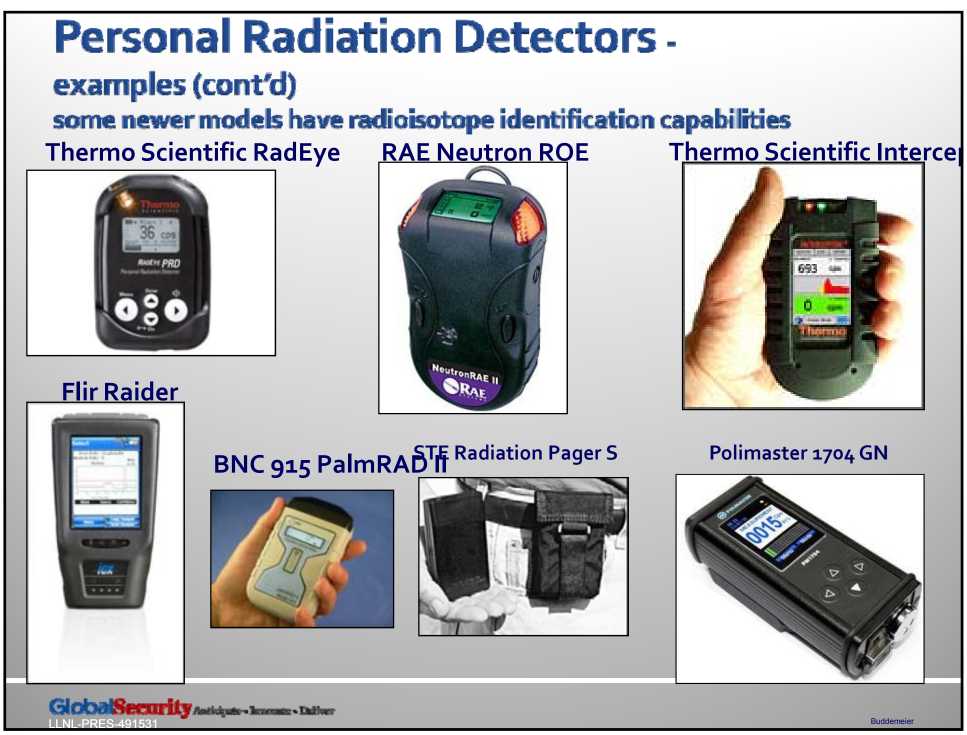
Personal Radiation Detectors -
examples (cont'd)
some newer models have radioisotope identification capabilities
Thermo Scientific RadEye
RAE Neutron ROE
Thermo Scientific Intercep
Flir Raider
BNC 915 PalmRAD II
STE Radiation Pager S
Polimaster 1704 GN
GlobalSecurity
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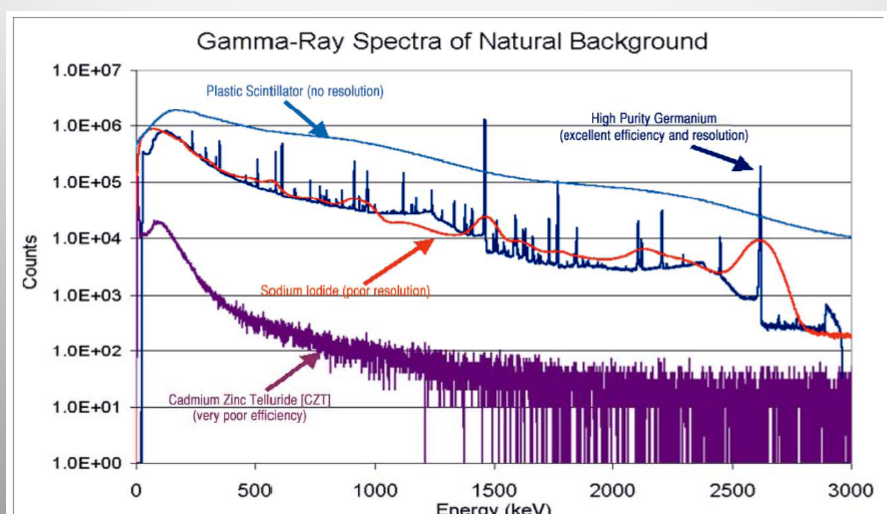
PRDs Specifications





	Thermo RadEye	Polimaster 1703 GNB	STE Radiation Pager	Thermo Sci. Interceptor	Ludlum Personal R.M.
Gamma Det'n	Yes	Yes	Yes	Yes	Yes
Neutron Det'n	Opt	Yes	No	Yes (He-3)	No
Weight (oz)	5.6	8.5	6.0	13.8	5.1
LxWxH (in)	1.25x2.4x3.78	3.38x1.25x2.88	4.1x0.9x2.4	4.4x2.4x1	3.0x0.69x5.4
Temp. (deg. F)	-22 to 141	-22 to 122	-13 to 122	-4 to 122	-40 to 150
I.D. Capability	Yes (NBR)	Yes	No	Yes	No
Battery Type	AAA	AA	AA	Li-Ion	Li-Ion
Detector Type	NaI(Tl)	CsI(Tl)	½x 1 ½ CsI(Tl)	CZT	E comp GM
Sensitivity	1.5 cps / µR/h (17 *cps/mR/hr*)	1 cps / uR/hr	Not advert.	1.5 cps / uR/hr	0.0003 cps/uR/hr
Range	1uR/hr - 25 mR/hr	0 – 7 mR/hr	X – 3.8 mR/hr		0.1 – mR/hr – 1000 R/hr

Quick detector resolution comparison



Quick detector resolution comparison

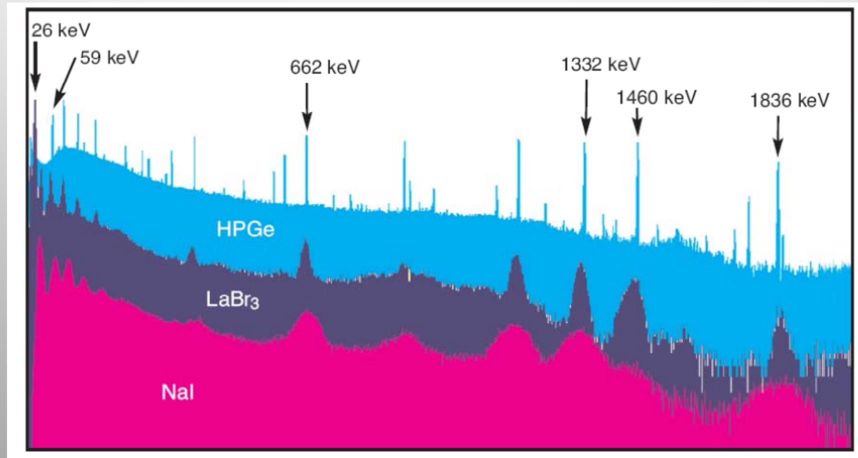


Figure 1. Comparison for $LaBR_3$(Ce), NaI(Tl), and HPGe spectra.

Quick detector resolution comparison

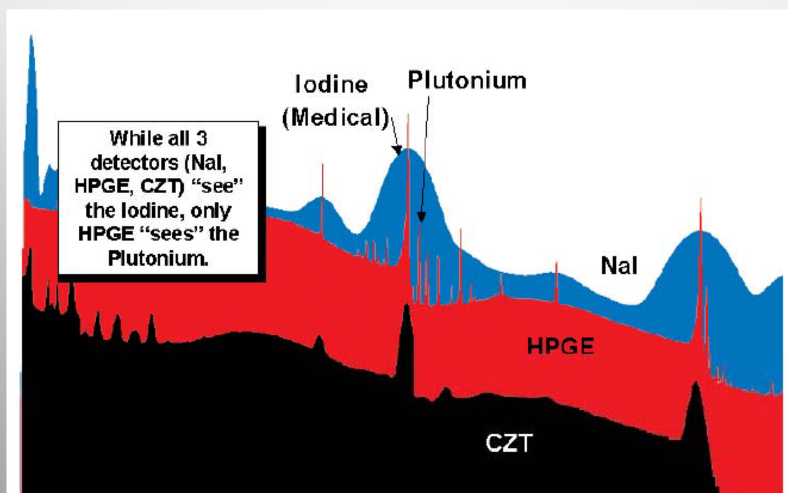
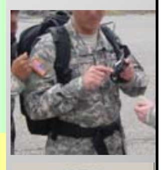


Figure 2. HPGe in comparison to NaI and CZT detectors.

Backpacks (larger, typically more sensitive devices carried in a b

Description: Backpack radiation detectors are designed for operators who need to quickly detect and locate a radiation threat in an unpredictable radiation background. The unit's detectors and associated electronics are hidden inside a backpack (or vest), allowing the operator to inconspicuously search public areas. They can incorporate larger gamma (plastic, NaI, CsI, LaBr) and neutron (^{3}H, ^{6}Li glass) detectors and even can have radioisotope identification capabilities. Some models are equipped with GPS and can communicate and transmit data to a command center.

Application: Backpack radiation detector systems provide portable, mobile detection and identification of radioactive material. These are ideal for use in large event venues such as political conventions, Super Bowl football and sporting events. Useful for emergency response, law enforcement, border security, non-proliferation enforcement, environmental waste monitoring, radiation safety. Can be used also for search and recovery of radioactive material. Configurations with radioisotope identification capabilities and GPS require more experienced users or well trained and practiced responders.



Backpacks, Pros & Cons

Pros

- Can incorporate larger and multiple detectors. Various sizes, sensors and configurations can be accommodated
- Very sensitive. Alerts the user of any significant changes to the natural background radiation levels.
- Useful for clandestine monitoring of radiation levels.

Cons

- Requires one person to carry only one unit.
- Suitable mostly for outdoor applications; indoors use is suspicious
- More sensitive units are bulkier and heavier
- Expensive ($10,000 - $20,000)
- Won't detect alpha or low energy beta

Backpacks - examples

Thermo Scientific Packeye Backpack

BNC RD-100

Nucsafe backpack/vest

Nucsafe backpack

Radio-Isotope Identification Devices (RIIDs)

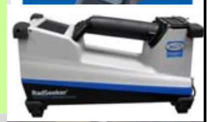
Description:

These expensive and sophisticated units use the different gamma ray "signatures" given off by the radioactive material to identify the originating isotope(s). Proper identification of the isotope is important for determining the appropriate response actions. Although the analysis being performed is complicated, these units offer a simple interface to help non technical users make a measurement. Many of the units have modes of operations similar to the proximity alert and electronic dosimeters.

Application:

Best suited for experienced users or well trained and practiced responders, these units will help identify the radioactive material involved at a scene or in contraband. Good for follow-on radiological emergency response teams or inspectors.

Radio-Isotope Identification Devices (RIIDs)



Pros

- Very sensitive. Alerts the user of any significant changes to the natural background radiation levels.
- Useful for finding contraband radioactive material.
- Often tracks dose rates and total dose of user while on.

Cons

- Although fairly good at identifying common isotopes with simple spectra, these units can not identify all possible isotopes of concern and can also mis-identify isotopes.
- Will alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation (though the analysis capability can often help resolve this)
- Expensive ($10,000 - $20,000)
- Won't detect alpha or low energy beta contamination.
- Requires extensive training or support to use properly

Radio-Isotope Identification Devices (RIIDs) – examples

Canberra InSpector-1000

Smith Detection RadSeeker

XRF ICS-4000

Thermo Scientific identiFinder-U, identiFinder-2

BNC SAM 935

Radio-Isotope Identification Devices (RIIDs) - examples (cont'd)

BNC SAM 940

Thermo Scientific FH 40 NBR

Polimaster PM1401K

Ludlum Model 703 Isotope Identifier

RIIDs Specifications





	identiFinder-U	BNC SAM 940	Polimaster PM1401K	Thermo Sci. FH 40 NBR	Ludlum Model 703
Gamma Det'n	Yes	Yes	Yes	Yes	Yes
Neutron Det'n (optional)	Yes	Yes	Yes	Yes	Yes
Weight (oz)	2.95	4.5	1.5	1.0	4.5
Length (in)	9 x 2.75 x 3.5	12 x 5 x 4	9.5 x 2.2 x 2.2	8 x 1.4 x 2	12 x 5 x 4
Detector	1.4 x 2 NaI	2 x 2 NaI (1.5 x 1.5 LaBr)	CsI(Tl)	NaI + Org. Scint	2 x 2 NaI (3 x 3)
Sensitivity	>10cps per uR/hr		2 cps per uR/hr	28 cps per uR/hr	15 cps per uR/hr (38)
Resolution	$\leq$8%	7% (2.8%)			7%
Temp. (deg. F)	4 to 131	4 to 131	-22 to 122	4 to 122	4 to 131
Battery Type	AA	AA	AA	AA	NiMH AA

Advanced Radio-Isotope Identification Devices (ARIIDs)

Description: These expensive and sophisticated RIID use mechanically cooled germanium detectors to identify the originating isotope(s). They must be plugged in at times. ARIID produce very high laboratory quality data and analysis. They are also capable of localizing the radiation source and providing dose rate information.

Application: Best suited for experienced users or well trained and practiced responders. Good for follow-on radiological emergency response teams or inspectors.

Pros

- Have superb radioisotope identification capabilities.
- Can have large source signature databases and can be uses in the field or in the lab.

Cons

- Expensive ($75,000 - $90,000)
- Heavy for long hand-held operation; more fragile than the rest
- Require extensive training and support to use advantageously

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Advanced Radio-Isotope Identification Devices (ARIIDs) - examples

ORTEC Detective

ORTEC Micro-Detective-HX

CANBERRA Falcon 5000

ORTEC Micro-Detective

ARIIDs Specifications



	ORTEC Detective	ORTEC micro-Detective	CANBERRA Falcon 5000	ORTEC micro-Detective-HX
Detectors	HPGe (γ), GM, optional He-3 (n)	HPGe (γ), GM, optional He-3 (n)	HPGe (γ), GM, optional He-3 (n)	HPGe (γ), GM, optional He-3 (n)
Weight (oz)	26.3	15.2	34.1 (with 2 batteries)	15.2
Length (in)	15.5 x 7 x 14	14.7 x 6 x 11	17 x 7 x 17	14.7 x 5.8 x 11
Temp. (°F).	32 - 104	14 - 104	(- 4) – 122	14 - 104
Time to cool	< 12 hours	< 12 hours	3- 4 hours	< 12 hours
Battery life	>3 hours	3 hours	8 hours	3 hours

Mobile devices (mounted on a vehicle)

Description:

Mobile detection equipment are vehicle-mounted detection systems which contain the largest detectors and are therefore the most sensitive. They can consist of multiple detectors, both gamma and neutron. Most of these systems are capable of both detection and radioisotope identification. They usually display alarms and analysis on laptops which interface with the detection system. Some are equipped with additional features as data transmission, GPS, image camera.

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Application:

Vehicle-mounted detectors are generally used for operations that need to cover large areas quickly. They are adaptable for clandestine monitoring and searching for radiation sources. Vehicle driving speed must be within the capabilities of the detection system.




Mobile devices

Pros

- Very sensitive; can incorporate large and multiple detectors
- Useful for covering large areas.
- Can be tailored towards specific requirements.
- Often have additional capabilities – radioisotope identification, GPS, data transmission, computer analysis, take images
- Can be used for clandestine monitoring of radiation levels.

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Cons

- Can be very expensive ($15,000 -50,000 or more)
- Won't detect alpha or beta contamination (sources)
- Requires training.

Mobile devices - examples

Thermo Scientific Mobile ARIS

TSA MDS134A

Mirion SPIR-Ident-mobile

BNC Textron IST RadTruck

SAIC Exploranium GR-460

Portal monitors

Description:

Radiation portal monitors are stand-alone units designed to automatically scan pedestrian, vehicle or rail traffic. The system comprises two or more detector panels that detect gamma-ray and often neutron radiation. All of the essential components are contained in the panels: radiation detectors, electronics, controller, and occupancy detector. Their gamma detectors are usually plastic but NaI and mechanically cooled HPGe detectors may be used for radioisotope identification.

Application:

The portal monitors may be designed and configured for overt or inconspicuous monitoring of traffic. They can be used at the entrance or exit of many different sites: Nuclear Power Plants, research centres, scrap & steel industries, waste disposals & waste incinerators, hospitals, border crossing points. These systems are often placed on both sides of a monitored lane, allowing the vehicle/object to pass through. Simpler units produce just an alarm, while more sophisticated systems can discriminate medical, industrial and natural radioactive sources and transmit the data to a command or monitoring center for further analysis.

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Portal monitors

Pros

- Can incorporate large and multiple detectors both for gamma and neutron emitting sources
- Very sensitive
- Most are maintenance free and do not require frequent calibration
- Can be set up for unattended and/or covert operation.
- More sophisticated systems have radioisotope identification capabilities.
- Optional vehicle speed alarm, video monitor, license plate image

Cons

- Simpler, non-spectroscopic systems produce false alarms due to legitimate radioactive material traffic (industrial and medical sources, natural radioactive materials)
- More sophisticated spectroscopic systems are expensive and require experienced or trained personnel
- Could be very expensive ($50,000 - $ 500,000)

This does not represent an endorsement

Portal monitors - examples

Canberra MiniSentry

Thermo Scientific TPM 903B

Mirion SPIR-Ident-Pedestrian G

Ludlum 52-1-1

Mirion Stride-200

TSA PM700AG-AGN

BNC ARAM

Portal monitors – examples (cont'd)

SAIC/Exploranium ST-20

TSA VM 250 AG/AGN

SAIC/Exploranium SRM 980

Transportable portal monitor

Portal monitors - examples

WF Portal monitor RCVL

Detectors inside a panel

Polimaster 5000A

Canberra GPS Portal SS

SAIC/Exploranium AT 980

Polimaster 5000A

Integrating Detection Equipment into PRND Mission

- **Mission planning:** Appropriate equipment selection
- **Primary Screening:** Detect and locate the presence of radioactive material
- **Secondary Screening**
  - After receiving alarm, identify and distinguish between:
    - False alarms
    - Background radiation alarms
    - Legitimate sources alarms
    - Illicit radiological material alarms
  - Measure approximate radiation level
- **Alarm Adjudication & Resolution**
  - Use radiological material recognition factors and measurement information to assist in assessing the situation
  - Initiate organizational protocols to ensure the health and safety of

Radiation safety instruments for the safety of personnel

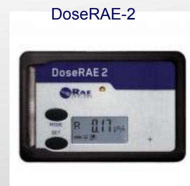
- **Main purpose – provide safety for the user**
  - Measure radiation dose (in mrem or μSv) or dose rate (mrem/hr or μSv/hr)
  - Alarm (often multiple alarms available) if radiation is above certain dose (rate) threshold
  - Usually smaller and less sensitive than PRDs (pagers)
  - No radioisotope identification capabilities
  - Often employs different type detectors – e.g. ion chamber
- **Examples**
  - Dosimeters
  - Dose rate meters

Personnel Safety: Electronic Dosimeters & Survey Instruments

Siemens MK-2

ALOKA PDM-122

RAE DoseRAE-2



Graetz X5 CEx

Atomtex AT 3509

Canberra Dosicard

EkoTest card

EkoTest DGC-Tera

Innovision 451 P

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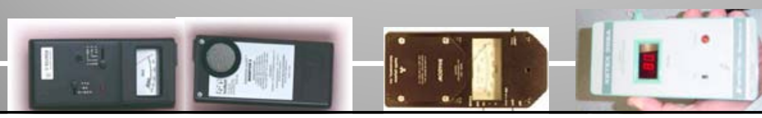
Tools: *Simplified Contamination Survey Instruments*

Pros

- "Open window" GM for alpha and beta contamination.
- Most have Good Sensitivity.
- Digital models can have set alarm levels
- Small Size
- Simple operation
- Rugged, simple technology.

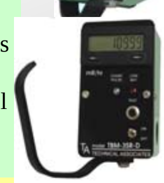
Cons

- Sensitive enough alarm in the presence of legitimate commercial, medical, or naturally occurring sources of radiation.
- Many models can not be used in high dose rates which would be of concern to emergency responders performing rescue operations (>0.1 Sv/hr | >10R/hr).
- Low accuracy (i.e., uses pancake GM for dose measurement)



Buddemeier

Tools: *Simplified Contamination Survey Instruments*



Description:

These simplified meters use thin window (GM) detectors to measure alpha & beta surface contamination as well as dose rates. Although often ***more sensitive than the electronic dosimeter***, these devices are not as sensitive as the radiation proximity alert systems. Although they have a ***higher range than the personal radiation proximity alert systems***, many models will still not function well in the emergency response dose rate ranges (0.1 Sv/hr or 0.1 Sv). Their simplified operation is designed for the occasional user.

Application:

Well suited for emergency responders and hospital staff who may need to quickly determine if radioactive ***contamination*** is present. The units can also alert the wearer when unusual radiation levels are present. Training must be provided on their use as successful contamination monitoring requires specific techniques.

Examples:

Canberra Industries: http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/radiagem4.pdf
T$_A$TECHNICAL ASSOCIATES http://www.tech-associates.com/dept/sales/product-info/tbm-3.html
Berkeley Nucleonics Corp: http://www.berkeleynucleonics.com/PalmRAD/
Health Physics Instruments: http://www.fwt.com/hpi/hpi_4020ds.htm
Radiation Alert Instruments: http://www.seintl.com/mon5.htm, http://www.seintl.com/dig50.htm, http://www.seintl.com/inspect.htm, http://www.seintl.com/insp_exp.htm

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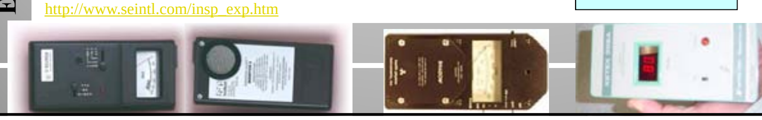

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