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Security of Radioactive Devices

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Sandia National Laboratories

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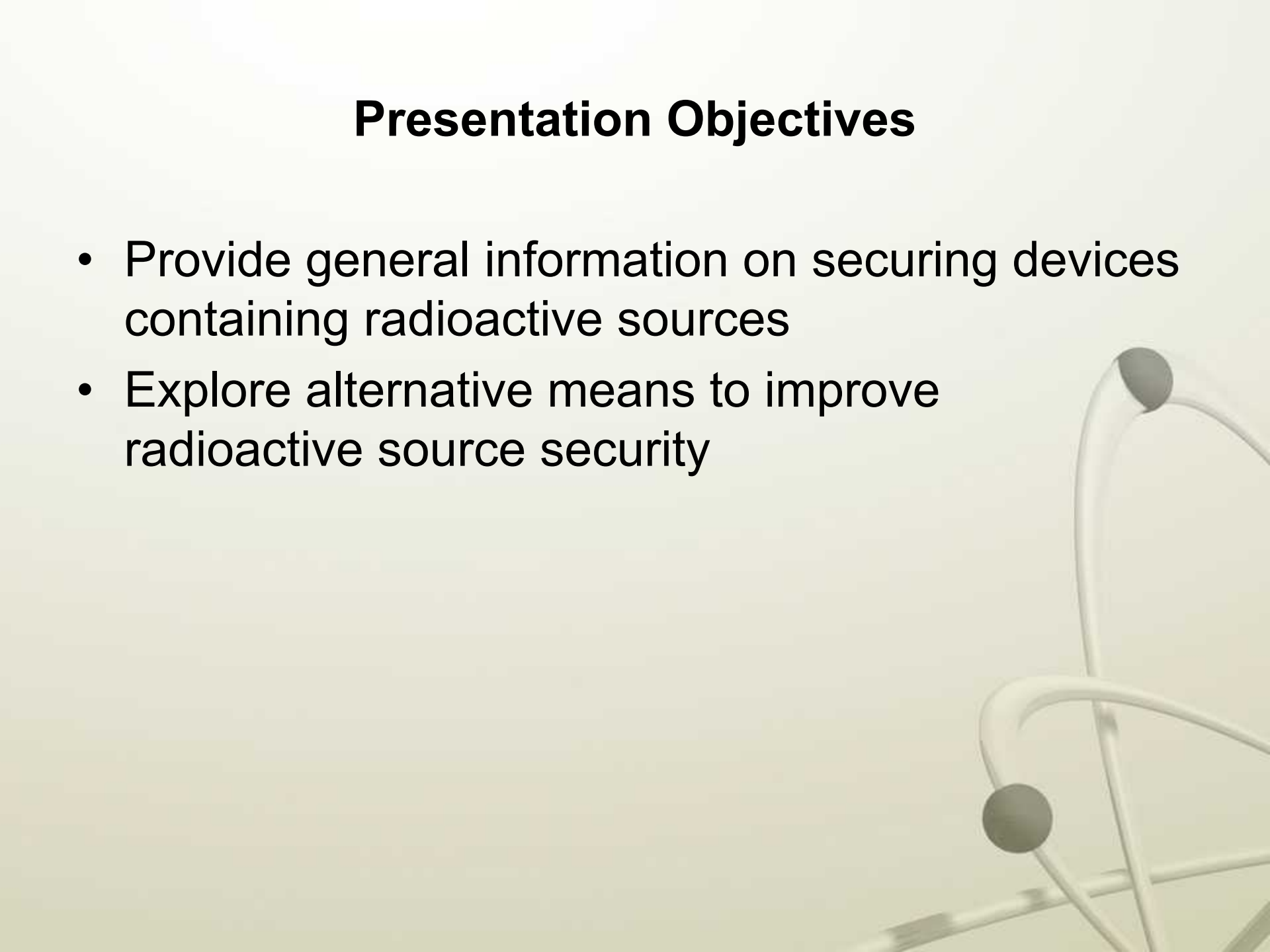
NNSA National Nuclear Security Administration

Sandia National Laboratories

Presentation Objectives

- Provide general information on securing devices containing radioactive sources
- Explore alternative means to improve radioactive source security



Safety or Security ?

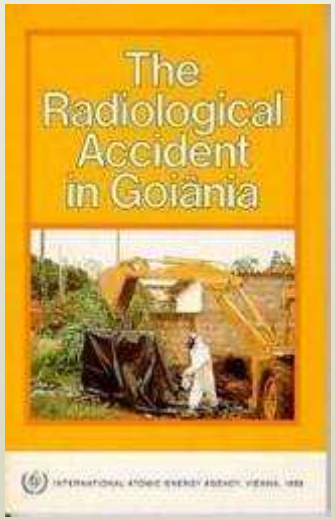
- **Same Objective**: Prevent avoidable hazards
- **Safety**: Minimize likelihood of accidents; mitigate consequences
- **Security**: Prevent unauthorized access and unauthorized transfer; recover material
- **Difference**: Inadvertent or intentional?

Loss of Control of Radioactive Source

SAFETY

Inadvertent loss or damage

- Misplaced
- Forgotten
- Accidents



SECURITY

Intentional

Damage

- Sabotage

Acquisition

- Theft
- Illegal purchase
- Legal purchase

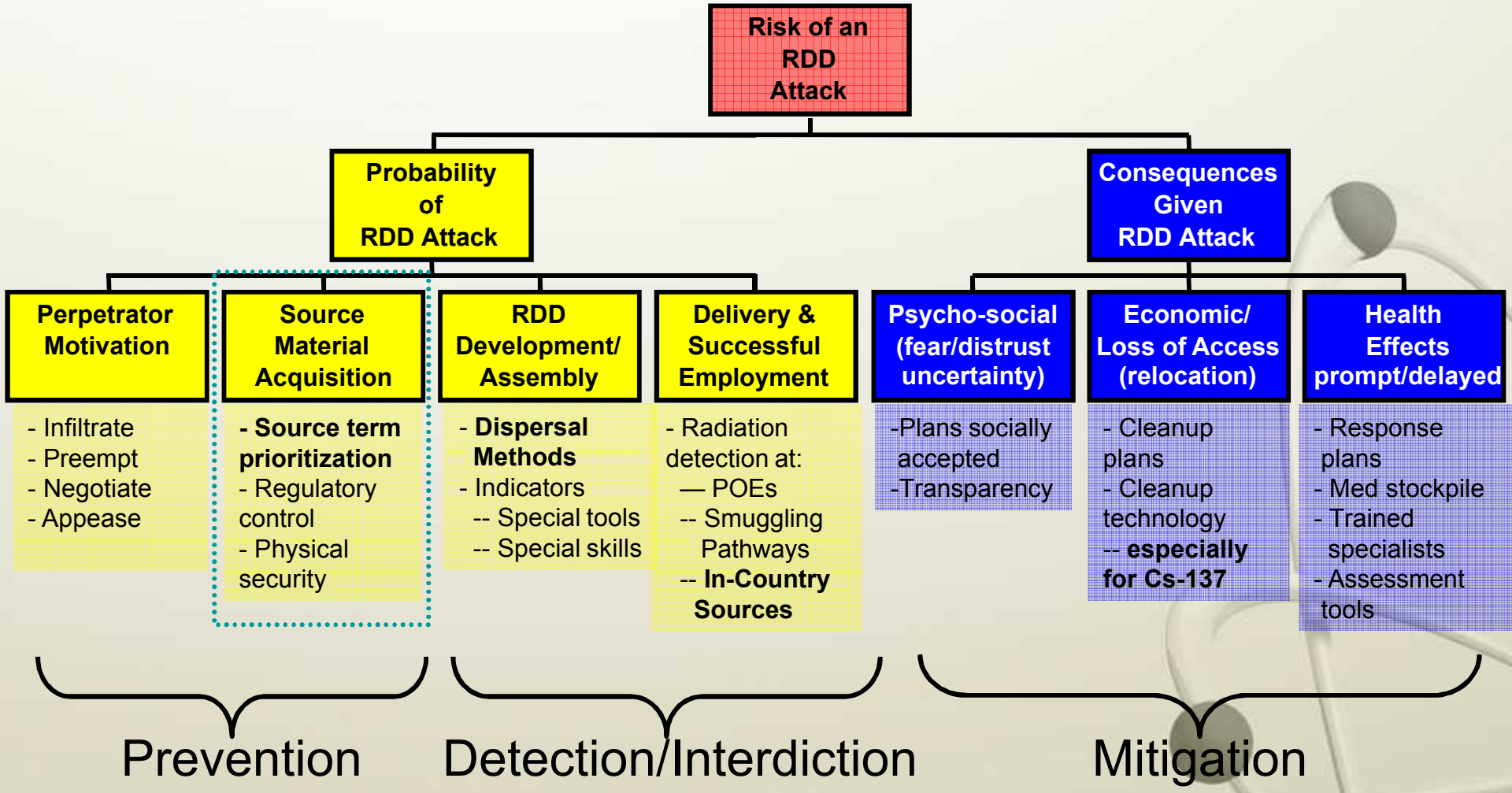
Malicious Motive

- Terrorism
- Individual's intent to harm other(s)

Financial Motive

- Illegal sale for profit
- Avoidance of costs of ownership
- Extortion

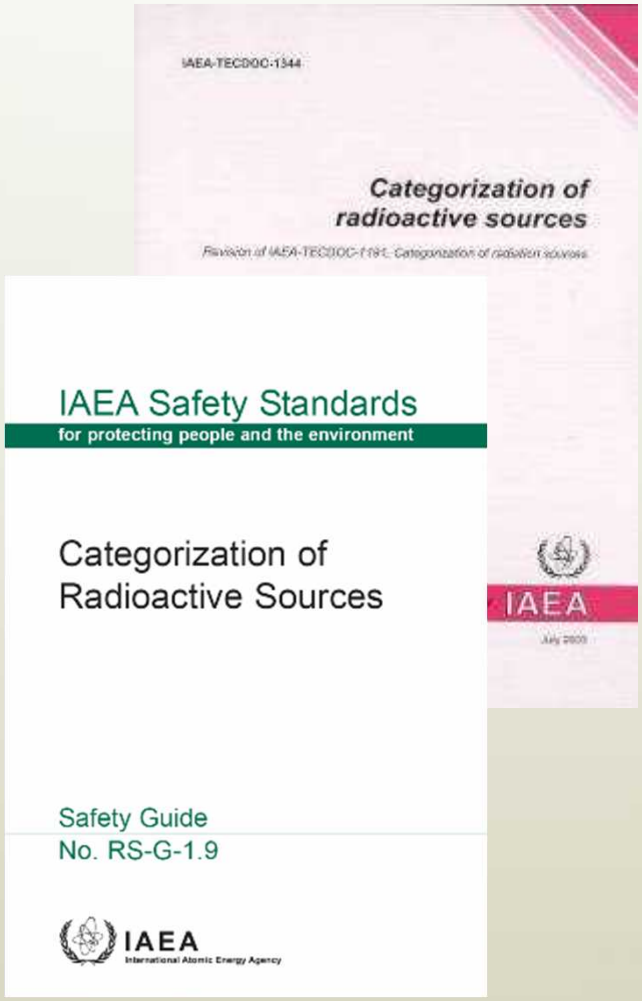
The RDD Risk Equation and Risk Reduction Countermeasures



Radioactive Material Prioritization

- Categorization Techniques
  - IAEA, NRC: Deterministic Methods (IAEA Category 1-5 and NRC Radionuclides of Concern)
  - IAEA: Transport Security
  - UN: Transport of Dangerous Goods
  - NNSA: Stochastic Methods (Assessment and Action Levels)
- Categories (levels, classes) determine levels of graded security

Categorization of Sources RS-G-1.9



The new categorization provides a fundamental and internationally harmonized basis for risk-informed decision making, by providing a relative ranking and grouping of practices and sources, which is based on a logical and transparent methodology

Table of Radionuclides of Concern
(IAEA Category 2)

Radionuclide	Quantity of Concern	Radionuclide	Quantity of Concern
Am-241	0.6 TBq (16 Ci)	**Pm-147**	400 TBq (11 KCi)
Am-241/Be	0.6 TBq (16 Ci)	**Pu-238**	0.6 TBq (16 Ci)
Cf-252	0.2 TBq (5.4 Ci)	**Pu-239/Be**	0.6 TBq (16 Ci)
Cm-244	0.5 TBq (14 Ci)	**Ra-226**	0.4 TBq (10 Ci)
Co-60	0.3 TBq (8.1 Ci)	**Se-75**	2 TBq (54 Ci)
Cs-137	1 TBq (27 Ci)	**Sr-90 (Y-90)**	10 TBq (270 Ci)
Gd-153	10 TBq (270 Ci)	**Tm-170**	200 TBq(5.4 KCi)
Ir-192	0.8 TBq (22 Ci)	**Yb-169**	3 TBq (81 Ci)

NNSA Assessment, Action Levels Based on Stochastic Evaluations

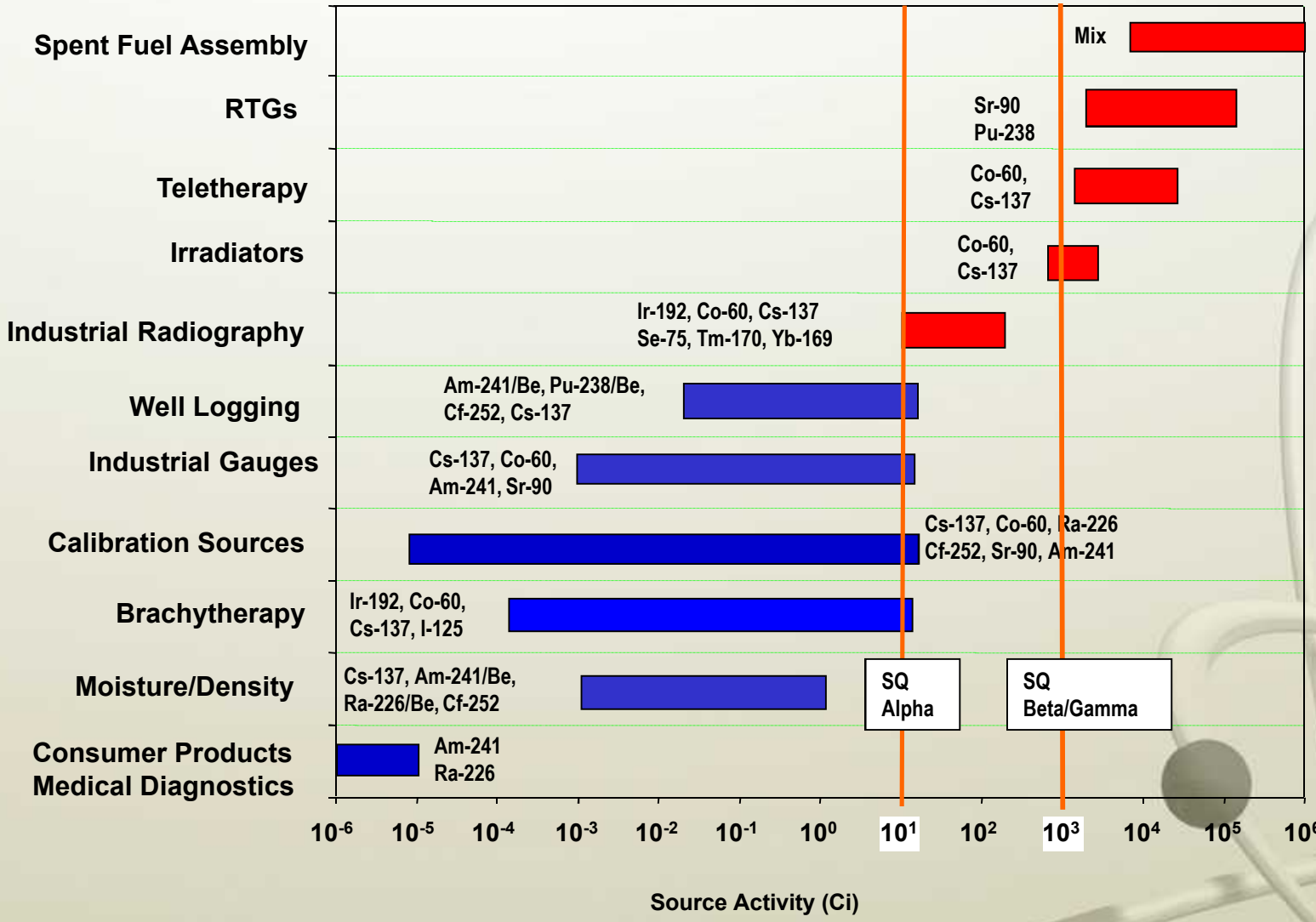
- General Rules*
  - Action Level
    - Beta/Gamma – 1000 Ci (37 TBq)
    - Alpha – 20 Ci (0.74 TBq)

* **See backup slides for a complete list of NNSA radionuclides**

Amount of Radioactive Material Needed for Area Denial

- Basis is US EPA Protective Action Guideline (PAG) for relocation
  - EPA recommends population relocation if the projected dose would exceed 2 rem (20 mSv) in the first year after the RDD event
  - 500-acre (2-sq-km) impact area
- IAEA Categorization (TECDOC 1344) of radiation sources
  - Not based on RDD area-denial scenarios

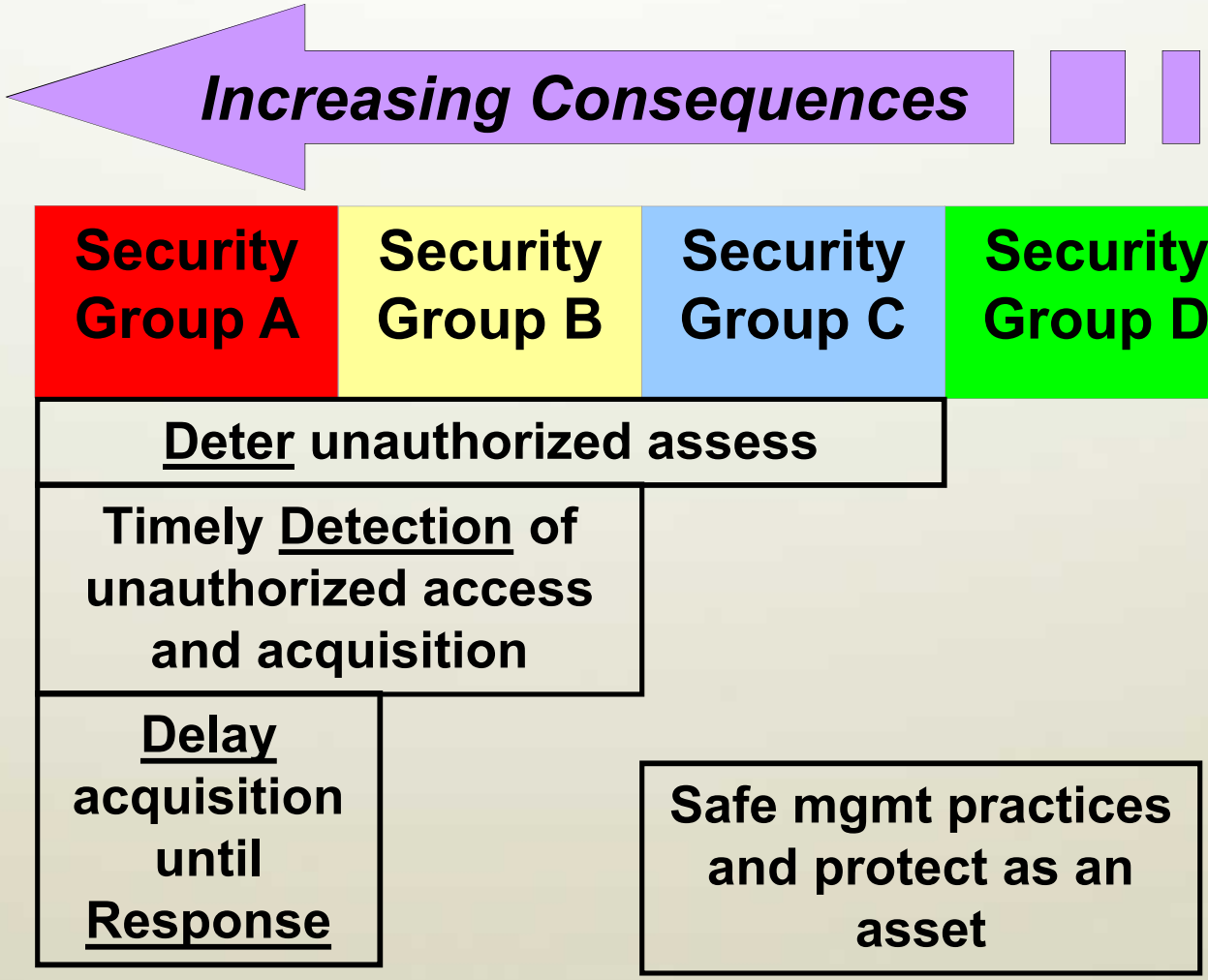
Source Activity/Application Matrix: Millions of Sources, but most < 10 Ci



IAEA Assignment of Sources to Security Groups

Security Groups	Source Category	Examples of Practices
A	1	Radioisotope Thermoelectric Generators (RTGs) Irradiators, Teletherapy Fixed multi-beam teletherapy (gamma knife)
B	2	Industrial radiography High/medium dose rate brachytherapy
	3	Fixed industrial gauges (e.g., level, dredger, conveyor), well-logging gauges
C	4	Low-dose rate brachytherapy. Thickness gauges. Portable gauges (e.g. moisture & density). Bone densitometers, Static eliminators
D	5	Low-dose rate brachytherapy eye plaques and permanent implant sources X-ray fluorescence and electron capture devices

IAEA Assignment of Sources to Security Groups: 1355 Security Objectives



A (Cat 1)
RTGs, irradiator, teletherapy
B (Cat 2,3)
Radiography, well logging
C (Cat 4)
Portable gauges
D (Cat 5)
Low-dose medical

IAEA Assignment of Sources to Security Groups: Security Measures for Groups

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td colspan="3">Deterrence provided by:</td><td rowspan="8">No specific provisions

Routine measures to ensure safe use and protect as an asset</td></tr>
<tr><td colspan="3">Measures separating the source from unauthorized personnel:</td></tr>
<tr><td>Two technical measures</td><td>Two measures (one technical)</td><td>One technical measure</td></tr>
<tr><td colspan="2">Specific emergency plan</td><td>Generic emergency plan</td></tr>
<tr><td colspan="2">Background checks</td><td rowspan="4"></td></tr>
<tr><td colspan="2">Security plan</td></tr>
<tr><td colspan="2">Information security</td></tr>
<tr><td colspan="2">Upgrade security for increased threat</td></tr>
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IAEA Assignment of Sources to Security Groups: Security Measures for Groups

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td colspan="2">Timely detection provided by:</td><td rowspan="3" colspan="2"></td></tr>
<tr><td>Remotely monitored intruder alarm</td><td>Local alarm</td></tr>
<tr><td>Timely response to an alarm</td><td></td></tr>
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Devices Studied

- Blood irradiation
- Research
- Teletherapy

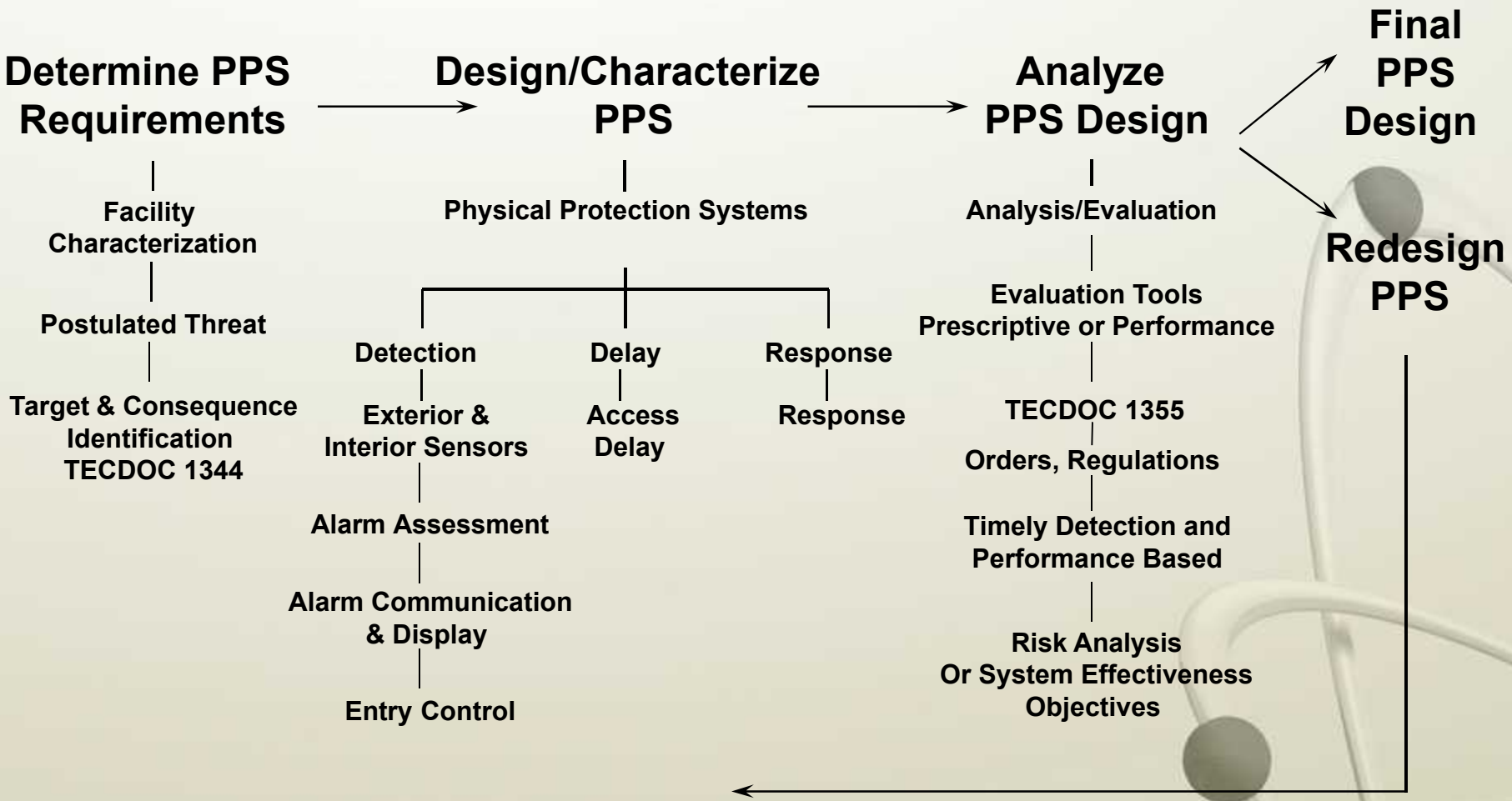
Objective

- Demonstrate removal of a radioactive source from self-shielded devices:
  - Remove source without regard to exposure level
  - Remove source, but minimizing exposure
  - Using open source information; minimal technical expertise
- Determine tools and time needed for source removal

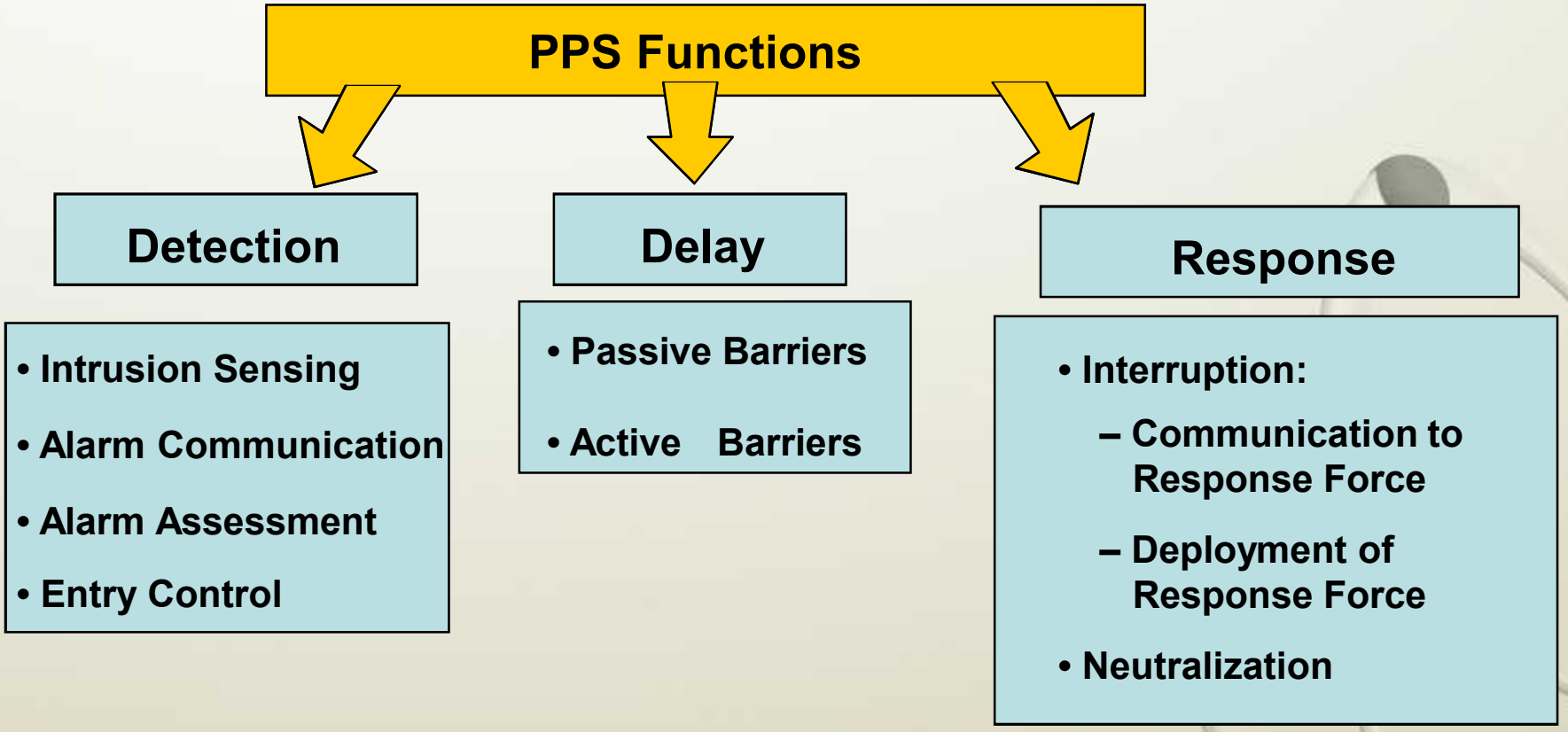
Findings

- Machines designed for field re-sourcing
- Shielding provides advantage
- Sources can be removed

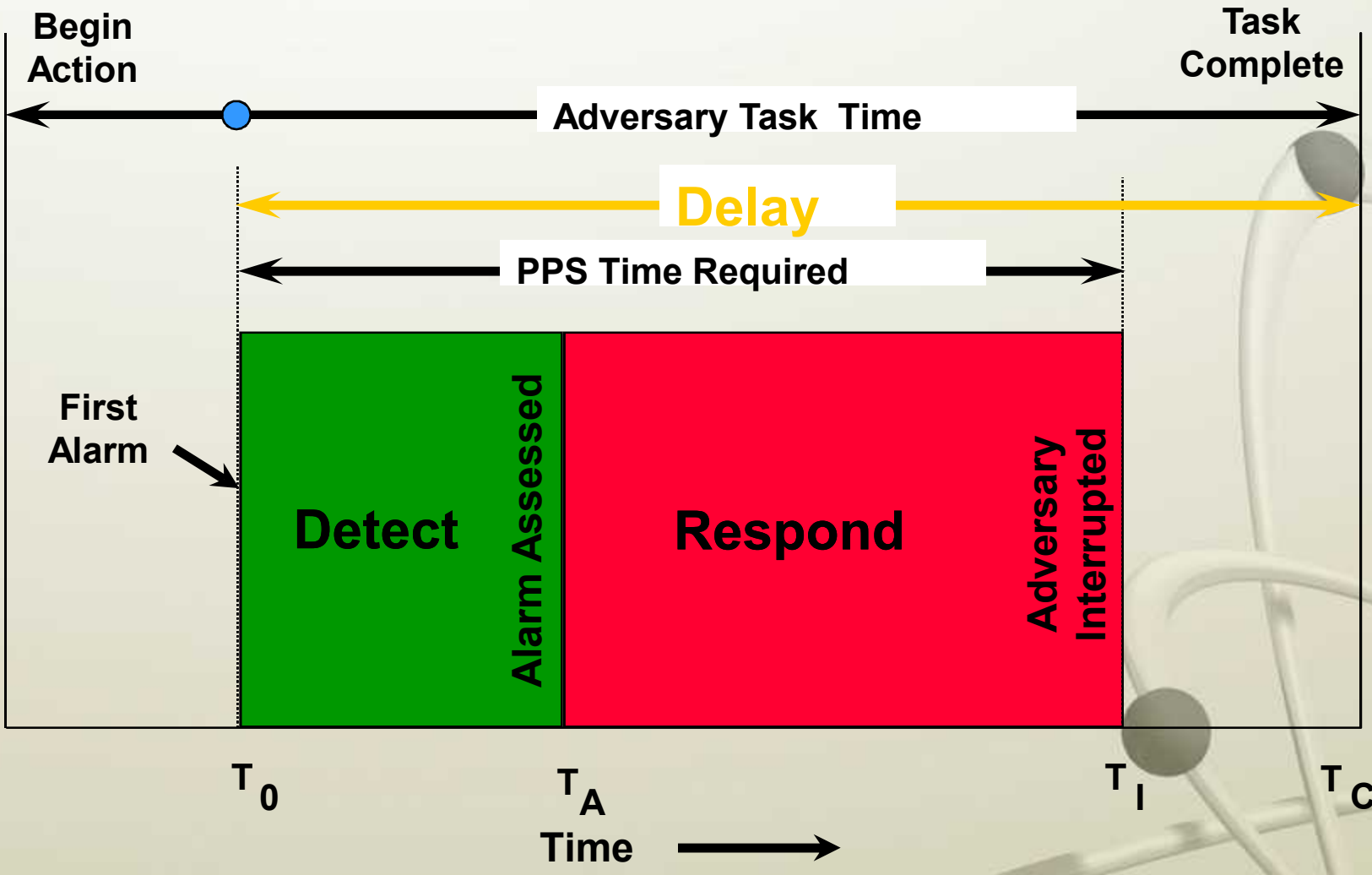
Physical Protection System (PPS) Fundamentals: Design and Evaluation Process Outline



PPS Functions

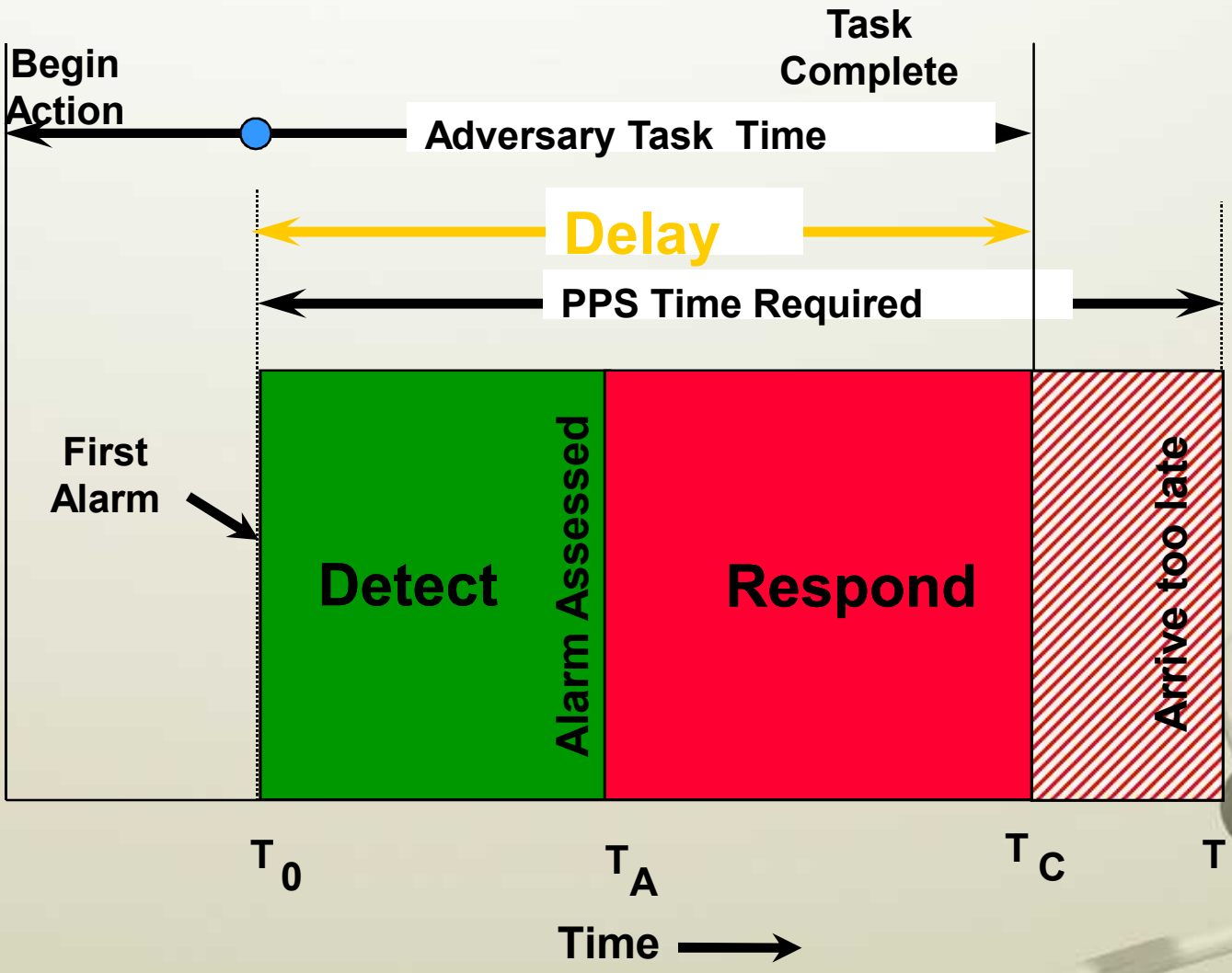


Adversary Task Time vs. PPS Time Requirements



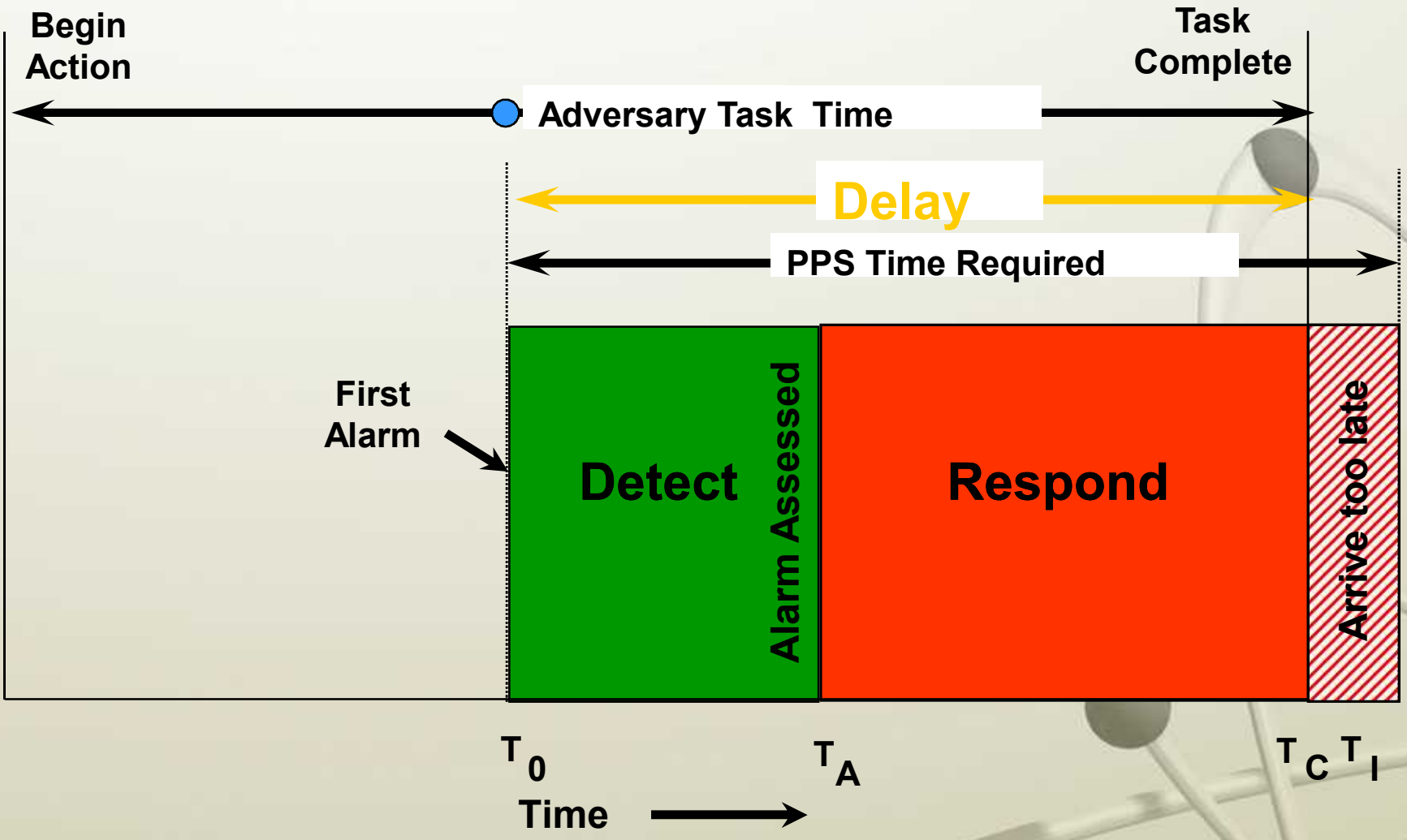
PPS not Effective

(Late response)



PPS not Effective

(Late detection)



PPS Design Principles

- Place *detection* toward the perimeter and *delay* toward the target
- Protection-in-depth
- Minimum consequence of component failure
- Balanced protection
- Combine physical protection components into a system within constraints of the host facility
- Use components that complement each other and correct for weaknesses
- Response able to arrive in time to defeat the threat

Sensor Technologies

- Balanced Magnetic Switches
- Vibration and Glass Break Sensors
- Microwave
- Ultrasonic
- Passive Infrared
- Video Motion Detection
- Fiber Optics
- Micro-Switches
- Tamper Switches
- Proximity Sensors
- Weigh Scales

Cameras for Assessment

- Camera on a Chip
- Rugged, Compact Construction
- Evidence-Quality
- Very-Low-Light Types of Cameras
- Infrared cameras
- LED Illumination
- Signal Verification
- Pan/Tilt/Zoom

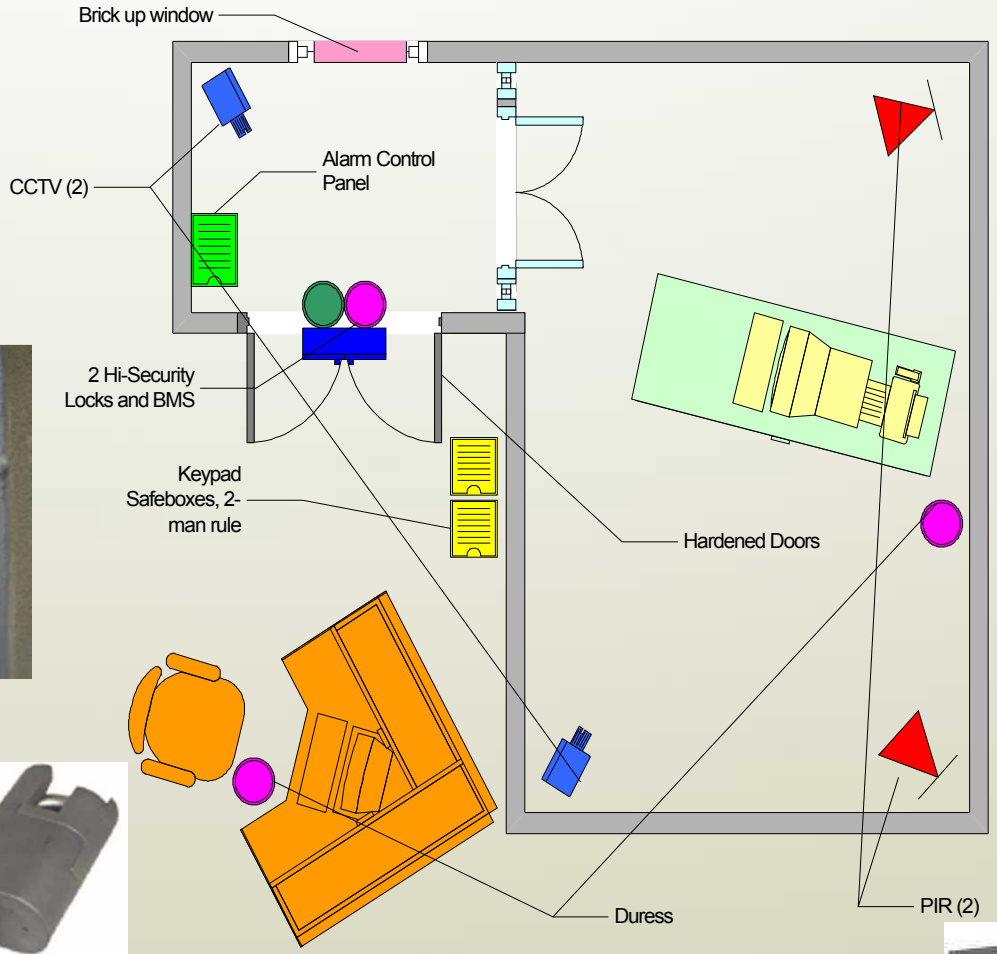
Physical Protection Summary

- Effective physical protection requires
  - Detection
  - Delay
  - Response
- The total time for detection and response must be less than adversary task time once the first detection occurs
- Protection-in-depth, minimum consequence of component failure, and balanced protection are all present in a well-designed system

Improving Source Security

- Detection
  - Intrusion sensors
  - Video assessment
  - Alarm control and display
- Delay
  - Locks/keys
  - Window gratings
  - Hardened doors
  - Cages
- Response
  - Communications equipment
  - Guard equipment

Upgrading Security for a Teletherapy Treatment Room



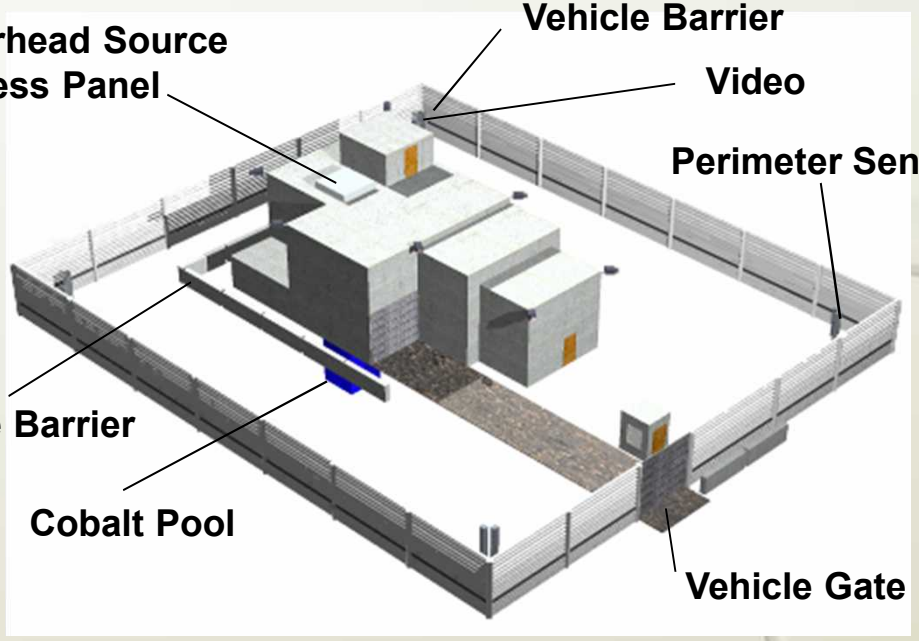
Upgrading Security for Self-Contained Irradiators

Blood Irradiator Unit. Sensor and fiber optic seal installed on each unit, so an alarm is triggered if an intruder attempts to remove the source.

Upgrading Security for Panoramic Irradiator Facilities

(15,000,000 Ci; 555,000TBq)

Alarm Monitoring



Interior Intrusion Detection

Entry Control

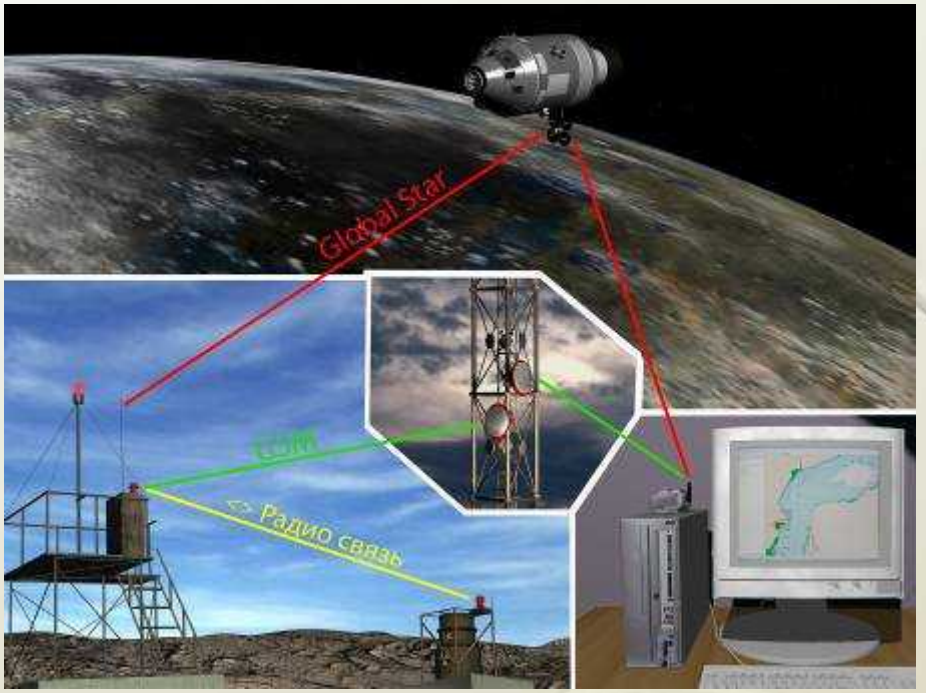
Upgrading Security for Radioisotopic Thermoelectric Generators

(30,000-300,000 Ci; 1,110-11,100 TBq)

- **GPS Position**
- **GSM / UHF Transmitter**

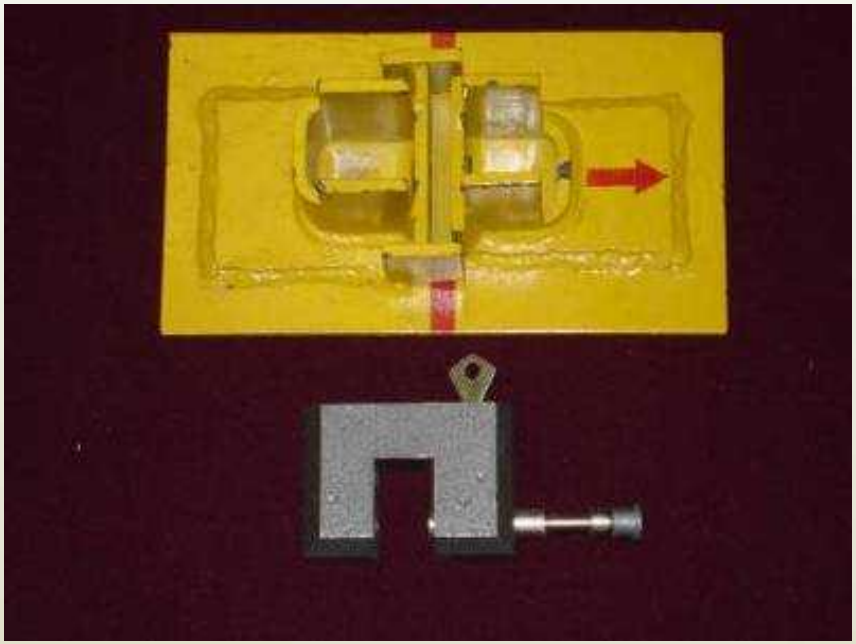
Monitor

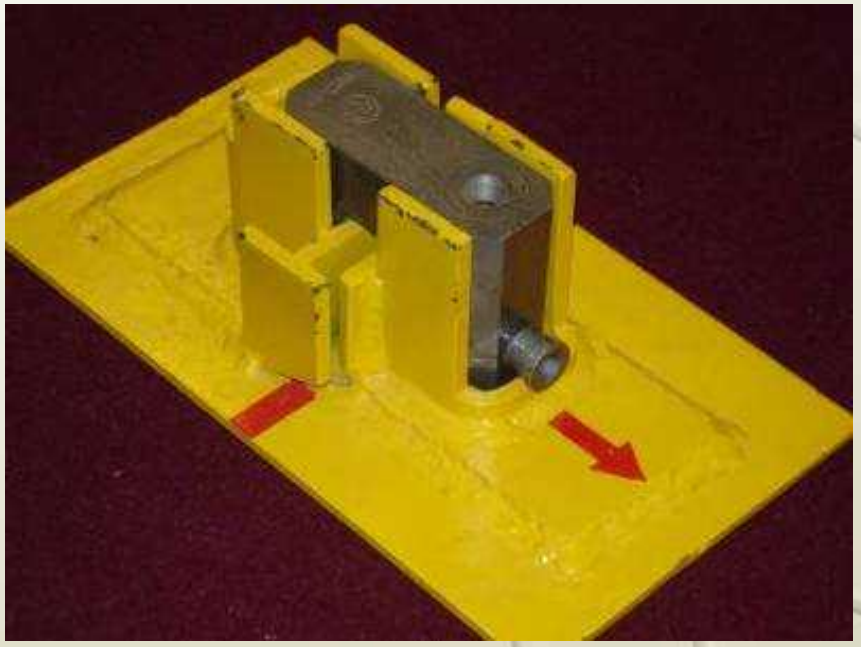
- **Vibration**
- **Tilt**
- **Voltage**
- **Temperature**



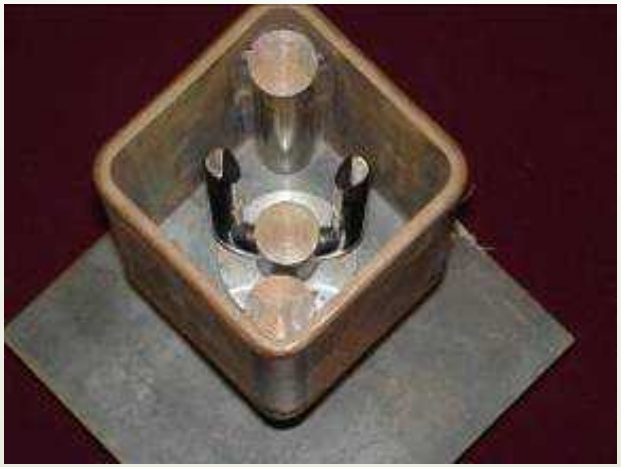
- **Remote, real-time monitoring of position and status of RTG**
- **Off-site monitoring through GSM / UHF and satellite communication**
- **Response dispatched**

Shielded Sliding Bolt Lock





High-Security Shielded Padlock



Shielded Hockey Puck Lock

Padlocks

Cages

Non-removable Screws

Summary

- Radioactive sources can be used by malevolents
  - Availability
  - Devices
- Not all radioactive materials are suitable
- Consequences of malevolent use are economic and long-term
- Physical protection methodology can be used to improve security

This Is the Limit of What We Can Do

- Add security exterior to devices
- Locate and make secure susceptible devices
- Recover abandoned or unwanted sources
- Collaborate with international partners

- Support and involvement of source owners and manufacturers is essential