

# Scope and Application of Nuclear Forensics

Practical Introduction to Nuclear Forensics

14-18 November 2022

Australia Nuclear Science and  
Technology Organisation

# Learning Objectives

Upon completion of this module, participants should be able to:

1. Differentiate between nuclear and other radioactive material from a nuclear security perspective
2. Appraise the implications to national security posed by the loss of nuclear or other radioactive material from regulatory control
3. Describe the role of nuclear forensics in a national response plan to the investigation of a criminal or other intentional unauthorized act involving MORC<sup>†</sup>
4. Describe how a nuclear forensic capability can deter the loss or theft of nuclear or other radioactive material from regulatory control

---

<sup>†</sup>MORC = *material out of regulatory control*

# Nuclear Security: Prevention, Detection, Response



Source: IAEA/Dean Calma



Source: IAEA/Dean Calma



Source: IAEA/Dean Calma

...to theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities

# Nuclear and Other Radioactive Materials Can Be Lost from Regulatory Control

Fuel pellets



Source: Shutterstock

Sealed radioactive sources



Source: Shutterstock

Spent fuel, waste products



Source: IAEA/Dean Calma

Radioactive scrap metal



Source: IAEA/Kirstie Hansen

Uranium ore concentrate



Source: IAEA/Dean Calma

Uranium hexafluoride



Source: IAEA/Dean Calma

# Loss Can Lead to the Creation of RED and RDD

Source: IAEA/Dean Calma



Radiation Exposure Device (RED)

- A device designed to **intentionally expose** members of public to radiation
- Example: radioactive source hidden in a highly populated common area (e.g., government building)

Source: IAEA/Susanna Lööf



Radiological Dispersal Device (RDD)

- A device designed to **spread radioactive material** using conventional explosives or other means
- Examples: (1) release of radioactive powder into a ventilation system of a building; or (2) conventional explosive coupled with radioactive material

# Consequences of **Using** an RED or RDD

- Exposure of a person/persons to radiation, potentially leading to radiation burns and internal exposure through inhalation or ingestion
- Physical damage from a chemical explosion (in the case of an RDD)
- **Fear and panic among the population**
- **Denied access to (or use of) affected area due to radioactive contamination**
- **Cleanup costs**



# Loss of Nuclear Material from Regulatory Control Can Also Lead to the Creation of:

Source: IAEA/Sandor Miklos Tozser



- A device incorporating **nuclear material** designed to result in **nuclear yield**
- May be fabricated in a completely improvised manner or may be a modification to a radiological dispersal device
- Consequences would likely be severe and could include:
  - Significant blast effects
  - Widespread radioactive contamination (fallout)
  - Psychological effects on population

# Considerations Regarding REDs, RDDs and INDs

Source: IAEA/Dean Calma



Radiation Exposure Device (RED)

- **Required material:**  
Radioactive source
- **Material availability:**  
Commercially available  
(medical, industrial)
- **“Know-how”:** Minimal

Source: IAEA/Susanna Lööf



Radiological Dispersal Device (RDD)

- **Required material:**  
Radioactive source  
(+chemical explosives)
- **Material availability:**  
Commercially available  
(medical, industrial)
- **“Know-how”:** Mid-level

Source: IAEA/Sandor Miklos Tozser



Improvised Nuclear Device (IND)

- **Required material:**  
Highly enriched uranium  
or plutonium
- **Material availability:**  
Nuclear fuel cycle,  
**quite complicated**
- **“Know-how”:** Complex,  
but available

# Likelihood Versus Consequences

**IND**



**HIGH**

Theft or purchase of nuclear material for the purposes of constructing an IND

Consequences

**RDD or RED**



Production of a “dirty bomb” or RED using purchased or stolen radioactive material

Likelihood

**HIGH**

# The Origin of Nuclear Forensics



- An increase in the number of reported incidents of nuclear and other radioactive material encountered out of regulatory control in the 1990s
- At this time, illicit trafficking of nuclear or other radioactive material was recognized as a challenge to nuclear security
- It was recognized that properties of nuclear and other radioactive material could be indicative of their origins
- Nuclear forensics was developed to enable national authorities to investigate these incidents, return the material to regulatory control and to identify vulnerabilities and weaknesses at border check points and in the physical protection system.

# Definition of Nuclear Forensics



Nuclear forensics is...

the examination of nuclear or other radioactive material,

or of evidence contaminated with radionuclides,

in the context of legal proceedings under international or national law related to nuclear security

IAEA Nuclear Security Series No. 2-G (Rev.1)

Implementing Guide

Nuclear Forensics in  
Support of Investigations

# Nuclear Forensics Seeks to Identify:

- What the materials are
- How, when and where the materials were made
- What the intended uses of the materials were



Uranium ore concentrate (yellowcake)



# What is the purpose of a nuclear forensics capability?



It can provide information that may assist investigators in **enforcing laws and regulations** that prohibit the possession and use of nuclear or other radioactive material out of regulatory control

Source: IAEA / Dean Calma

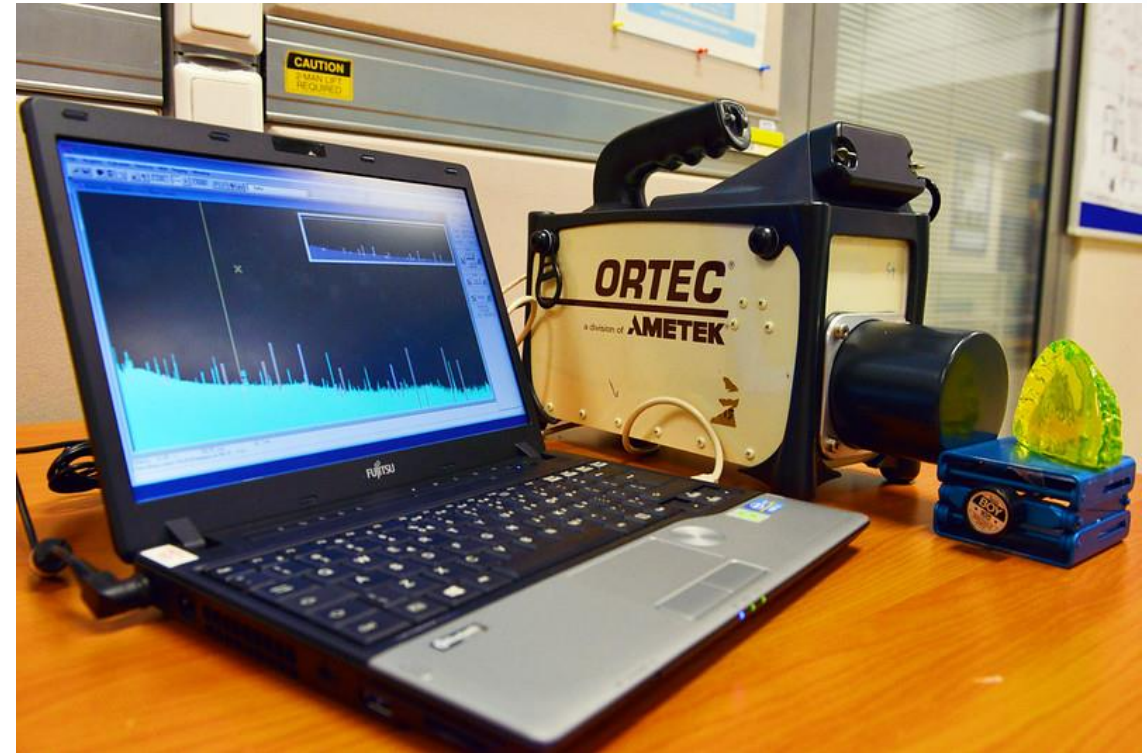
# What is the purpose of a nuclear forensics capability?

It can help identify **linkages** between nuclear or other radioactive material out of regulatory control and people, places and events subject to the investigation...



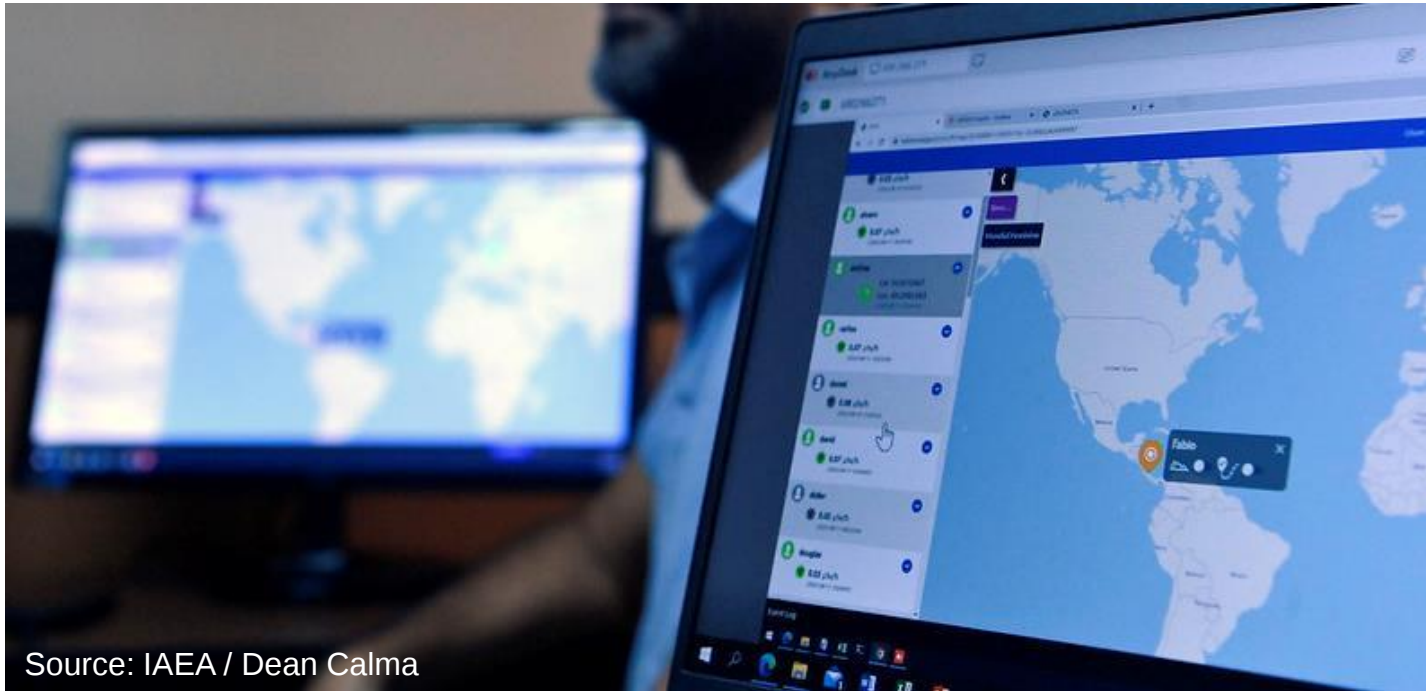
Source: IAEA / Dean Calma

Source: IAEA / Dean Calma



... and between **disparate criminal activities** involving nuclear or other radioactive material

# What is the purpose of a nuclear forensics capability?



Source: IAEA / Dean Calma

It may also be used to assist in determination of the **time, manner and place** from which nuclear or other radioactive material was lost from regulatory control

# What is the purpose of a nuclear forensics capability?

Source: IAEA / Dean Calma

It can aid investigators in the **identification of deficiencies and weaknesses in nuclear material accountancy and control systems,...**

...as well as **vulnerabilities in physical protection systems** and nuclear facilities and radiation detection systems at borders, ports and other points of entry



# Nuclear Security Objectives of a State



Nuclear forensics, using capabilities maintained by the State, can assist in investigations of nuclear or other radioactive materials out of regulatory control

# Nuclear Forensics as a Preventative Measure



- Findings from nuclear forensic examinations may assist in determination that a material had been removed from a facility or site previously deemed secure
- This can help identify deficiencies in material accountancy or nuclear security systems
- Knowledge that a State has nuclear forensic capabilities may function as a deterrent to perpetrators who may otherwise intend to divert or illicitly traffic nuclear or other radioactive materials



# Nuclear Forensics as a Mechanism of Response

- Nuclear forensics can be utilized alongside traditional forensics to support criminal investigations
- Nuclear forensics is considered a key part of a State's national response plan in cases when nuclear or other radioactive material are encountered out of regulatory control



# A State's Nuclear Forensics Capability should be “Right-Sized” to Meet These Needs

- Enforcing laws and regulations
- Identifying linkages between nuclear or other radioactive material out of regulatory control and people, places and events
- Determining the time, manner and place from which nuclear or other radioactive material was lost from regulatory control
- Identification of deficiencies and weaknesses in nuclear material accountancy and control systems



Source: IAEA / Dean Calma

# How much nuclear forensics capability does a State require?



Source: IAEA / Dean Calma

- The answer to this question **depends on the State's needs and requirements!**
- It is up to the State to make this determination, but partners can help and assist!
- At a minimum, a State should have sufficient capacity to enforce laws and regulations

# How much nuclear forensics capability does a State require?

## For example...

A State with a research reactor that uses enriched uranium may decide that they require a nuclear forensics capability that can determine uranium isotopic composition with high precision

Source: IAEA / Edgard Perez Alvan



# How much nuclear forensics capability does a State require?

## For example...

A State with **no nuclear material** may decide that they **do not require** a nuclear forensics capability that can measure uranium or plutonium isotopes with high precision



Source: IAEA / Dean Calma

# Incidents Recorded in ITDB (1993-2021)



**Group 1:** Incidents that are, or are likely to be, connected with trafficking or malicious use

**Group 2:** Incidents of undetermined intent

**Group 3:** Incidents that are not, or are unlikely to be, connected with trafficking or malicious use

# Types of Material that can Occur Outside of Regulatory Control

Nuclear material



Source: IAEA/Dean Calma

Radioactive sources



Source: Shutterstock

Other radioactive material



Source: IAEA/Kirstie Hansen

## Uranium, plutonium, other actinides

- Improvised nuclear device
- Radiological dispersal device
- Radiation exposure device

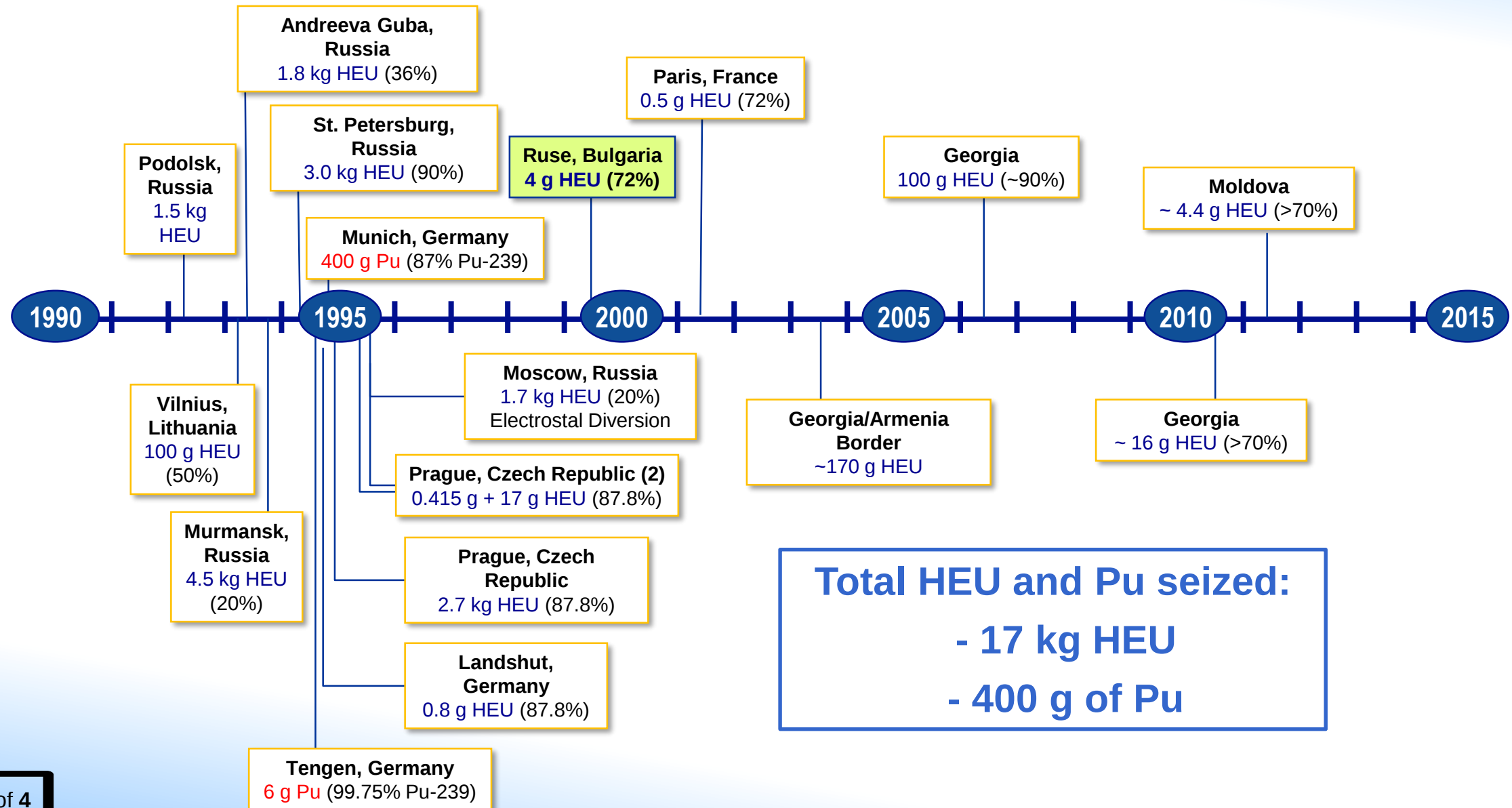
## Variety of high-activity sources (e.g. $^{137}\text{Cs}$ , $^{192}\text{Ir}$ )

- Radiological dispersal device
- Radiation exposure device

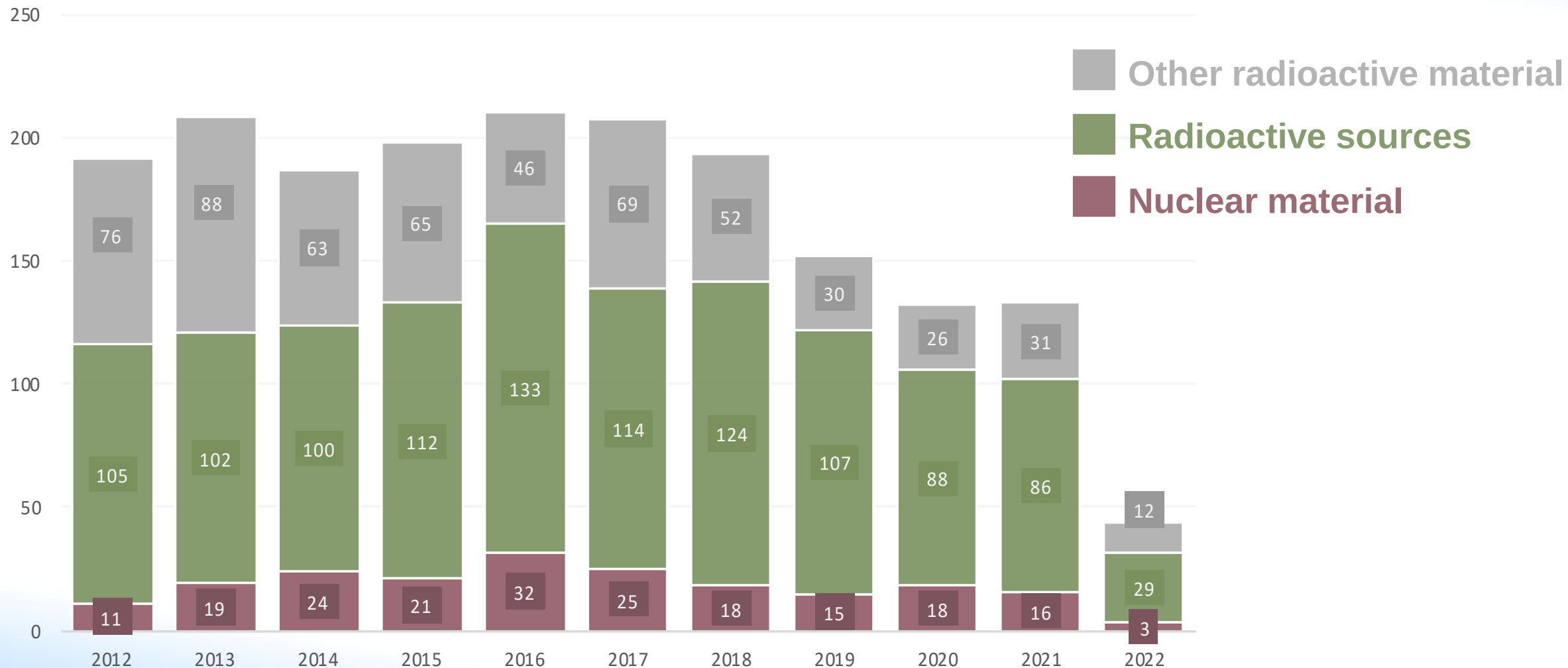
## Other radioactive material (e.g. radioactive scrap metal)

- Radiological dispersal device
- Radiation exposure device

# Significant MORC Cases Involving Nuclear Material



# Recent trends in MORC



# Summary

1. Reviewed basic principles of radioactivity as they relate to nuclear security
2. Differentiated between nuclear and radioactive material from a nuclear security perspective
3. Appraised the implications to national security posed by the loss of nuclear and other radioactive material from regulatory control
4. Described the role of nuclear forensics in a national response plan to the investigation of a criminal or other intentional unauthorized act involving MORC
5. Described how a nuclear forensic capability can deter the loss or theft of nuclear or other radioactive material from regulatory control



**IAEA**

International Atomic Energy Agency  
*Atoms for Peace and Development*

# Questions or comments?

Up next:  
**Lunch**





**IAEA**

International Atomic Energy Agency

*Atoms for Peace and Development*

*Thank you!*

