# Incident Scene Considerations

## Evidence Collection to Nuclear Forensics

June 4, 2013

# Outline of a Response

- Initial Priorities upon arrival
- Potential Hazards
- Integration into other activities
- Data gathering
- Chain of Custody
- Documentation
- Lessons Learned

# Sample Scenario

- Your team has been asked to respond to a private residence where radioactive material is believed to be present.

# Sample Scenario

- Other responders that will meet you there are police and fire department personnel
- You are the radiological experts and the other responding agencies are expecting you to take the lead role in the entry along with their assistance.
- Using this scenario, what actions do you take prior to deployment, upon arrival, and during initial entry?

# Scenario Discussion

# Concept Review for Incident Scenes

- Incident scene complexity can vary widely
  - Could be a simple scene with a radioactive source setting in a remote location
  - Could be a major disaster location with many injured and large structures collapsed
- Priority for "forensics" will depend on the situation, but remember that saving lives comes first!

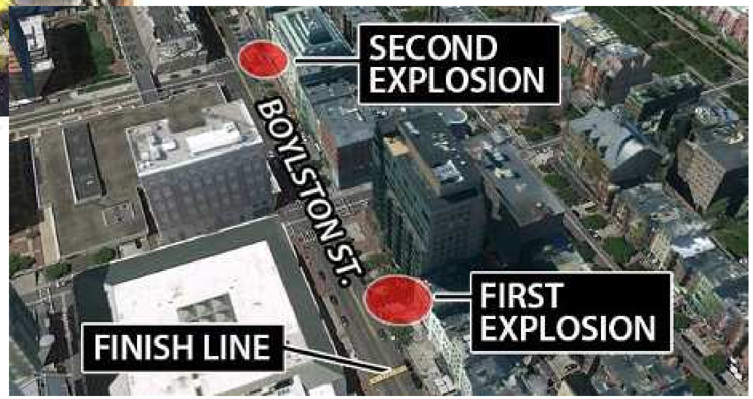
# Remote location

# Large Scenes

# Building Collapse

# Special Event

# Forensics Nightmare?



# Good Reference

UNODC
United Nations Office on Drugs and Crime

**Crime scene and physical evidence awareness**
for non-forensic personnel

# Initial Priorities

- Information gathering begins upon initial notification – long before the team arrives at the scene
- Information can come from many sources, both official and unofficial
- Use pre-deployment time wisely to gather information, consider what resources are needed, and make initial team assignments
- Ensure that you have a point of contact at the scene if there are already people there
- If people are already there, try to get as much data as possible from them without affecting their ability to perform their initial response duties

# Potential Hazards

Potential hazards may arise from a number of sources:

- Chemicals (either those present at the scene, for instance, in the case of clandestine laboratories, or chemicals used as part of the investigation);
- Biological materials (e.g. blood and body fluids may present a risk of HIV/AIDS and other infections);
- Unexploded explosives (e.g. booby traps);
- Firearms;
- Environmental factors (e.g. excessive heat or cold);
- Unsafe structures (especially when collecting evidence at fire and bombing scenes);
- Insecure environment (e.g. offender still present at the scene);
- Other risks: sharp objects, radiological, nuclear and electrical risks, gases, etc.

Note that radioactive material is just one of many potential hazards!
Health and Safety of responders take priority over evidence collection!

# Planning, organization and coordination of the work at the scene

- **The planning, organization and coordination of the work at the scene aims at deploying resources commensurate to the case being investigated and using these resources efficiently and effectively.**

# Planning, organization and coordination of the work at the scene

- **Why is it important ?**
- Arriving unprepared at the scene, especially without the commensurate equipment and expertise, may result in missed opportunities and compromise the entire investigation.
- An uncoordinated approach can lead to misunderstanding, to duplication of effort or to wrong assumptions that someone else is taking care of a particular assignment.
- Without clear assignments of responsibility, important elements at the scene may be overlooked, evidence may go unrecognized or worse, may be lost.
- Having too many or inappropriate people involved also runs the risk of compromising or destroying relevant evidence.
- Establishing early communication at the scene and between scene and laboratory personnel creates a better understanding of possible further examinations that could be conducted on physical evidence and significantly improves the outcome of the case.

# Preservation of the scene and its evidence

- Preservation of the scene and its evidence aims at implementing appropriate protective and anti-contamination measures to keep disturbances of the scene and the physical evidence to a minimum.

# Preservation of the scene and its evidence

- **Why is it important ?**
- A scene not properly secured and preserved will lead to unnecessary activity at the scene, which may irreversibly modify, contaminate and compromise the scene and its evidence.
- Lack of protective measures can result in the destruction of important evidence, and thus misdirect investigators and adversely influence the final result of the investigation. In the worst situation it may prevent the solution of the case or result in a wrong conclusion.
- No or unsystematic use of protective clothing by the personnel working at the scene will lead to irrevocable contamination of the scene (e.g. hairs, fingermarks, shoemarks, cigarettes left by the personnel working at the scene). Those contaminations may ultimately prevent the solution of the case.
- No or unsystematic use of protective clothing will also expose personnel to unnecessary health and safety hazards.
- Once the scene is released, opportunities to correct errors or recover unrecognized or overlooked evidence seldom exist.

# Typical Advice for First Responders

Note the time that you:

1. Were dispatched
2. Arrived on the scene
3. Called for supervisory or specialized personnel to respond to the scene
   - get used to looking at your watch
4. Record the names and contact numbers for anyone present at the scene upon your arrival.

# Typical Advice for First Responders

1. Rope off a VERY LARGE area around the scene (utilizing standard police crime scene tape)
2. Keep EVERYONE out and back
3. Ensure that only authorized persons are allowed inside the crime scene
   - this should be limited to the crime scene investigators only

# Typical Advice for First Responders

Establish a Crime Scene Attendance log and maintain until the scene is released.

The log should include:

- The name of each person entering the scene
- The date and time each person entered the scene
- The reason for each person entering the scene
- The date and time each person exits the scene

# Typical Advice for First Responders

A UNIFORMED OFFICER SHOULD PROVIDE CRIME SCENE SECURITY, AT ALL TIMES, UNTIL THE SCENE IS RELEASED.

The crime scene should be protected from:

1. Human or vehicular traffic
2. Animals
3. Crime scene personnel
   - use personal protective equipment
4. Do not use toilets or telephones within the crime scene

# Documentation of the scene and its evidence

- **Documentation aims at producing a permanent, objective record of the scene, of the physical evidence and of any changes that take place. Documentation at the scene is also the starting point for the chain-of-custody.**

# Documentation of the scene and its evidence

- **Why is it important ?**
- Personnel working at the scene may be called upon to recount certain details and demonstrate actions taken during the scene investigation. Memory cannot be relied on for this.
- Documentation is crucial to recall and demonstrate, at a later stage, the initial status of the scene and what was done, when, how and by whom.
- Chronological and careful documentation is important to ensure the “traceability” and “continuity” of the evidence throughout the process. The chain-of-custody establishes that what is produced in court relates to the specified item recovered from the scene.
- All subsequent examinations and analyses can be compromised if the chain of custody is not properly initiated and maintained at the scene.

# Recognition, recovery and preservation of physical evidence

- Recognition, recovery and preservation of physical evidence is the central part of the work at the scene. It aims at locating and identifying a maximum of potentially relevant evidence, and selecting appropriate recovery methods and adequate packaging to preserve the evidence integrity.

# Recognition, recovery and preservation of physical evidence

- **Why is it important ?**
- Relevant evidence that is present at the crime scene but that goes unrecognized cannot contribute to the solution of a case. It may be irretrievably lost or may send an investigation in a costly and unproductive direction.
- Recovery of only the most obvious and visible evidence may result in leaving the most relevant evidence behind.
- Adequate recovery methods avoid loss, degradation or contamination of the evidence.
- Indiscriminate evidence recovery might potentially overburden the laboratory with irrelevant items and thus hinder the investigation.

# Transportation, storage and submission of evidence to the laboratory

- **This last phase of the crime scene investigation process aims at selecting the means of transportation and storage that are appropriate for the type of physical evidence to ensure the integrity of evidence submitted to the laboratory.**

# Transportation, storage and submission of evidence to the laboratory

- **Why is it important ?**
- To be useful to the case, the evidence that is recovered at the scene must ultimately reach a forensic laboratory in a way that maintains its integrity and identity.
- Adequate conditions will avoid degradation of evidence during the transport and storage.
- Secured access during transportation and storage will prevent any unauthorized access and possible tampering or loss of evidence.

# Forensics vs Nuclear Forensics

- Forensic science, referred to as forensics, is the comprehensive scientific analysis of physical, biological, behavioral, and documentary evidence in the context of civil, criminal, or international law. The goal of forensics is to discover linkages among people, places, things, and events.

# Forensics vs Nuclear Forensics

- Nuclear Forensic science is a sub-discipline of forensic science and is referred to as Nuclear Forensics (NF). It is the comprehensive scientific analysis of nuclear or other radioactive materials or radioactively contaminated materials in the context of civil, criminal, or international law. The analysis of nuclear or other radioactive material seeks to identify what the materials are, how, when, and where the materials were made, and what were their intended uses. The analysis of radioactively contaminated material may determine whether there are linkages among people, places, things, and events.

# The problem

- Since the beginning of the 1990’s, more than 600 cases of illicit trafficking involving radioactive or nuclear material have been reported in the IAEA database. The reported seizures obviously represent only the tip of an iceberg and we have to assume that the real number of cases of illicit trafficking of nuclear and radioactive material is significantly higher.


Ref:

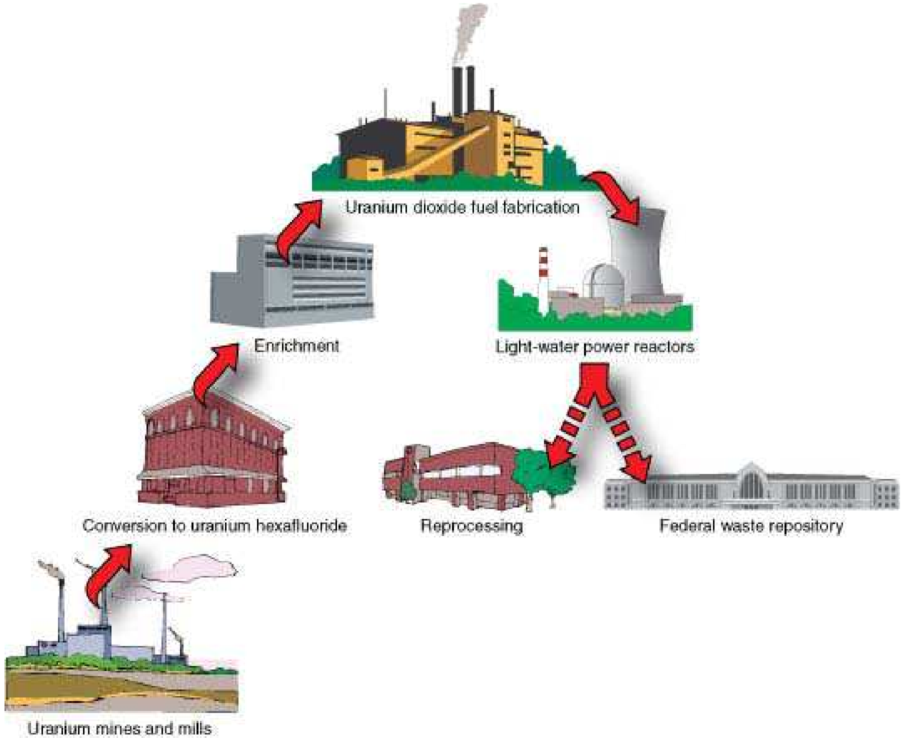
- Tracing the Origin of Diverted or Stolen Nuclear Material through Nuclear Forensic Investigations
- Klaus Mayer, Maria Wallenius and Ian Ray

# Basics Nuclear Forensics Questions

- What is the material?
- What is its origin?
- How did it get there?
- Who was involved?

- Answering those questions with 100% accuracy is of utmost importance!

# Nuclear Fuel Cycle




Because nuclear material goes through several transformations during the uranium concentration and enrichment cycle, specific signatures may be unique to different stages of the cycle. Scientists want to develop signatures across the entire nuclear fuel cycle.

# Nuclear Forensics

- Nuclear forensics relies on the fact that certain measurable parameters in a sample are characteristic for the given material
- These parameters can be radiological in nature, but chemical analysis is also very important
- The main challenges in nuclear forensics are with the identification of characteristic parameters and with the availability of reference information.

# Nuclear Forensics

- Nuclear forensics is a multidisciplinary field, drawing on analytical methods adapted from safeguards, materials science, and isotope geology to investigate nuclear or radiological material for
  - isotopic and elemental composition
  - Geometry
  - Impurities
  - macroscopic appearance
  - microstructure.

- This information can be used to establish
  - material's age
  - intended use
  - method of production.

- Establishing the material's age, surface roughness and identifying the reactor in which it was used are key signatures needed to determine: when the material was last chemically processed; if it was formed as fuel in a nuclear power reactor; and what type of reactor it was burnt in. If all this information can be compared with external reference data, then it is possible to determine where the material was produced. From that information, it may be possible to deduce its last legal owner, and the smuggling route.

# Nuclear Attribution

- The process of identifying the source of nuclear or radioactive material used in illegal activities, to determine the point of origin and routes of transit involving such material, and ultimately to contribute to the prosecution of those responsible.
- Nuclear attribution utilizes many inputs, including:
  - Results from nuclear forensic sample analyses;
  - Understanding of radiochemical and environmental signatures;
  - Knowledge of the methods used for producing nuclear material and nuclear weapons and the development pathway;
  - Information from law enforcement and intelligence sources.
- Nuclear attribution is the integration of all relevant forms of information about a nuclear smuggling incident into data that can be readily analyzed and interpreted to form the basis of a confident response to the incident. The goal of the attribution process is to answer the needs, requirements and questions of policy makers for a given incident.

# Nuclear Forensics

- The analysis of intercepted illicit nuclear or radioactive material and any associated material to provide evidence for nuclear attribution. The goal of nuclear analysis is to identify forensic indicators in interdicted nuclear and radiological samples or the surrounding environment, e.g. the container or transport vehicle. These indicators arise from known relationships between material characteristics and process history.
- Thus, nuclear forensic analysis includes the characterization of the material and correlation with its production history.

# IAEA Definitions

- ***Categorization*** is performed to address the threat posed by a specific incident. The goal of categorization is to identify the risk to the safety of first responders, law enforcement personnel and the public, and to determine if there is criminal activity or a threat to national security. Further analysis will be guided by the initial categorization.

# IAEA Definitions

- ***Characterization*** is performed to determine the nature of the radioactive and associated evidence. Basic characterization provides full elemental analysis of the radioactive material, including major, minor and trace constituents.

# IAEA Definitions

- *Nuclear forensic interpretation* is the process of correlating the material characteristics with the production history. The goal of nuclear forensic interpretation is to determine the method and time of production. The interpretation may include reactor and process modeling and/or database searches to identify the method of production

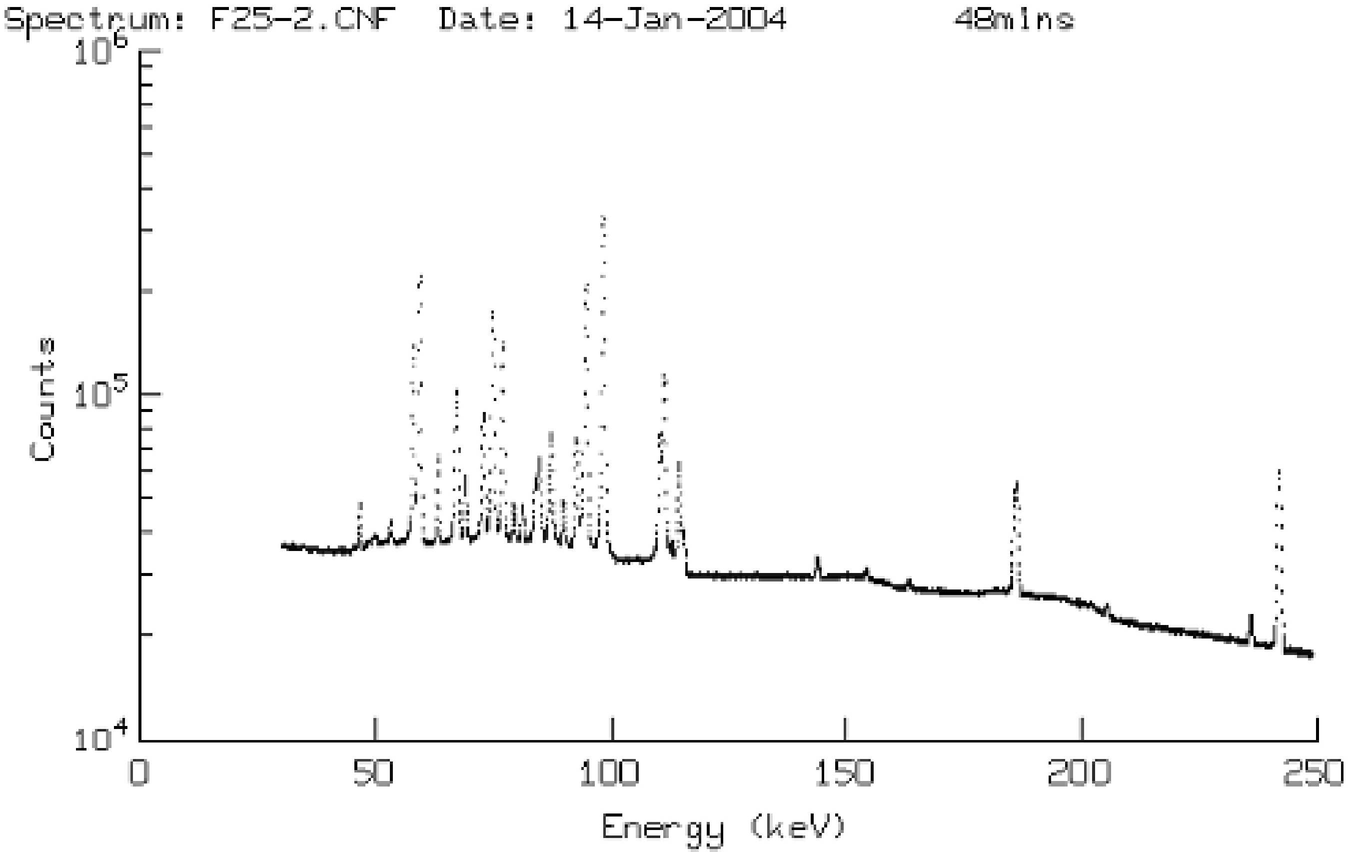
# Nuclear Material

- Nuclear material can be divided into five general categories
- (1) Unirradiated direct use material;
- (2) Irradiated direct use material;
- (3) Alternative material;
- (4) Indirect use material;
- (5) Commercial radioactive sources.

# Yellowcake

The yellowcake was uncovered Dec. 16 by Rotterdam-based scrap metal company Jewometaal, which had received it in a shipment of scrap metal from a dealer in Jordan. Apparently the Jordanian dealer didn't know that the scrap metal contained any radioactive material. Jewometaal detected the radioactive material during a routine scan and called in the Dutch government, which in turn asked the IAEA to examine it. The Rotterdam sample contained an estimated 5 pounds of uranium oxide.

# Yellowcake




- Gamma spectrum of the yellow cake sample shown. The spectrum proves that the material consists of natural uranium, the isotopic composition was determined by analyzing the energy range indicated

# Laboratory Procedures

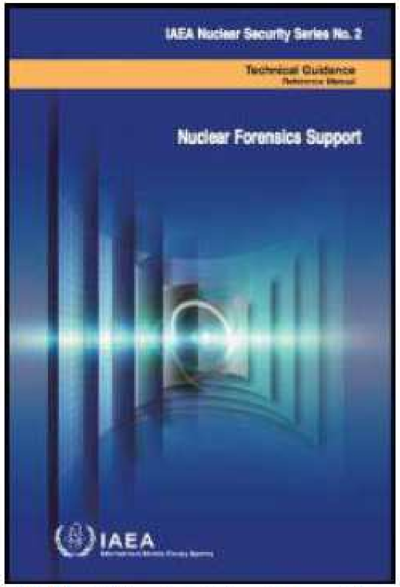
**Interdicted Sample**

*Nuclear material*

Nuclear Chemistry

Radiochemical diagnostics

Age dating, U & Pu isotopics, stable isotopes for geolocation, trace elements, electron microscopy, x-ray diffraction, ICP-MS, SIMS



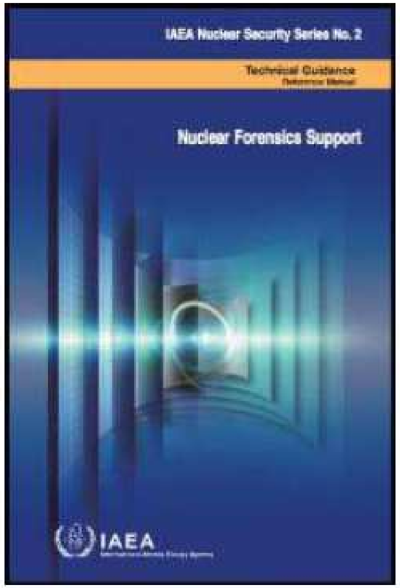

*ITWG Model Action Plan*
*Published by the IAEA*

**One part of working with an interdicted sample involves various laboratory procedures associated with nuclear chemistry – necessary to identify and characterize the nuclear material itself**

# Traditional Forensics

A second, equally important, part of working with an interdicted sample involves various laboratory procedures associated with forensic sciences – conventional examinations such as fingerprints & DNA

**Interdicted Sample**




*ITWG Model Action Plan Published by the IAEA*

*Traditional evidence and Non-nuclear material*

Forensic Sciences

↓

Complete forensic analysis

↓

Chain of custody, photography, fingerprints, hair, fibers, pollens, plant DNA, explosives: SPME-GC/MS, ion trap MS

# Putting it all Together

**Interdicted Sample**

*Nuclear material*

Nuclear Chemistry

Radiochemical diagnostics

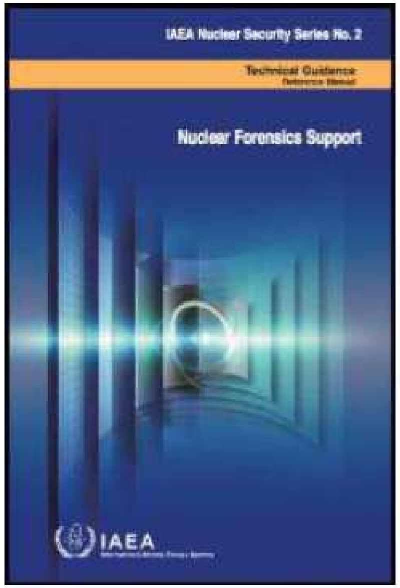
Age dating, U & Pu isotopics, stable isotopes for geolocation, trace elements, electron microscopy, x-ray diffraction, ICP-MS, SIMS

*Traditional evidence and Non-nuclear material*

Forensic Sciences

Complete forensic analysis

Chain of custody, photography, fingerprints, hair, fibers, pollens, plant DNA, explosives: SPME-GC/MS, ion trap MS




*ITWG Model Action Plan Published by the IAEA*

**Interpretation, analysis and case development**

**Aids in attribution & formulating response**

# Field Equipment

- Radiation Dose Rate
- Contamination Measurement
  - Alpha
  - Beta
  - Gamma
  - Neutron?
- Low resolution gamma spectroscopy
- High Resolution gamma spectroscopy
- PPE
- Data/voice communications

# Laboratory Equipment

- Radiation Counting Systems
  - Alpha Counter
  - Beta Counter
  - Gamma Counter
  - Neutron Counter
  - Alpha/Beta/Gamma Spectral Analysis
  - Tritium Analysis
- Radiochemical Analysis

# Laboratory Equipment

- Imaging and Microscopy
  - Optical Microscopes
  - Scanning Electron Microscopes
  - Transmission Electron Microscopes
  - Electron Microprobe
  - X-Ray Microanalysis
  - Infrared Spectroscopy
  - Mass Spectroscopy

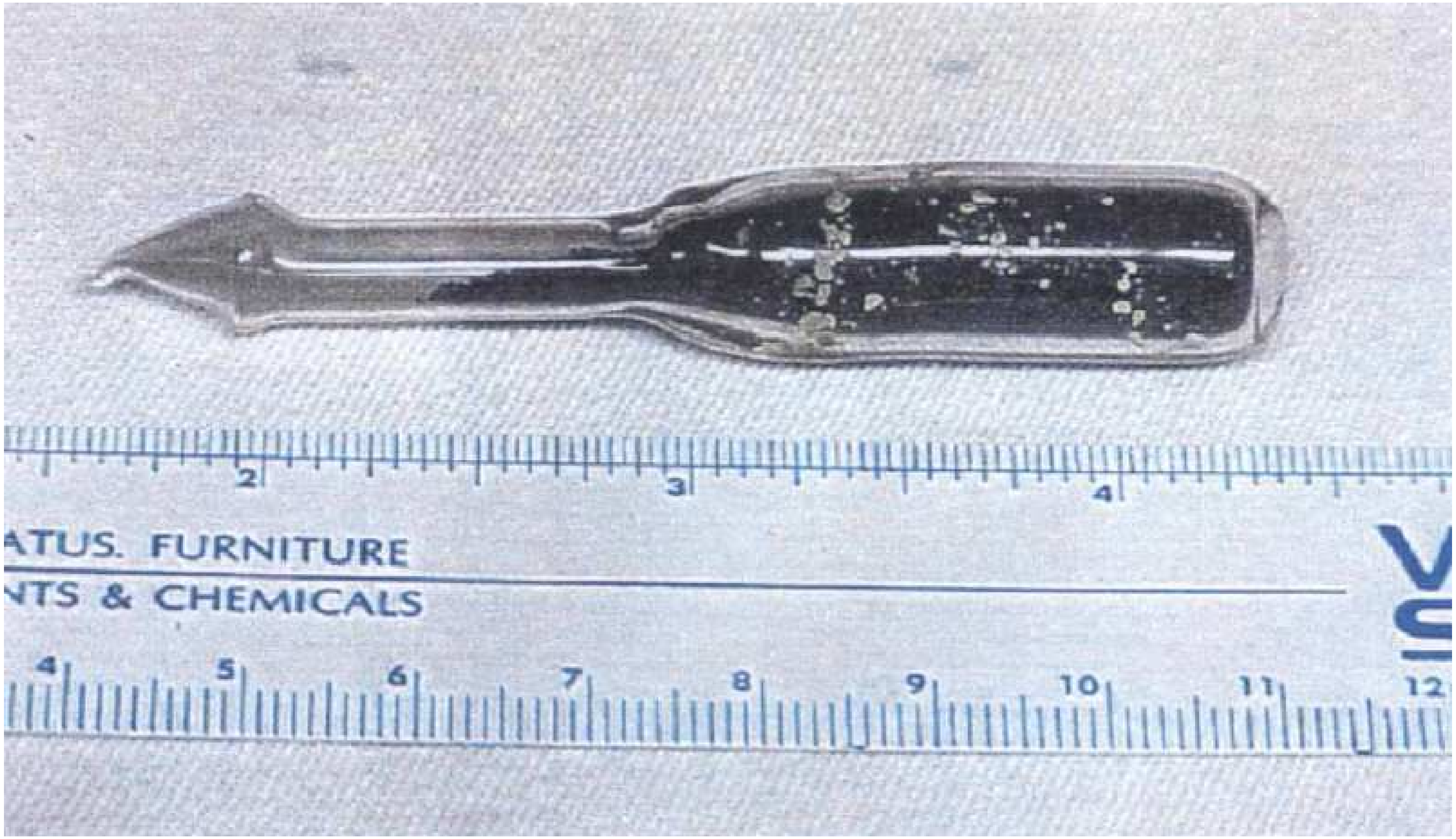
# Sample Analysis Lab

# Bulgarian Example

- May 29, 1999
- Urskan Hanifi attempted to enter Bulgaria from Turkey
- His behavior was suspicious resulting in a search of his car
- Bill of lading written in Cyrillic for a quantity of “99.99% uranium-235” was found
- Further search revealed a 2.5 kg lead container hidden in portable air compressor in the trunk of the car

# Lead Container

# Glass Ampoule



# Bulgarian Example

- Ampoule sent to scientists who confirmed that it was highly enriched uranium (HEU)
- Subject was arrested and admitted that he had purchased the U in Moldova but sale fell through
- About 9 months later a decision was made to have the material sent to U.S. for full forensics analysis
- Purpose was to determine the origin and original use of the HEU

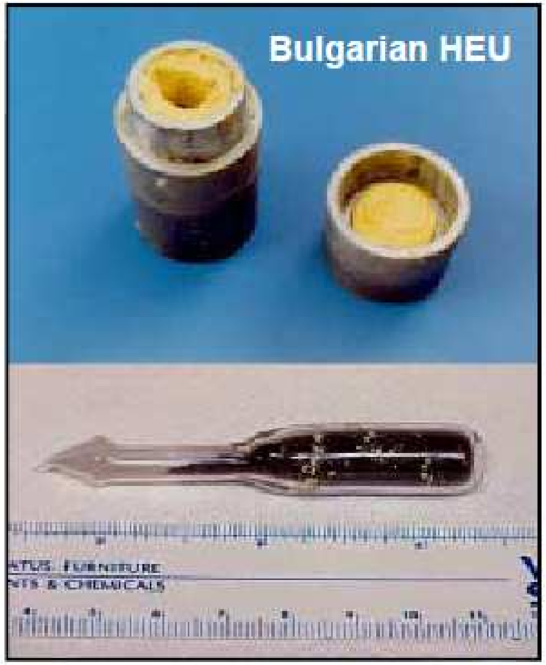
# Bulgarian Example

- Initial step was to ensure that there was not a significant radiological hazard
- Note that throughout the following process, many photographs were taken and chain of custody process was followed
- Container was opened and ampoule was found to be in a cavity in the center of some yellow wax.  A piece of paper separated the ampoule from the wax

# Bulgarian Sample

**Non-nuclear forensics**

- Wax material fingerprint
- Wax colorant
- Paper origin
- Pb metallurgy
- Pb isotopics
- Ampoule material




**Nuclear material forensics**

- Morphology
- Stoichiometry
- Impurity elements
- Residual radionuclides
- Age-dating
- U & Pu isotopics

**Highly-enriched uranium (73%, ~4 grams)**
**Trace plutonium (2.8 ppbw)**

# Bulgarian Example

**Radiochemical analysis of the material indicates that it was recovered from used reactor fuel**

Uranium isotopics:

| | |
|---|---|
| $^{238}$**U** | (13.996 $\pm$ 0.015) at% |
| $^{236}$**U** | (12.133 $\pm$ 0.010) at% |
| $^{235}$**U** | (72.693 $\pm$ 0.013) at% |
| $^{234}$**U** | ( 1.177 $\pm$ 0.001) at% |
| $^{233}$**U** | (299 $\pm$ 7) ppb |
| $^{232}$**U** | (10.8 $\pm$ 0.2) ppb |

Material is 2.8 ppb **Pu** and 7.7 ppb $^{237}$**Np**.

The $^{238}$**Pu** content of the plutonium fraction is very high, consistent with the burn of light-mass uraniums in a reactor

$^{134}$**Cs**, $^{137}$**Cs**, and $^{125}$**Sb** fission products were observed in the sample

Absence of other fission products gives clues to the reprocessing chemistry used

# Bulgarian Example

- Note that the analyses did not stop with just the analysis of the radioactive powder!
- Forensics techniques were used to evaluate all components
- Lead container
- Yellow wax
- Paper liner
- Glass ampoule

# Bulgarian Sample Conclusions

- Sample was from irradiated fuel.
- Chemical reprocessing of fuel was completed in November 1993 with an uncertainty of +/- 1 month.
- PUREX process was used for reprocessing
- Grain structure of powder was unlike U.S. processes
- Glass container was very similar to those used to archive samples in nuclear fuel reprocessing centers

# Bulgarian Sample Conclusions

- Barium chromate that gave the wax the yellow color was banned in U.S. but still in use in many countries
- Wood fibers of paper were common to paper products produced in Europe
- Lead in container was consistent with Pb ores mined in Asia or Europe
- Based in all info, the sample was believed to be from outside U.S.
- Smuggler was fined and released and his body was discovered a few months later

# Questions?