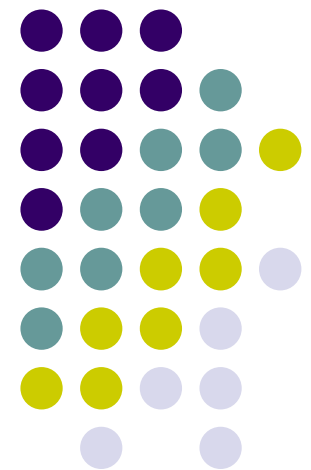


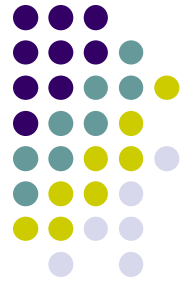
Nuclear Forensics and the requirement of Certified Reference Materials

SSA Jeff Leggitt,
FBI Laboratory
Quantico, Virginia





Goals of Forensic Science



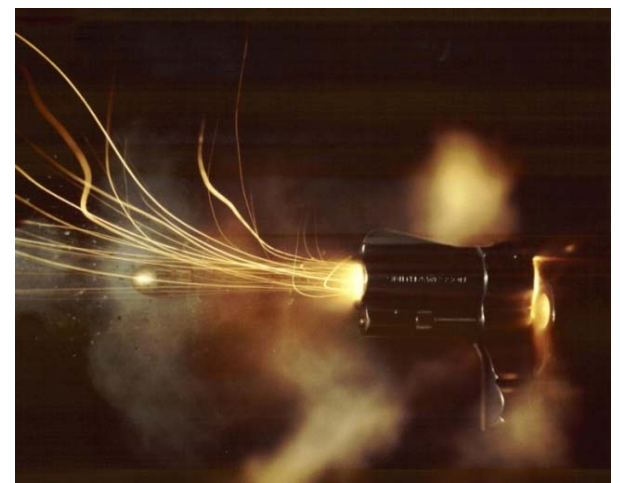
- Associate an item of physical evidence with a person, place, or event.
- Associate two items of evidence with each other.
- Associate an item of evidence with information from existing data base.





Traditional Forensics

- Firearms example
 - Recovered bullet matches gun
 - Two bullets match each other
 - Bullet exam provides indication of what type of weapon.

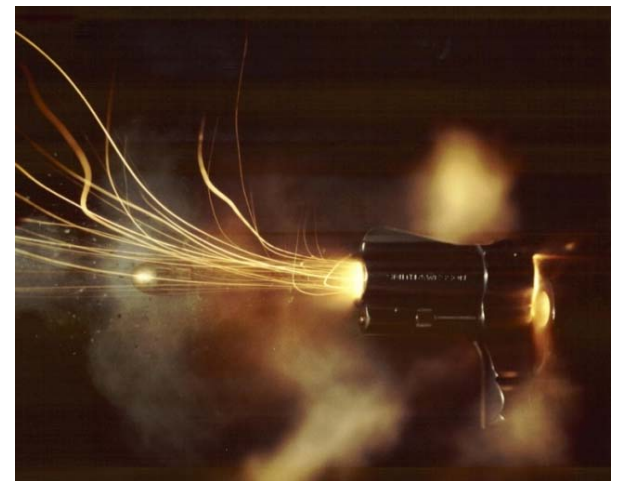




Traditional Forensics

- Firearms example
 - Recovered bullet matches gun
 - Two bullets match each other
 - Bullet exam provides indication of what type of weapon.

Lead and trace metal analysis is calibrated with NIST CRM solutions.



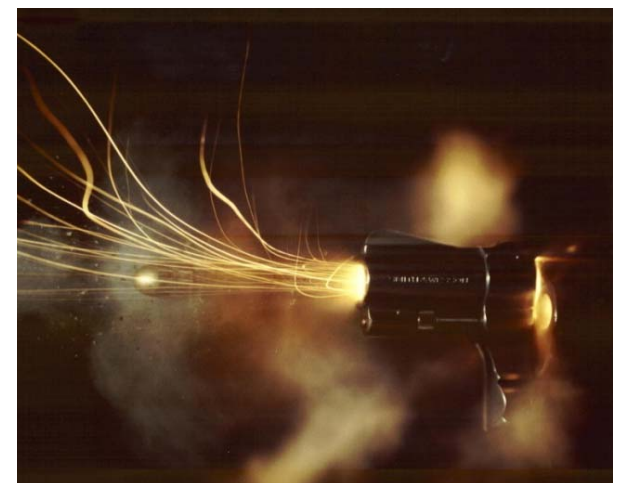


Traditional Forensics

- Firearms example
 - Recovered bullet matches gun
 - Two bullets match each other
 - Bullet exam provides indication of what type of weapon.



Microscope is calibrated with optical standards for color and size determination





Traditional Forensics

- Firearms example
 - Recovered bullet matches gun
 - Two bullets match each other
 - Bullet exam provides indication of what type of weapon.



The cartridge case can be queried in the national database (NIBIN) which was compiled from a large number of standardized examinations.



Legal Standard

- Frye (293 F. 2d 1013 - D.C. Circuit 1923):

Two-step analysis:

- Is the underlying theory generally accepted in the relevant scientific community?
- Are there procedures available that can produce reliable results and are the procedures accepted in the relevant scientific community?
 - Problem: “general acceptance” in the scientific community is difficult to define.

Legal Standard



- Daubert v. Merrell Dow Pharmaceuticals [113 S. Ct. 2786 (**1993**)]
 - Has the technique been validated?
 - What is the existence and maintenance of standards controlling the technique's operation?
 - Were the results peer reviewed?
 - Does the method lead to any erroneous results, if so how often? (false positives and/or negatives)
 - Has the technique been generally accepted in the scientific community?

Legal Standard



- Rule 702 (2002)
 - *If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education may testify thereto in the form of an opinion or otherwise, if*
 - (1) *the testimony is based upon sufficient facts or data,*
 - (2) *the testimony is the product of reliable principles and methods, and*
 - (3) *the witness has applied the principles and methods reliably to the facts of the case.*

FBI Laboratory Expectation



- FBI Laboratory is accredited by American Society of Crime Laboratory Directors, Laboratory Accreditation Board (ASCLD/LAB)
- ASCLD/LAB adds a forensic QA component to the basic ISO-17025 requirements.
- ISO-17025 requires the use of traceable certified reference materials to calibrate instruments and validate methods.
- FBI Laboratory expects affiliated laboratories which provide analysis to the FBI, to be ISO-17025 accredited

Nuclear Forensics vs. Nuclear Analysis/Research



- Similarities
 - Validating measurement sensitivity and selectivity
 - Insuring sample integrity
 - Sample tracking -- Chain of custody
 - Multiple independent methods as orthogonal evidence
- Differences
 - Legal Standard
 - National Security; Dire Consequences
 - Unique specimens of limited quantity
 - Timely analysis
 - A repeat or defendant's analysis is problematic

Forensic questions in Radiological investigations



Technical Nuclear Forensics

Material Analysis
Irradiation
Physical Composition
Engineering Design

Enrichment
Reprocessing
Chemical form
Date of reprocessing

Traditional Forensics Examinations

Chemistry
Latent Prints
Document Analysis

DNA
Trace Evidence
Tool Mark Analysis

Field Investigation

Shipping routes
ID of traffickers
Capability for large quantities

Search for bulk R/N
End-user application
Environmental samples

Targets of nuclear forensic measurements



- Design and Composition:
 - Radionuclide
 - Isotopics
 - Metal,
 - Salt,
 - Oxidation State,
 - Purity, Trace Elements,
- Chronology:
 - $^{60}\text{Co}/\text{Ni}$, $^{90}\text{Sr}/\text{Zr}$, $^{137}\text{Cs}/\text{Ba}$,
 - Am, Pu, U, Th + daughters

Radiochemical Analysis



- Cm-(242, 244)
- Am-(241, 242m)
- Pu-(236, 238, 239, 240, 241, 242, 244)
- Np-(237)
- U-(232, 233, 234, 235, 236, 238)
- Pa-(231)
- Th-(228, 229, 230, 232)
- Ac-(227)
- Ra-(226)
- Eu-(155)
- Ce-(144)
- Cs-(134, 137)
- Sn-(125, 126)
- Ag-(110m)
- Tc-(99)
- Nb-(94)
- Co-(60)

Chronometers



- Pu Pu236 Pu238 Pu239 Pu240
Pu241
- Am Am241
- Np Np237
- U U232 U238 U235 U236
U233 U234
- Pa Pa231
- Th Th228 Th230 Th232
Th229
- Ac Ac227
- Ra Ra226 Ra228
- Pb Pb210



Chronometer Pair	Age (yrs \pm 2s)
$^{232}\text{U}/^{228}\text{Th}$	6.1 ± 1.0
$^{233}\text{U}/^{229}\text{Th}$	7.7 ± 1.7
$^{234}\text{U}/^{226}\text{Ra}$	5.93 ± 0.26
$^{234}\text{U}/^{230}\text{Th}$	6.40 ± 0.28
$^{235}\text{U}/^{227}\text{Ac}$	6.83 ± 0.24
$^{235}\text{U}/^{231}\text{Pa}$	6.50 ± 0.42
$^{236}\text{U}/^{232}\text{Th}$	<16
$^{241}\text{Pu}/^{237}\text{Np}$	~132
$^{241}\text{Pu}/^{241}\text{Am}$	7.13 ± 0.55
Wt Mean Age	6.46 ± 0.14

Nuclear Forensics CRM Partners



- US National Laboratories –
 - LLNL, SRNL, LANL, ORNL, PNNL,
- International Laboratories
 - NPL, CEA, IRMM, ITU
- NIST, Ionizing Radiation Division
- Reference Laboratory –
 - NBL (CRM Coordinator)
- DHS, National Technical Nuclear Forensics Center.
- FBI Laboratory, CBRN Sciences Unit

CRMs and Metrology tools are required to meet the Legal Standards



- Calibrations with CRMs
- Method validation
- 17025 Quality System
- Third Party Traceability Testing
- External Technical Assessment
- Accreditation

