Nuclear Forensics at ITU

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Introduction

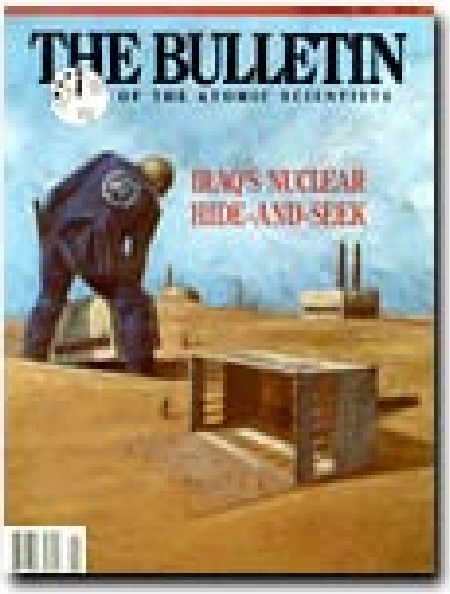
- Nuclear Forensics shall provide information on nuclear material of immediate relevance to law enforcement

- Nuclear Forensics aims at providing clues on the history (production process, date of production, place of production,intended use) of (seized) nuclear material

History

1991

- Discovery of Iraq's clandestine nuclear programme
- New phenomenon appeared: illicit trafficking of nuclear material
- First reported seizures in Switzerland (LEU) and Italy (Pu)



Nuclear Forensics - Evolution

Illicit trafficking of NM in central Europe

HEU and Pu

Changed geographical focus

Changed political landscape

Ad-hoc analysis

Identifcation of R&D Needs

Systematic Approach

Study of Methods and Parameters

Evaluation and Interpretation

Nuclear Forensics Capabilities

Methods

- Radiochemistry
- Microanalysis
- Chemistry
- Physics
- Surface analysis
- Material science

Techniques

Alpha Spectrometry

Gamma Spectrometry

Liquid Scintillation Counting

Optical Microscopy

Scanning Electron Microscopy

Secondary Ion Mass Spectrometry

Thermal Ionization Mass Spectrometry

ICP- Mass Spectrometry

Chemical Separations

Ion Chromatography

IR-Spectroscopy

Raman-Spectroscopy

Surface roughness

Nuclear Forensics Capabilities

- Development of Analytical Scheme Based on
  - appearance of sample/material
  - questions to be answered
  - available methods
- Dynamic execution of Analysis
  - Guided by (intermediate) results

Seized sample

Visual Inspection

γ-spectrometry

Weighing, homogeneity

Optical Microscopy

Electron Microscopy XRF

Secondary Ion Mass Spectrometry

Subsampling Dissolution

Thermal Ionisation Mass Spectrometry

ICP- Mass Spectrometry

Alpha Spectrometry

Iterative Approach using Prioritized Data

Data Acquisition

- Prioritize Parameters
- Measurement of most relevant parameters

Data Interpretation

- Data evaluation
- Data base query

- Prioritize Parameters
- Measurement of next relevant parameter(s)

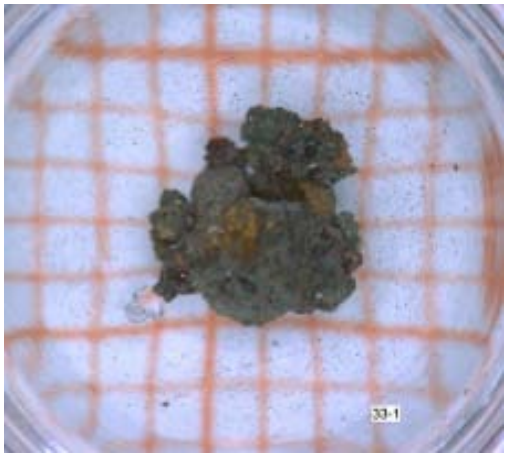
- Data evaluation
- Data base query

Attribution

Example: Find-33

- Three separate shipments of scrap metal from St. Petersburg
- Detected at European scrap metal yard in July, August and October 2009
- IAEA and ITU visited the scrap metal yard in October 2009
- Samples were received at ITU in December 2009
- Analysis report completed

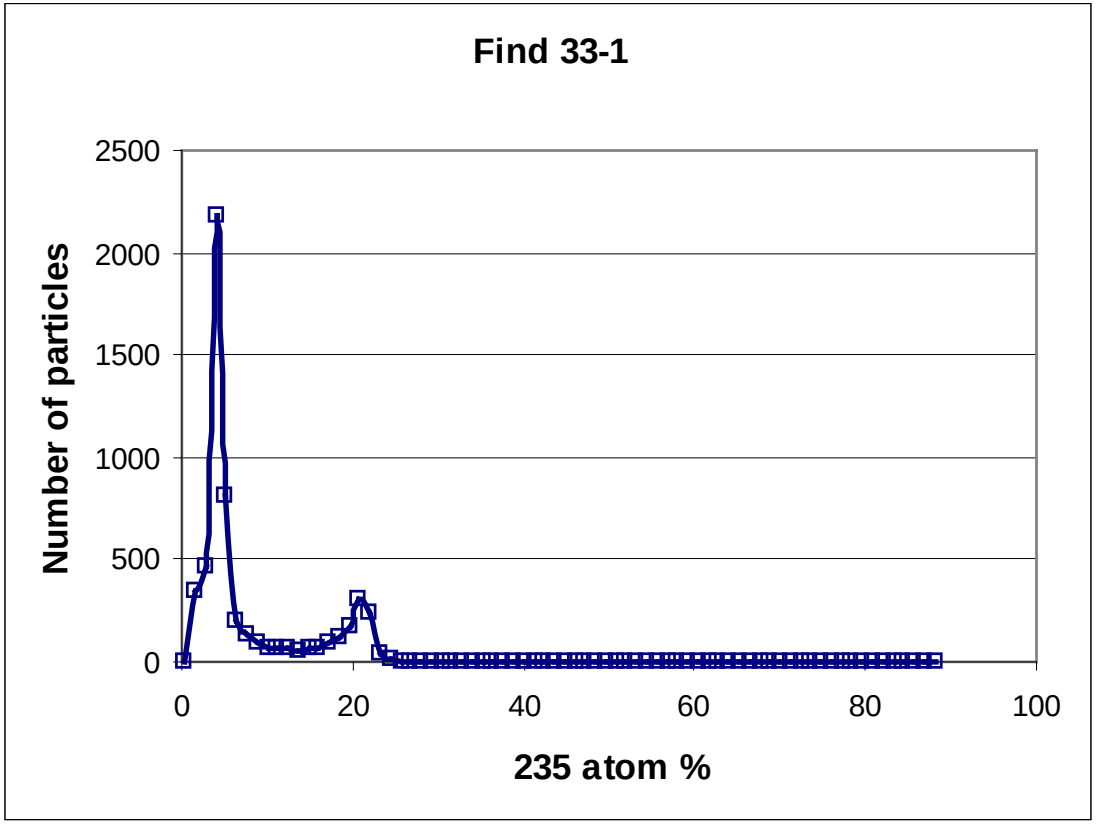
Find-33

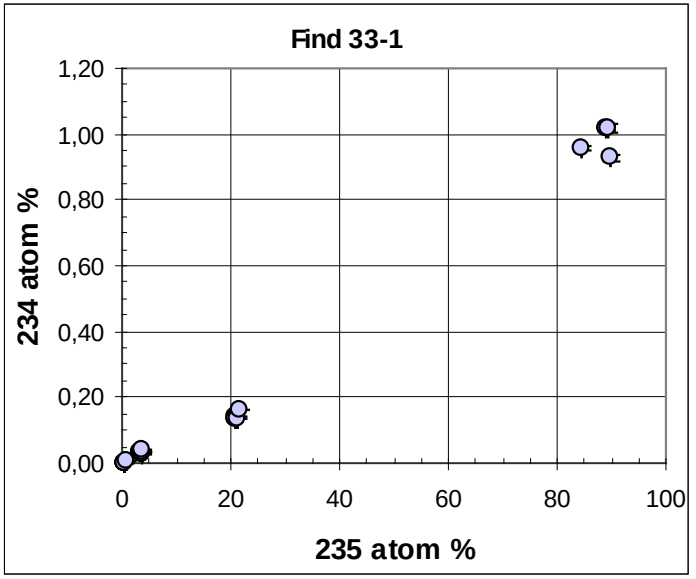


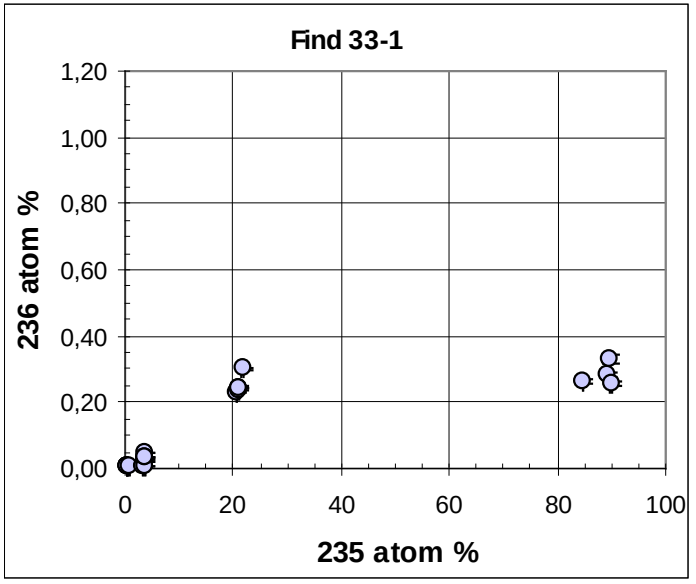
F33/1	^{234}U	^{235}U	^{236}U	^{238}U	U-c (wt-%)
Gamma	0.071 ± 0.061	7.84 ± 0.48	-	92.09 ± 0.49	-
MC-ICP-MS	0.0677 ± 0.0008	9.0380 ± 0.0079	0.0896 ± 0.0011	90.805 ± 0.010	-
TIMS	0.0670 ± 0.0007	9.0333 ± 0.0052	0.0904 ± 0.0005	90.8093 ± 0.0037	0.3362 ± 0.0011

Age (in December 2009): 47.6 ± 0.6 ⇒ April 1962 ± 7 months

Find-33/1

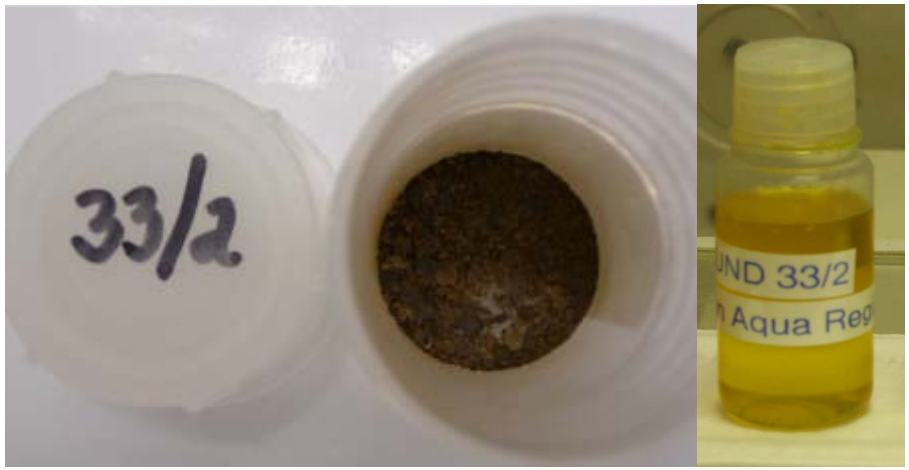






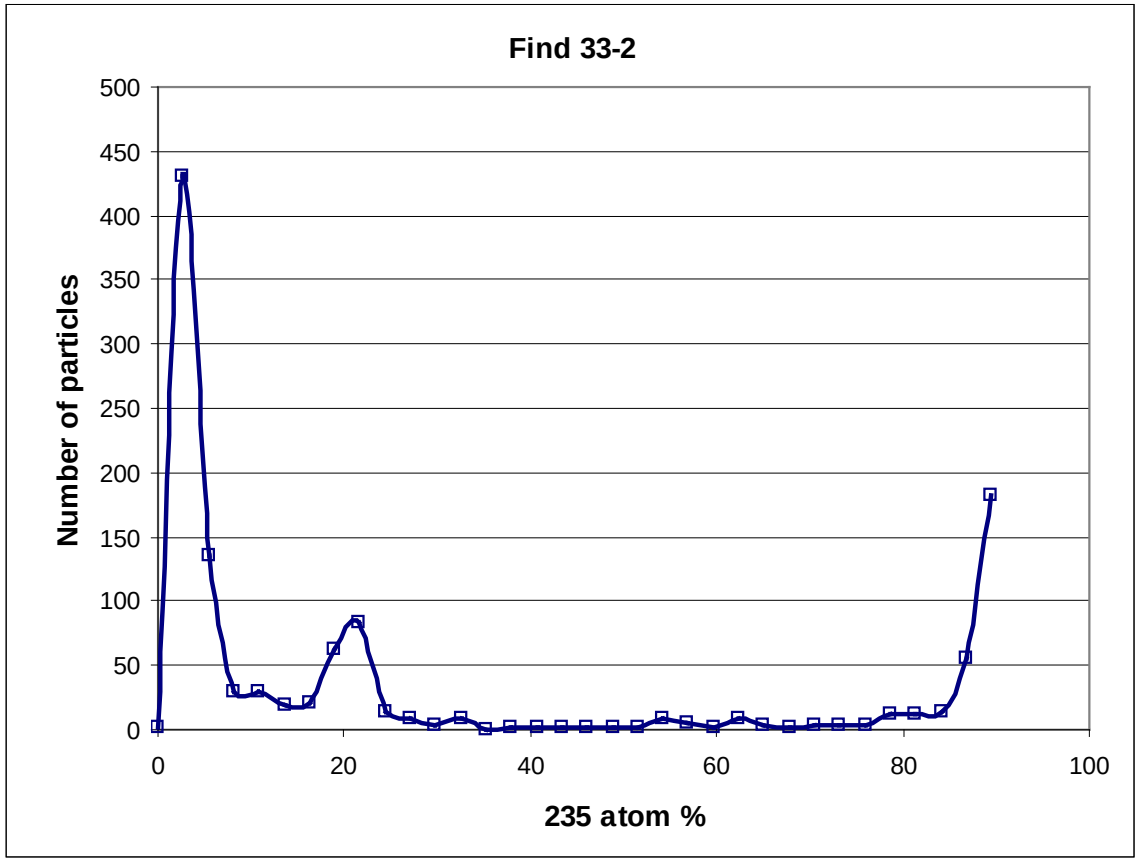
Two populations: 3.6 and 21 w-%.

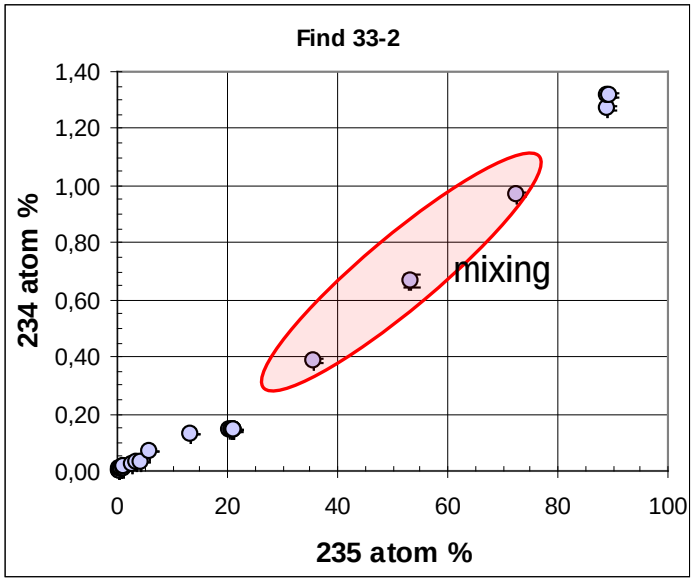
Find-33

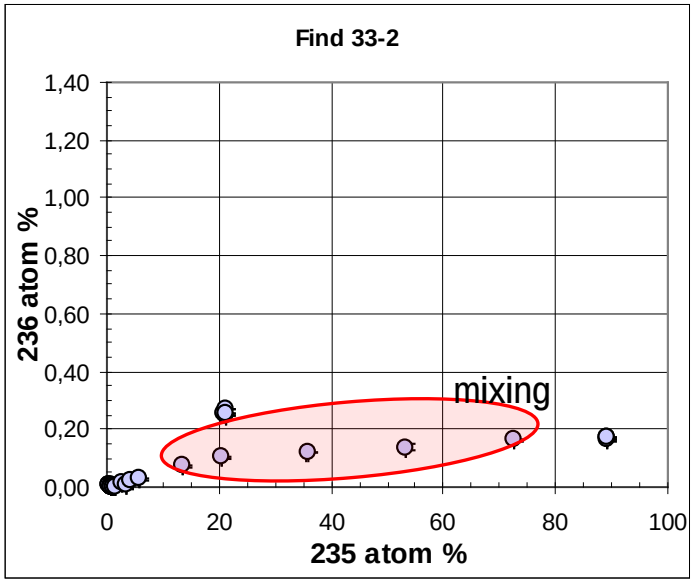


F33/2	^{234}U	^{235}U	^{236}U	^{238}U	U-c (wt-%)
Gamma	0.709 ± 0.242	47.61 ± 5.94	-	51.36 ± 6.02	-
MC-ICP-MS	0.5637 ± 0.0013	45.838 ± 0.033	0.1286 ± 0.0011	53.470 ± 0.035	-
TIMS	0.5643 ± 0.0003	45.847 ± 0.017	0.1281 ± 0.0006	53.461 ± 0.020	1.4769 ± 0.0047

Age (in December 2009): 50.5 ± 0.6 ⇒ June 1959 ± 7 months

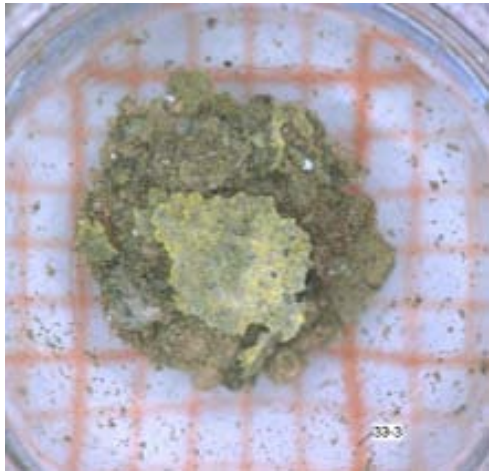






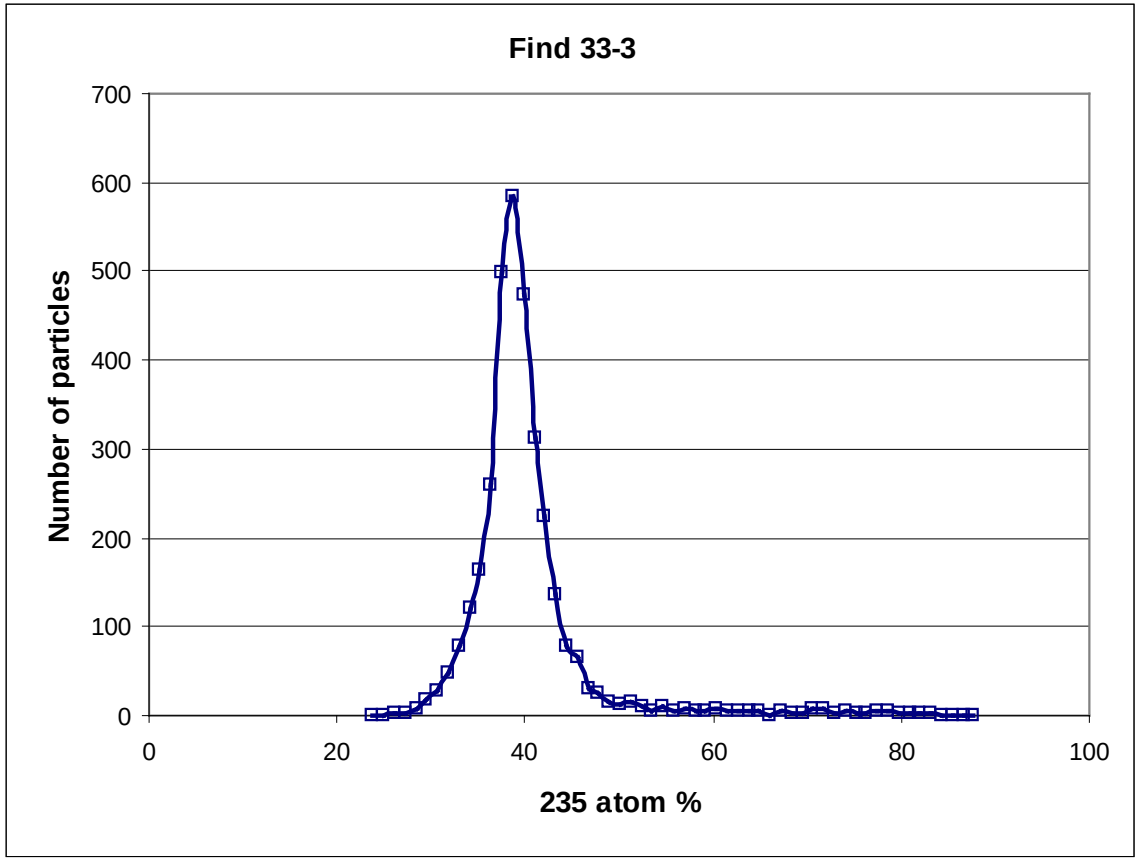
Three populations: natural, 21 and 90 w-%.

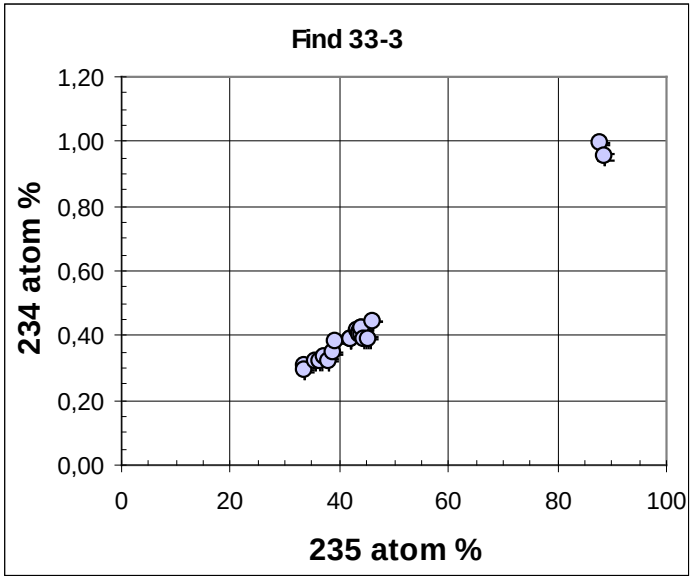
Find-33

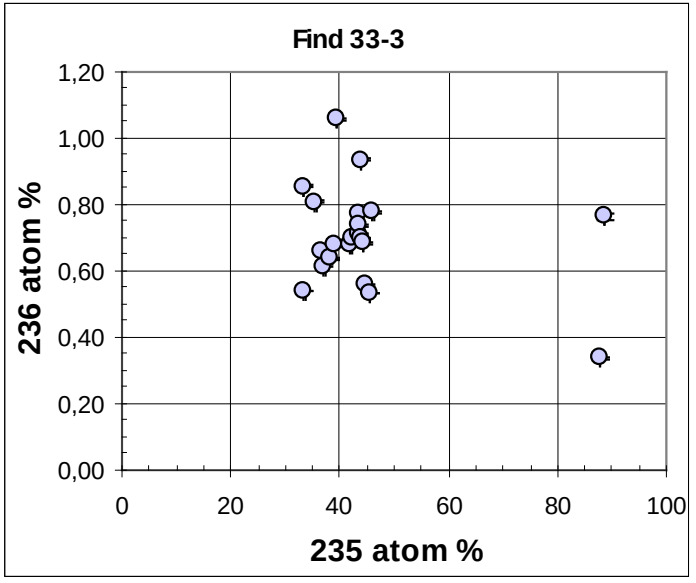


F33/3	^{234}U	^{235}U	^{236}U	^{238}U	U-c (wt-%)
Gamma	0.382 ± 0.049	42.37 ± 2.07	0.1-1	57.63 ± 2.10	-
MC-ICP-MS	0.4088 ± 0.0013	43.811 ± 0.063	0.7181 ± 0.0011	55.062 ± 0.065	-
TIMS	0.4092 ± 0.0021	43.800 ± 0.016	0.7200 ± 0.0004	55.073 ± 0.020	3.409 ± 0.011

Age (in December 2009): 37.5 ± 0.5 ⇒ June 1972 ± 6 months



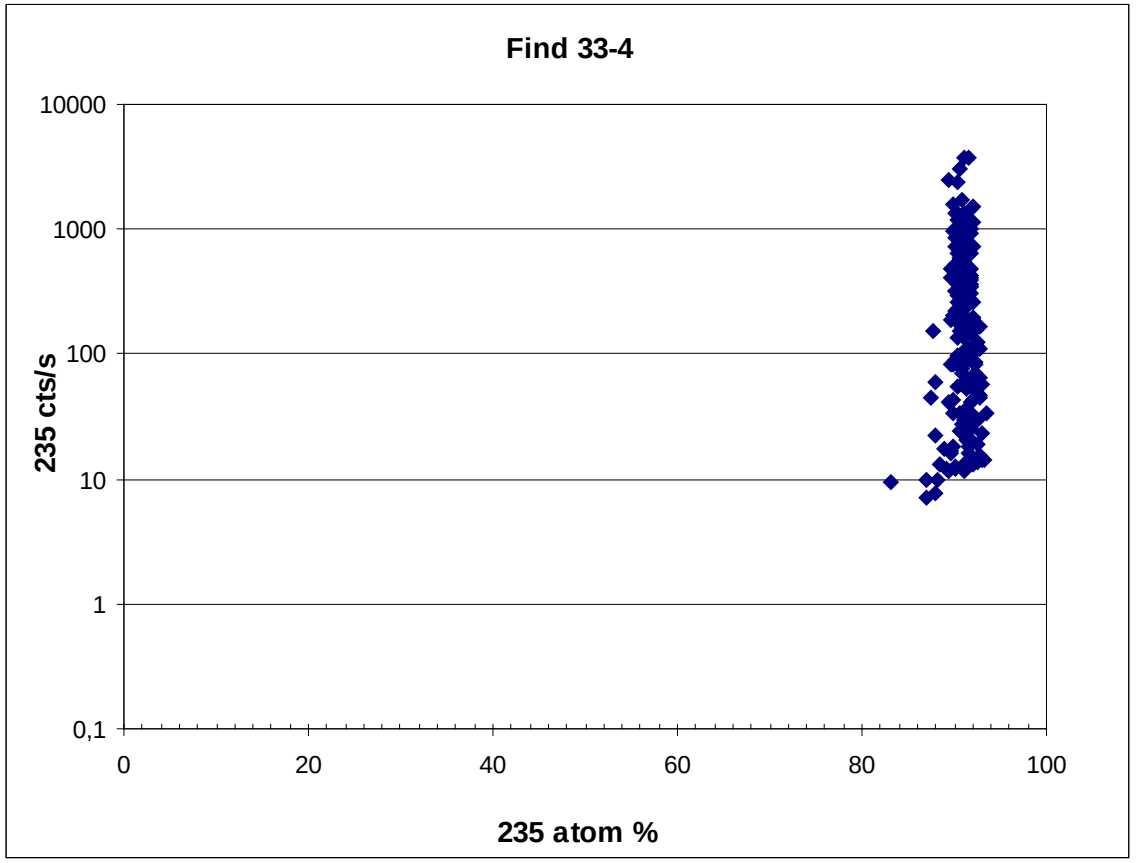


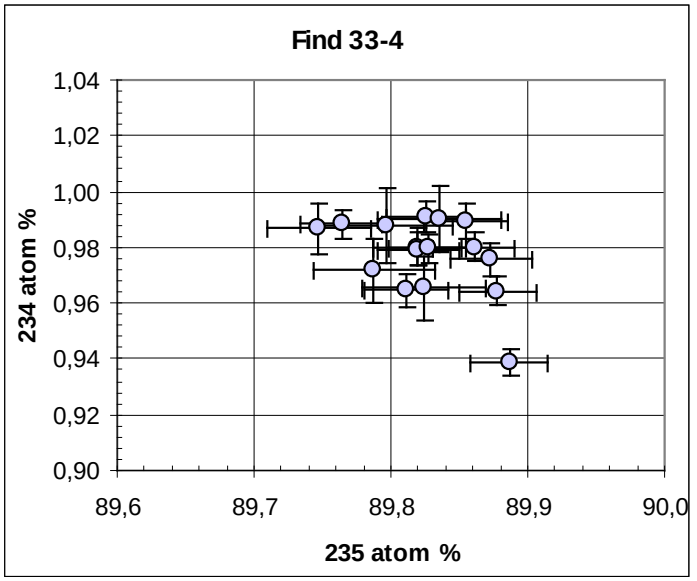


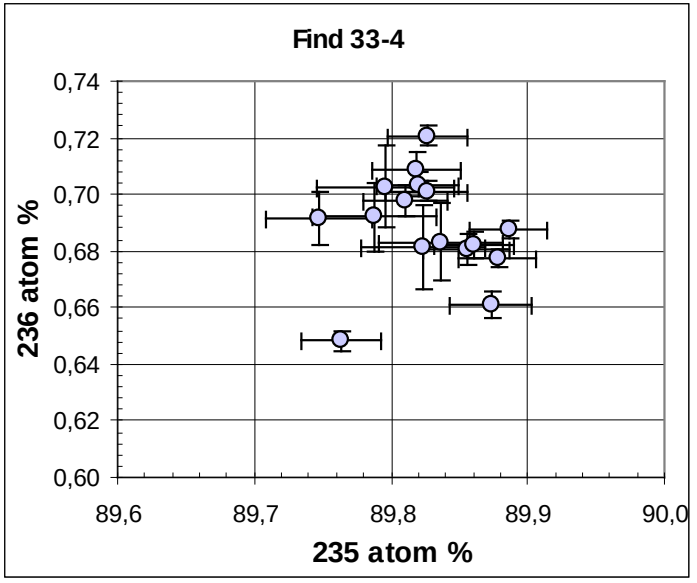
One population in ~40 w-%.

F33/4	^{234}U	^{235}U	^{236}U	^{238}U	U-c (wt-%)
Gamma	0.971 ± 0.070	90.21 ± 4.18	-	8.82 ± 4.28	-
MC-ICP-MS	0.9721 ± 0.0014	89.689 ± 0.017	0.6986 ± 0.0025	8.6406 ± 0.0160	-
TIMS	0.9741 ± 0.0006	89.730 ± 0.036	0.6981 ± 0.0035	8.5867 ± 0.0034	16.930 ± 0.053

Age (in December 2009): 26.2 ± 0.4 ⇒ October 1983 ± 5 months







One population in 90 w-%.

Conclusions on Find-33

The U-235 enrichments found in the particles could origin from the following reactor fuels:

- VVER-type fuel – 3.6 and 4.4 %
- Fast breeder reactor BN-600 and BN-350 – 17, 21 and 26 % (and natural U in the breeding zone)
- 3rd generation submarine fuel in Russia – 21/45 % (1st and 2nd – 21 %)
- Research reactor fuel – up to 90 %

Two Russian facilities identified as possibled origin

Based on enrichments and age of material

Challenges

Scientific

- Consolidate list of characteristic parameters
- Streamline analytical procedures
- Adapt/improve analytical methods

Procedural

- Further perfection of cooperation with law enforcement
- Facilitate sample transport/exchange

General

- Ensure knowledge management

Opportunities

Capacity Building

- Nuclear Forensics Awareness
- Establishing Core Capabilities
- Training
- Networking

International Cooperation

- IAEA
- ITWG
- Bi- and multilateral through TACIS, Instrument for Stability, EU-CBRN Action Plan

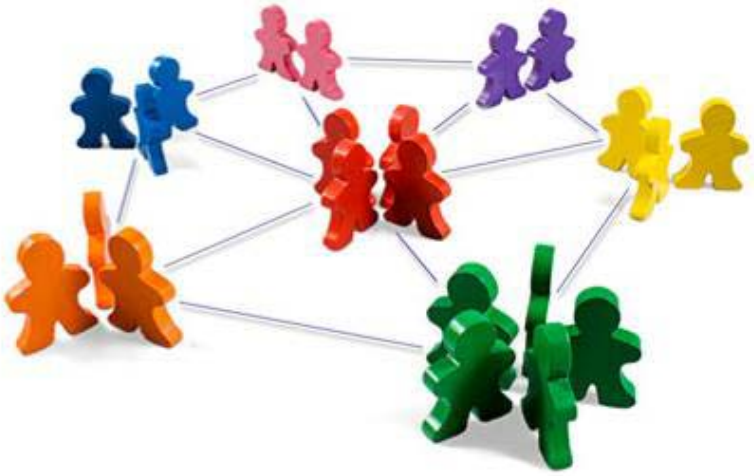
Opportunities - Training

Establishing an EU **Nuclear Security Training Center** at the JRC

- With support of EC Directorate-General of Justice, Freedom and Security (DG-JLS)
- Ensuring high standard in detection and response
- Complementary to national training activities
- Focus on advanced training using nuclear material
- In collaboration with the EU MS, the IAEA and international initiatives

Opportunities - Training

- Benefiting from expertise of IPSC Ispra and ITU Karlsruhe
- Located at ITU Karlsruhe
- Harmonisation of procedures
- Sharing best practices
- Platform for networking
- Implementation in 2011, fully operational by mid 2012



Subject	Target audience	Main Topics
National Response Plan	- Regulatory Authority - Decision makers - Expert institution	•MAP, RITNUM •Responsibilities •Communication •Processes
First responders	- Customs - Border Guards - Police - Security Service	•Procedures for detection •Verification of alarm •Securing material & site •Self –protection
Measurement Experts	- Research Institutes - Envir. Protection - Health and Safety - Rad. Protection	•Categorization •Preservation of evidence •Sample taking/shipment •Radiological advice
Nuclear Forensics	-Research Institutes - Measurement Labs	•Material categorization •Data interpretation •Source attribution •Expert opinion
Exercises Table -top	All targets groups	•Response processes •Response procedures •Scenario development

Tacis

IAEA International Atomic Energy Agency

EUROPOL

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
Fortbildungszentrum für Technik und Umwelt

TREN Directorate General

Advanced Training Activities

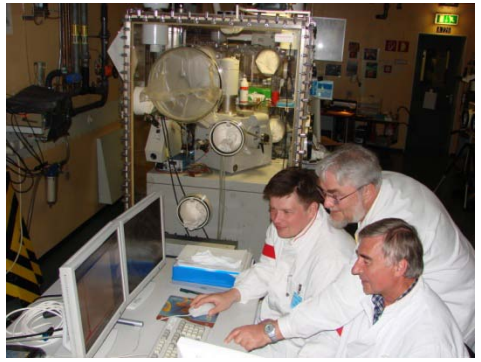
Training of MEST

Gamma spectrometry of nuclear materials

- Portable equipment
- Challenging
  - Libraries
  - Interpretation skills

Training in Nuclear Forensic Analysis

- Chemical Separations
- Age Dating
- Electron Microscopy
- Impurity Measurements
- Mass Spectrometry



Opportunities - Cooperation

Capacity building in countering illicit nuclear trafficking (Pilot regional project, South East Asia)

- Nuclear Forensics Awareness
- Development of a National Response Plan
- Response Procedures
- Basic nuclear forensics
- National reach back capability

Nuclear Forensics at ITU

- Providing Nuclear Forensics support (case work)
- Pursuing R&D activities
- Expanding existing capabilities
- Benefiting from synergies with Nuclear Safeguards
- Enhancing training activities (EU Nuclear Security Training Centre)
- Involved in International collaborations
- Networking with other key players in the field

Actively contribute to fight illicit trafficking, nuclear proliferation, nuclear terrorism