International Workshop on Nuclear Forensics Following on Nuclear Security Summit

5-6 October 2010

Techno Community Square "Ricotti", Tokai, Japan

JAEA

JAEA/NPSTC

Japan Atomic Energy Agency

WORKSHOP BOOKLET

Agenda of International Workshop on Nuclear Forensics

	Tuesday, 5th October Lecture Hall, 1F, Ricotti
8:30 - 9:00	Participant Registration (Lobby, 1F)
	Session 1: Present Status and Discussion Chair: Mitsutoshi Suzuki (JAEA)
9:00 - 9:10	Welcome Address Masao Senzaki (JAEA)
9:10 - 9:30	1-1: Toward Establishment of Nuclear Forensics System in Japan Naohito Kimura (JSGO/MEXT)
9:30 - 9:50	1-2: Nuclear Forensics — Analytical Potential in JAEA Yusuke Kuno (JAEA)
9:50 - 10:30	1-3: Overview of U.S. Technical Nuclear Forensics and Material Forensics R&D Activities Frank Wong (DHS/USA)
10:30 - 11:00	COFFEE BREAK
11:00 - 11:30	1-4: GICNT Objectives, Activities and Plans on Nuclear Security, and in Particular, Nuclear Forensics Carlos Torres Vidal (MAEC/Spain)
11:30 - 12:00	1-5: Recent Technical Activities of the International Atomic Energy Agency to Combat Illicit Trafficking of Nuclear and Other Radioactive Materials David K Smith (NSS/IAEA)
12:00 - 12:30	1-6: Building International Cooperation in Nuclear Forensics: 'The ITWG' Benjamin Garrett (FBI/USA)
12:30 - 13:30	LUNCH BREAK
	Session 2: Forensics Technology and Quality Assurance Chair: Yusuke Kuno (JAEA)
13:30 - 13:55	2-1: Nuclear Forensics Activities at ITU Klaus Mayer (ITU/EC)
13:55 - 14:20	2-2: Identification of Origin of Actinides in Environmental Samples with Radioanalytical Technologies Myung Ho Lee (KAERI)
14:20 - 14:45	2-3: Determination of Isotope Ratios for Individual Plutonium Particles with ICP-MS Fumitaka Esaka (JAEA)
14:45 - 15:10	2-4: Ultra-Trace Sample Analysis and Data Reduction Robert Steiner (LANL/USA)
15:10 - 15:35	2-5: Nuclear Forensics & Bulk Special Nuclear Material (SNM) Characterization Lav Tandon (LANL/USA)
15:35 - 16:00	COFFEE BREAK
	Session 3: Database, Data Assessment, Handling, Sharing, International Frameworks, Cooperation Chair: Masato Hori (JAEA)
16:00 - 16:25	3-1: Spent Fuel Forensics Mark Scott (LANL/USA)
16:25 - 16:50	3-2: National Nuclear Forensics Libraries Stephen LaMont (LANL/USA)
16:50 - 17:15	3-3: The Uranium Sourcing Database: Development of Techniques and Protocols Martin Robel (LLNL/USA)
17:15 - 17:40	3-4: Nuclear Forensics and Law Enforcement James Blankenship (FBI/USA)
17:40	Adjourn
18:00 - 19:30	Reception at 3F Rooms #1 and #2

Agenda of International Workshop on Nuclear Forensics

	Wednesday, 6th October Lecture Hall, 1F, Ricotti
8:30 - 9:00	Participant Registration & Administrative (Lobby, 1F)
9:00 - 10:30	Session 4: Technology to Support Nuclear Forensics Chair: Klaus Mayer (ITU)
	Panelists: IAEA, DHS, DOE/NBL, DOE/NNSA, ITWG, KAERI, JAEA
	4-1: What information and signatures are essential for supporting nuclear forensics analysis?
	4-2: What are the fundamental technologies and techniques required for materials characterization?
	4-3: What methods and technologies are needed to advance nuclear forensics analysis state-of-the-art particularly for new signatures?
10:30 - 11:00	COFFEE BREAK
11:00 - 12:15	Session 5: Information Resources and Cooperation Chair: Benjamin Garrett (FBI)
	Panelists: GICNT, IAEA, ITWG, DHS, FBI, DOE/NNSA, JAEA
	5-1: What information, evaluations, and procedures are needed to support nuclear attribution?
	5-2: How can database content and design, and protocols be optimized to support nuclear forensics interpretation?
	5-3: What are the existing legal frameworks, and lessons learned from national and international coordination and cooperation?
	5-4: Quality Assurance Practices: laboratory qualification, standards, material exchanges, and round-robin exercises
	5-5: Milestones: Outline goals and potential partnerships and collaborations
12:15 - 12:30	Wrap-up and Closing Remarks Yusuke Kuno (JAEA)
12:30 - 13:30	LUNCH BREAK
	SITE TOUR
14:00	Departure at Ricotti
	J-PARC : Japan Proton Accelerator Research Complex CLEAR : Clean Laboratory for Environmental Analysis and Research
17:10	Closing (Drop off at Tokai Station)

1-1

Toward Establishment of Nuclear Forensics System in Japan

Naohito Kimura

Japan Safeguards Office,
Ministry of Education, Culture, Sports, Science and Technology

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Establishing a nuclear forensics system is one of the issues that were stated in Japan's National Statement at the Nuclear Security Summit. Our opening remarks will address the reasons why Japan develops the forensics technology, Japan's efforts and activities such as reorganization within MEXT, development of nuclear forensics technologies, and the need for international cooperation for the establishment to achieve our final goal.

1-2

Nuclear Forensics — Analytical Potential in JAEA

Yusuke Kuno and Masato Hori
Japan Atomic Energy Agency

One specific promise made by the Japan Government during 2010 Nuclear Security Summit, was to develop its nuclear forensics detection and analysis technologies in a three-year period and to share them with the international community to contribute to strengthening the nuclear security regime.

The Japan Atomic Energy Agency (JAEA) is the organization that possesses analytical capabilities with the potential to fulfil this nuclear forensics mission. Since JAEA has been developing a wide range of analytical techniques for large size nuclear material samples down to trace level nuclear samples for so-called environmental sampling, we are prepared to apply such technologies and experiences to establishing fundamental analytical capabilities for nuclear forensics.

In order to effectively pursue nuclear forensics a nuclear security goal, international collaborations with nuclear forensics experts are essential.

In this presentation, JAEA's tentative idea to establish nuclear forensics analytical capabilities as well as development of the international nuclear forensics framework will be given.

1-3

Overview of U.S. Technical Nuclear Forensics and Material Forensics R&D Activities

Frank M.G. Wong

National Technical Nuclear Forensics Center,
U.S. Department of Homeland Security

Technical Nuclear Forensics (TNF) is the thorough collection, analysis, and evaluation of interdicted nuclear and radiological materials, devices, and post-detonation debris and the immediate effects created by a nuclear detonation. TNF conclusions span a continuum from exclusion of options at one end to narrowing of candidates at the other end (for potential origins of materials, pathways, device types, manufacturing processes, types of facilities, and geographic locations). In the United States, six Federal entities form the core of the TNF community: the Departments of Energy (DOE), Defense (DoD), Homeland Security (DHS), Justice (DOJ), State (DOS), and the Office of the Director of National Intelligence (ODNI). Each entity has a role in the TNF mission areas: 1) interdicted materials, 2) interdicted device, and 3) post-detonation event. The U.S. TNF capability addresses these strategic goals:

1. Enhance deterrence and enable prevention with a credible, publicized TNF capability that can support identification of perpetrators before or in response to a nuclear or radiological attack.
2. Enable and support attribution with a fully integrated, modernized, and effective TNF capability.
3. Cultivate and sustain a vibrant and enduring nuclear forensics expertise pipeline and workforce.
4. Foster and advance international cooperation in nuclear forensics.

The National Technical Nuclear Forensics Center (NTNFC), within the Department of Homeland Security (DHS), conducts material forensics R&D activities that are rooted in fundamental science, engineering, and mathematics to determine and leverage the

most discriminating characteristics in nuclear materials. Measurement analyses and data evaluation R&D activities include developing reference materials necessary for the validation of methods used for characterizing materials; identifying and developing new signatures or combinations of signatures to uniquely identify the origin and pathway of materials; and creating and improving data evaluation and simulation tools to enable the linking of measurement results to both comparison samples and predictive results, which enable linking (or excluding) materials with geographic regions, types of manufacturing processes, or types of production facilities.

1-4

GICNT Objectives, Activities and Plans on Nuclear Security, and in Particular, Nuclear Forensics

Carlos Torres Vidal

Ministry for Foreign Affairs and Cooperation (MAEC.ES), Spain

1-5

Recent Technical Activities of the International Atomic Energy Agency to Combat Illicit Trafficking of Nuclear and Other Radioactive Materials

David K. Smith

International Atomic Energy Agency

Episodes of the occurrence of nuclear and radioactive material outside of regulatory control continue in 2010. Recently Georgia notified the International Atomic Energy Agency (IAEA) that it had seized approximately 15 grams of highly enriched uranium that had been offered for sale illegally. This year authorities in Moldova also confiscated more than 1700 grams of depleted uranium possessed by criminals. In total for 2010, the IAEA's Illicit Trafficking Database reports 16 confirmed cases of attempted sales, unauthorized possession, or scams involving an array of radioactive contraband. These incidents require that States maintain an effective nuclear security framework to prevent further events of this kind, establish capabilities to detect smuggled radioactive materials, and respond effectively to criminal acts or suspected proliferation involving the same.

The IAEA views nuclear forensics as a key piece of a nuclear security national response framework. The current IAEA program in international nuclear forensics includes comprehensive training to foster response to radiological crime scenes including a realistic scenario-based exercise involving nuclear forensics interpretation, a 'coordinated research program' to promote national technical best practice, and an initiative to help states develop national libraries of nuclear forensic data as well as an international directory of this information to enable effective and credible analysis. As requested, the IAEA will work with Member States to improve their application of nuclear forensics. The IAEA is committed to working with its international partners including the Global Initiative to Combat Nuclear Terrorism (GICNT), and the Nuclear Forensics International Technical Working Group (ITWG) to advance awareness, research, training, and analysis in this important discipline.

1-6

Building International Cooperation in Nuclear Forensics: 'The ITWG'

B.C. Garrett, K. Mayer, T. Bıro, B. Chartier, & P. Thompson

Federal Bureau of Investigation, U.S.A.

The Nuclear Forensics International Technical Working Group (ITWG) is a multinational, informal association of practitioners of nuclear forensics. Established in 1995, the ITWG advances best practices for nuclear forensics, starting at the site of an incident or event and running through data interpretation and delivery of a final report. The work of the ITWG is conducted primarily through Task Groups. Currently, there are five: Communication & Outreach; Evidence Collection; Exercises; Guidelines; & National Nuclear Forensics Libraries. Membership in the ITWG is open to competent qualified individuals from any national who has an interest in nuclear forensics and who is affiliated with a competent national or international authority.

2-1

Nuclear Forensics Activities at ITU

K. Mayer, M. Wallenius, Z.Varga, & K.Lutzenkirchen

European Commission, Joint Research Centre, Institute for Transuranium Elements (ITU)

Illicit trafficking of nuclear and other radioactive material is a subject of serious concern due to the radiological hazard and the proliferation risks associated with such material. Nuclear forensics is a scientific discipline interfacing law enforcement, nuclear science and non-proliferation. Through nuclear forensic analysis, information on the history and on the potential origin of intercepted nuclear material can be obtained. To this end, we make use of characteristic parameters that are inherent to the material. For almost two decades the Institute for Transuranium Elements (ITU) has been involved in nuclear forensic investigations. Significant research and development work has been carried out and a systematic and efficient methodology for analyzing seized material has been implemented. Substantial support to the national authorities of EU Member States has been provided in more than 35 cases through nuclear forensic analysis performed at ITU. The paper will illuminate the parameters to be measured (such as isotopic and elemental composition, macroscopic and microscopic appearance) as well as the methodology and analytical techniques applied. Examples of case work will be given to demonstrate the opportunities and limitations associated with nuclear forensics. Moreover, the interaction with other competent national and international authorities involved in nuclear security incidents and the associated training activities will be discussed.

2-2

Identification of Origin of Actinides in Environmental Samples with Radioanalytical Technologies

M. H. Lee, J. H. Park, & K. Song

Korea Atomic Energy Research Institute

Investigation on the identification of origin of actinides in environmental soil samples contaminated by different sources with radioanalytical technologies has been performed. Screening technology with gamma spectrometric method was used to detect the presence of U, Pu, Am or other important elements. The Pu isotopes were purified from other nuclides through the anion exchange column, while the uranium isotopes were purified from other nuclides through the UTEVA column. After α source preparation for the purified Pu and U isotopes with the micro-coprecipitation method, the activity concentrations and activity ratios of Pu and U isotopes were measured by alpha spectrometry, respectively. Also, the atomic ratios of Pu and U isotopes were measured by ICP-MS and/or TIMS. The atomic ratios and isotopic ratios for Pu and U isotopes measured by mass and alpha spectrometric methods in environmental samples were identified the source of actinides. The accumulated databases may be applied for nuclear fingerprint method to characterize unknown nuclides in the environmental sample.

2-3

Determination of Isotope Ratios for Individual Plutonium Particles with ICP-MS

F. Esaka, M. Magara, D. Suzuki, Y. Miyamoto, C.G. Lee, & T. Kimura

Japan Atomic Energy Agency

Plutonium is one of the key elements for nuclear weapons as well as electric power generation. For peaceful use of plutonium, undeclared nuclear activities must be checked and unveiled. For this purpose, it is necessary to develop techniques to analyze plutonium isotope ratios in individual particles taken at nuclear facilities. In this study, inductively coupled plasma - mass spectrometry (ICP-MS) is applied to the analysis of plutonium isotope ratios in individual particles. Prior to the measurement, individual plutonium particles in samples are identified by using scanning electron microscope (SEM) and are transferred to each Si chip by a micro-manipulator attached to the SEM system. Each particle is dissolved with HF-HNO_3 solution and chemical separation is performed for subsequent ICP-MS analysis. As the result, the plutonium isotope ratios in individual particles with the diameters less than 1 micro-meter are successfully determined with good accuracy and precision. This technique will also be applied to the age determination of individual plutonium particles for nuclear forensics.

This work was supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan.

2-4

Ultra-Trace Sample Analysis and Data Reduction

R. Steiner, S. LaMont, F. Roensch, J. Roach, W. Kinman, R. Foley,
& L. Riciputi
Los Alamos National Laboratory, U.S.A.

Los Alamos National Laboratory (LANL) has a long history of supporting bulk ultra-trace level environmental analyses for forensic applications. Laboratory facilities are available to handle many types of samples with varying levels of radioactivity. Samples are initially screened and analyzed via a suite of radiation spectrometry techniques to quantify short lived isotopes and to determine in which laboratory to initially process the samples. Once the samples are thermally ashed and/or dissolved and an appropriate aliquot taken, they are moved to the clean chemistry facility for further radiochemical purification and analysis using alpha spectrometry and thermal ionization mass spectrometry (TIMS) or inductively coupled plasma mass spectrometry (ICP/MS). Strict protocols must be followed to ensure that samples do not contaminate each other or laboratory facilities. Once sample analysis is completed a rigorous uncertainty analysis is performed using the Guide to Uncertainty in Measurement (GUM) principles.

This presentation will focus on the protocols and techniques used for the chemical processing and analysis of environmental samples. Special attention will be focused on screening and sample handling techniques used to minimize sample and facility contamination. An example of an uncertainty analysis using the GUM principles will also be presented.

LA-UR 10-05845

2-5

Nuclear Forensics & Bulk Special Nuclear Material (SNM) Characterization

L. Tandon, K. Kuhn, D. Schwartz, & L. Drake
Los Alamos National Laboratory, U.S.A.

Nuclear forensics involves the investigation of a suspect special nuclear material to establish an unambiguous link between confiscated nuclear material and its origin. Specific chemical and physical characteristics that are unique “fingerprints” or signatures for identifying manufacturing processes, intended use, route attribution, and the point of origin on an either interdicted special material or for materials obtained by other means. Total actinide content, isotopics, activation and fission products, metallic and non-trace elemental data are an integral part of a forensic investigation. The team at Los Alamos National Laboratory has also focused on the microstructural and morphological features of materials. Reactor modeling is also applied in certain cases. A focus of the presentation will be some recent case studies. Key part of these analysis include applying highest data quality objectives and demonstrated long term “statistical control” of quality control data. An example special nuclear materials characterization with a statement of uncertainty derived using ISO/IEC Guide 98-3:2008 - Uncertainty of Measurement - Part 3: Guide to the Expression of Uncertainty in Measurement (GUM: 1995) will be discussed. Forensic investigations of several actinide materials composed of primarily uranium and plutonium, will be presented to demonstrate the team’s successes and forensic capabilities. Bulk special nuclear material characterization capabilities of actinide analytical chemistry will also be discussed.

3-1

Spent Fuel Forensics

M. Scott & G. Eccleston

Los Alamos National Laboratory, U.S.A.

Reactor modeling codes have been developed over several decades and are in a mature state. A few common uses for these forward reactor modeling codes are to design reactor cores, plan for refueling and characterize spent fuel. Inverse reactor modeling software to aid nuclear forensics is still in its infancy and lacks the mature development of the forward reactor modeling codes. Recent progress has been made and a few innovative techniques have been developed to characterize unknown spent fuel samples by analyzing measured actinides and fission products. Inverse modeling can be used to determine the fuel burn up, initial fuel enrichment, time of fuel discharge, and other reactor and fuel parameters. These techniques require the use of forward reactor modeling codes in conjunction with newly developed algorithms for inverse modeling. Knowing characteristics of irradiated fuels can contribute towards spent fuel forensics and the validation of reactor operational histories.

LA-UR 10-06139

3-2

National Nuclear Forensics Libraries

Stephen P. LaMont

Los Alamos National Laboratory, U.S.A.

Nuclear forensics assessments to determine material process history requires careful comparison of sample data to both measured and modeled nuclear material characteristics. Developing centralized databases, or nuclear forensics libraries, to house this information is an important step to ensure all relevant data will be available for comparison during a nuclear forensics analysis and help expedite the assessment of material history. The approach most widely accepted by the international community at this time is the implementation of National Nuclear Forensics Libraries, which would be developed and maintained by individual nations. This is an attractive alternative to an international database since it provides an understanding that each country has data on materials produced and stored within their borders, but eliminates the need to reveal any proprietary or sensitive information to other nations. To support the concept of National Nuclear Forensics Libraries, the United States Department of Energy has developed a model library, based on a data dictionary, or set of parameters designed to capture all nuclear forensic relevant information about a nuclear material. Specifically, information includes material identification, collection background and current location, analytical laboratories where measurements were made, material packaging and container descriptions, physical characteristics including mass and dimensions, chemical and isotopic characteristics, particle morphology or metallurgical properties, process history including facilities, and measurement quality assurance information. While not necessarily required, it may also be valuable to store modeled data sets including reactor burn-up or enrichment cascade data for comparison. It is fully expected that only a subset of this information is available or relevant to many materials, and much of the data populating a National Nuclear Forensics Library would be process analytical or material accountability measurement data as opposed to a complete forensic analysis of each material in the library.

3-3

The Uranium Sourcing Database: Development of Techniques and Protocols

M. Robel

Lawrence Livermore National Laboratory, U.S.A.

Nuclear proliferation and smuggling present a very real threat to all states. Accountability is an important tool for discouraging and preventing nuclear proliferation and illicit trafficking. Nuclear forensic analysis enhances accountability by applying technical methods and interpretation to determine the provenance of nuclear materials across the nuclear fuel cycle. International cooperation in nuclear forensic activities increases the credibility of nuclear forensic assessments, strengthening their use in an international forum. Uranium ore concentrate (a.k.a, “yellowcake”) is particularly appealing as a vehicle for the development of both technical methods and international protocols and agreements because of the global and relatively open nature of the uranium mining and milling industry (as compared to more sensitive technologies and materials later in the fuel cycle). Because of the variations in source ore compositions and processing methods, there is a diverse spectrum of quantifiable signatures (e.g., major and trace elements, isotope ratios, grain size and texture) that can be measured and recorded for samples of yellowcake. The current generation of commercial and open source database management and statistical analysis software is well suited to catalogue, retrieve, and perform data analysis on thousands of yellowcake samples representing hundreds of sources. The Uranium Sourcing Database developed by Lawrence Livermore National Laboratory leverages these tools to both catalogue and perform automated statistical classification queries of unknown material from sources around the globe. Microsoft SQL Server, The Mathworks MATLAB, and Eigenvector Research Inc.’s PLS_Toolbox form the backbone of the Uranium Sourcing Database. We will discuss the practical issues we have encountered and how we have addressed them in the ongoing effort to build an effective, versatile, and efficient data management and analysis system with yellowcake as the primary working material.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LLNL-ABS-451335

3-4

Nuclear Forensics and Law Enforcement

James Blankenship
Federal Bureau of Investigation, U.S.A.

After the anthrax attacks of 2001, the FBI Laboratory placed significant emphasis on being able to perform examinations on chemical, biological, radiological and nuclear materials and evidence contaminated with these hazardous materials.

To analyze radiological and nuclear materials, the FBI established formal relationship with the US Department of Energy laboratory system. This effort included improving existing radioanalytical techniques so as to allow their use in the US court system.

To examine evidence contaminated with radiological and nuclear materials, the FBI established dedicated forensic laboratories at US Department of Energy laboratory system. These facilities are capable of handling the material safely while allowing FBI forensic examiners (latent finger prints, DNA, trace evidence, etc) to work with evidence traditionally used in law enforcement.

By analyzing the radioactive and nuclear materials and contaminated evidence, a more complete investigative picture can be given to the investigators and the court system.

Contact Us

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