

# NUCLEAR FORENSICS AS NUCLEAR MATERIAL ANALYSIS FOR SECURITY PURPOSES

VITALY FEDCHENKO

## INTRODUCTION

The discipline of nuclear forensic science (or nuclear forensics) has been firmly associated with combating illicit trafficking of nuclear or other radioactive materials (NORM).<sup>1</sup> In its broadest sense, illicit trafficking refers to criminal or unauthorized acts involving NORM outside of regulatory control, such as their 'import, export, possession, sale, delivery, movement, use, storage, disposal or transfer'.<sup>2</sup> The more colloquial term of 'nuclear smuggling' is also used to describe the same phenomenon, especially where nuclear materials suitable for the manufacture of nuclear explosive devices are concerned.

Illicit trafficking is a threat that is meant to be addressed by nuclear security, which is the complex of laws, regulations, institutions, systems and measures aimed at the 'prevention of, detection of, and response to, criminal or intentional unauthorized acts involving or directed at nuclear material, other radioactive material, associated facilities, or associated activities'.<sup>3</sup> Even though it is not stated directly in the above-mentioned definitions, both nuclear security and illicit trafficking imply that the perpetrators

## SUMMARY

Nuclear forensic science is normally seen as a discipline pertinent to nuclear security and intended to support investigations of illicit trafficking or nuclear terrorism cases. This view, while certainly correct in most cases, may be worth revisiting at a time when the process of the Nuclear Security Summits is over, and when the political support for nuclear security may diminish in the future in at least some key states.

Nuclear smuggling was happening before nuclear security was formally defined as a discipline, and nuclear material analysis and data interpretation techniques employed by nuclear forensic science have also been used to investigate cases not pertinent to illicit trafficking.

An argument can be made that nuclear forensics would benefit from taking stock of its roots and considering an expansion of its scope or improved awareness of and collaboration with other frameworks, such as verification of non-proliferation and disarmament treaties. The consolidation of various dimensions of nuclear forensics—or of nuclear material analysis for security purposes—would cut costs and provide new and possibly unexpected synergies between different applications.

This paper provides some background to that discussion and describes European contributions to the development of nuclear forensics as a discipline.

## ABOUT THE AUTHOR

Vitaly Fedchenko (Russia) is a Senior Researcher in SIPRI's European Security Programme, responsible for nuclear security issues and the political, technological and educational dimensions of nuclear arms control and non-proliferation. He is the author or co-author of several publications on nuclear security, nuclear forensic analysis and treaty verification.

<sup>1</sup> According to the most recent IAEA definition, the terms 'nuclear forensic science' and 'nuclear forensics' are interchangeable and are defined as the 'discipline of forensic science involving the examination of nuclear and other radioactive material, or of other evidence that is contaminated with radionuclides, in the context of legal proceedings'. IAEA, *Nuclear Forensics in Support of Investigations: Implementing Guide*, IAEA Nuclear Security Series no. 2-G (IAEA: Vienna, 2015), p. 62. For a more detailed review of the origins of nuclear forensics see Fedchenko, V. (ed.), *The New Nuclear Forensics: Analysis of Nuclear Materials for Security Purposes* (Oxford University Press: Oxford, 2015).

<sup>2</sup> IAEA, *Combating Illicit Trafficking in Nuclear and Other Radioactive Material*, IAEA Nuclear Security Series no. 6, (IAEA: Vienna, 2007), <[http://www-pub.iaea.org/MTCD/Publications/PDF/pub1309\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/pub1309_web.pdf)>, p. 2.

<sup>3</sup> IAEA, *Nuclear Security Series, Glossary, Version 1.3* (Nov. 2015), <<https://www-ns.iaea.org/downloads/security/nuclear-security-series-glossary-v1-3.pdf>>, p. 18.

# New Nuclear Forensics Nuclear Material Analysis For Security Purposes Sipri Research Reports

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## **New Nuclear Forensics Nuclear Material Analysis For Security Purposes Sipri Research Reports:**

*The New Nuclear Forensics* Vitaly Fedchenko, 2015 Nuclear material changes its form and properties as it moves through the nuclear fuel cycle from one facility to another Each step of the fuel cycle or each use of the material will inevitably leave its mark The science of determining the history of a sample of nuclear material through the study of these characteristics is known as nuclear forensics While nuclear forensic analysis has normally been associated with investigations and prosecutions in the context of trafficking of nuclear materials or nuclear terrorism it had wider applications in national security contexts such as nuclear non proliferation disarmament and arms control The *New Nuclear Forensics* is the first book to give a definitive guide to this broader definition of nuclear forensic analysis This book describes the various methods used in nuclear forensics giving first a broad introduction to the process followed by details of relevant measurement techniques and procedures In each case the advantages and limitations are outlined To put these methods in context the book also recounts the history of the discipline and describes the diverse contemporary applications of nuclear forensics

**Routledge Handbook of Nuclear Proliferation and Policy** Joseph Pilat, Nathan Busch, 2015-05-15 This new Handbook is a comprehensive examination of the rich and complex issues of nuclear proliferation in the early 21st century The future of the decades long effort to prevent the further spread of weapons of mass destruction is at a crossroads today If international nonproliferation efforts are to be successful an integrated multi tiered response will almost certainly be necessary A serious thorough and clear eyed examination of the range of threats challenges and opportunities facing the international community is a necessary first step This Handbook which presents the most up to date analysis and policy recommendations on these critical issues by recognized leading scholars in the field intends to provide such an examination The volume is divided into three major parts Part I presents detailed threat assessments of proliferation risks across the globe including specific regions and countries Part II explains the various tools developed by the international community to address these proliferation threats Part III addresses the proliferation risks and political challenges arising from nuclear energy production including potential proliferation by aspiring states and nonstate groups This Handbook will be of great interest to students and practitioners of nuclear proliferation arms control global governance diplomacy and global security and IR general **SIPRI**

**Yearbook 2008** Stockholm International Peace Research Institute, 2008 The 39th edition of the SIPRI Yearbook analyses developments in 2007 in Security and conflicts Military spending and armaments Non proliferation arms control and disarmament The SIPRI Yearbook contains extensive annexes on the implementation of arms control and disarmament agreements and a chronology of events during the year in the area of security and arms control **Defence Against**

**Weapons of Mass Destruction Terrorism** NATO Advanced Research Workshop on Defence Against Weapons of Mass Destruction Terrorism, 2009-06-26 In *Defence Against Weapons of Mass Destruction Terrorism* the editors examined the class of Weapons of Mass Destruction WMD for terrorist use and have found that their effects range from serious nuisance value

up to catastrophic destruction of a large urban area There are some differences in the effects depending on whether they are used against military or civilian targets whether they are used from inside the target area or outside and between those weapons for which MOPP Mission Oriented Protective Posture gear can provide useful protection Biological Weapons Chemical Weapons and those for which it often cannot radiation nuclear explosions These are useful ways to begin thinking about establishing protocols for protecting our armed forces and the civilian population they are sworn to defend **SIPRI**

**Yearbook 2007** Stockholm International Peace Research Institute, 2007 The 38th edition of the SIPRI Yearbook analyses developments in 2006 in Security and conflicts Military spending and armaments Non proliferation arms control and disarmament The SIPRI Yearbook contains extensive annexes on the implementation of arms control and disarmament agreements and a chronology of events during the year in the area of security and arms control The annual accounts and analyses are extensively footnoted providing a comprehensive bibliography in each subject area **Strategic Yearbook**

**2018** P K Singh, B K Sharma, Roshan Khanijo, 2018-06-27 There is a widespread perception amongst the intelligentsia that India lacks strategic culture The deficiency if any perhaps lies in the reluctance to articulate India's perceptions on strategic issues as also to formulate a long term strategic view As the oldest think tank in Asia United Services Institution of India USI decided to address the above issue and how it could contribute to evolution and dissemination of strategic thought on challenges facing the Nation To this end the publication of a USI Strategic Yearbook 2016 which was the maiden attempt which received wide appreciation for its quality and contents This current issue of the Yearbook contains series of articles by eminent persons and experts on various aspects of national security the aim is to provide a strategic perspective which will create awareness and also help the policymakers in giving a strategic direction for India to transform into a developed society and a secured nation USI hopes that readers will find this publication useful and interesting *The World Today*, 1987 **Annuaire Des Organisations Internationales**, 1967 Edition for 1983 84 published in 3 vols vol 1 Organization descriptions and index vol 2 International organization participation vol 3 Global action networks edition for 2012 2013 published in 5 vols vol 4 International organization bibliography and resources vol 4 Statistics visualizations patterns

**Nuclear Forensics** Division on Earth and Life Studies, Nuclear and Radiation Studies Board, 2010-07-29 Nuclear forensics is important to our national security Actions including provision of appropriate funding are needed now to sustain and improve the nation's nuclear forensics capabilities The Department of Homeland Security DHS working with cooperating agencies and national laboratories should plan and implement a sustainable effective nuclear forensics program Nuclear forensics is the examination and evaluation of discovered or seized nuclear materials and devices or in cases of nuclear explosions or radiological dispersals of detonation signals and post detonation debris Nuclear forensic evidence helps law enforcement and intelligence agencies work toward preventing mitigating and attributing a nuclear or radiological incident This report requested by DHS the National Nuclear Security Administration and the Department of Defense makes

recommendations on how to sustain and improve U S nuclear forensics capabilities The United States has developed a nuclear forensics capability that has been demonstrated in real world incidents of interdicted materials and in exercises of actions required after a nuclear detonation The committee however has concerns about the program and finds that without strong leadership careful planning and additional funds these capabilities will decline [Subject Guide to Books in Print](#)

,1997 [NUCLEAR FORENSICS SUPPORT](#). IAEA.,2012 **Nuclear Forensics** ,2016 **Analytical Methods for Nonproliferation** Edward C. Morse,2016-04-04 This book is intended to be used as a textbook and research reference for the field of nuclear nonproliferation The book is primarily technical and focussed on methods of detecting clandestine nuclear material that might be illicitly transported The book also touches on nuclear forensics i e methods for identification attribution and establishment of transport pathways for illicit nuclear material Also covered are topics of methods used for arms control and treaty verification and an assessment of technologies under development for all of the above A description of the government and international agencies involved in nuclear terrorism prevention nuclear safeguards and arms control is also included **Development of a National Nuclear Forensics Library** International Atomic Energy

Agency,2019-02-04 This publication provides the rationale for the development of a national nuclear forensics library and addresses how a State may use such a national system in investigations of nuclear and other radioactive material out of regulatory control Nuclear forensics is the examination of nuclear or other radioactive material or of evidence that is contaminated with radionuclides in the context of legal proceedings under international or national law related to nuclear security 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 their intended uses were Important when conducting a nuclear forensics examination is the ability of States to identify nuclear and other radioactive material within the State and determine whether those materials are consistent with domestic holdings As a system for the identification of nuclear or other radioactive material a national nuclear forensics library can facilitate interpretation of findings and assist States in this determination This publication seeks to assist States that choose to develop such a library tailored to their individual circumstances national legal requirements and security needs [Advances in Nuclear Forensics](#) International Atomic Energy Agency,2015

Addresses the role of nuclear forensics in a nuclear security infrastructure the elements of a nuclear forensic examination confidence in findings development and sustainability of a nuclear forensic capability at the national level lessons learned from case studies and international cooperation with scientific and law enforcement partners [Nuclear Forensics of Special Nuclear Material at Los Alamos](#) ,2010 Nuclear forensics of special nuclear materials is a highly specialized field because there are few analytical laboratories in the world that can safely handle nuclear materials perform high accuracy and precision analysis using validated analytical methods The goal of nuclear forensics is to establish an unambiguous link between illicitly trafficked nuclear material and its origin The Los Alamos National Laboratory Nuclear Materials Signatures

Program has implemented a graded conduct of operations type approach for determining the unique nuclear chemical and physical signatures needed to identify the manufacturing process intended use and origin of interdicted nuclear material In our approach an analysis flow path was developed for determining key signatures necessary for attributing unknown materials to a source This analysis flow path included both destructive i e alpha spectrometry ICP MS ICP AES TIMS particle size distribution density and particle fractionation and non destructive i e gamma ray spectrometry optical microscopy SEM XRD and x ray fluorescence characterization techniques Analytical techniques and results from three recent cases characterized by this analysis flow path along with an evaluation of the usefulness of this approach will be discussed in this paper

**Nuclear Forensics** WESLEY A. SCHULER, 2025-05-22 Over the past decade law enforcement governmental and public agencies have been stymied by the threat of the trafficking of nuclear materials During this time span reports from the International Atomic Energy Agency of illicit trafficking have increased eightfold from 20 to 160 For this reason nuclear forensics is a burgeoning science focused on the identification of seized special nuclear materials Identification of these materials is based upon the wealth of information that can be obtained by applying multiple analytical and measurement technologies All of the information gained from each sample can then be used to further characterize other samples culminating in the inclusion of all of the collected data into a central database Information must be reported in a timely manner as actionable results need to be presented as quickly as possible if there is to be any attribution for trafficking of nuclear material Identification parameters such as uranium content isotopic composition and levels of impurities can be measured simultaneously in an effort to completely characterize a sample All of these measurements combined can offer information as to the source of the material and its intended use Many of the current analytical techniques used in nuclear forensics require extensive sample preparation and offer minimal amounts of information about the sample Time of Flight Secondary Ion Mass Spectrometry TOF SIMS is presented as a rapid analytical technique that provides many of these identification parameters with minimal sample preparation TOF SIMS spectra were collected on eight different standard reference materials covering a range of stoichiometries and levels of enrichment Samples included UO<sub>2</sub> UO<sub>3</sub> and U<sub>3</sub>O<sub>8</sub> stoichiometries ranging from slightly depleted 0.5% <sup>235</sup>U to highly enriched 90.0% <sup>235</sup>U uranium Spectra were simulated in an effort to deconvolve composite peaks resulting from the protonation of cluster ions This work has been selected by scholars as being culturally important and is part of the knowledge base of civilization as we know it This work was reproduced from the original artifact and remains as true to the original work as possible Therefore you will see the original copyright references library stamps as most of these works have been housed in our most important libraries around the world and other notations in the work This work is in the public domain in the United States of America and possibly other nations Within the United States you may freely copy and distribute this work as no entity individual or corporate has a copyright on the body of the work As a reproduction of a historical artifact this work may contain missing or blurred pages

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**Application of Nuclear Forensics in Combating Illicit Trafficking of Nuclear and Other Radioactive Material** International Atomic Energy

Agency,2013-06-30 This publication presents the outcome of an IAEA coordinated research project CRP which served as a technical forum for sharing international experiences in the field of nuclear forensics with a focus on improved procedures and techniques optimization of nuclear forensic analysis preservation of evidence and provision of support to Member States The CRP results address both technical needs to develop the discipline of nuclear forensics as well as to promote confidence in the application of analytical methods and understanding of the nuclear fuel cycle applied to nuclear forensics Topics include instrumentation and field work for evidence collection novel laboratory methods supporting a nuclear forensic examination and modeling for interpretation of nuclear forensic results

**Establishing a Nuclear Forensic Capability: Application of Analytical Techniques** International Atomic Energy Agency,2023-06-15 Nuclear forensics supports national nuclear security measures and criminal investigations by providing information on the identity origin and history of nuclear or other radioactive material found out of regulatory control This publication provides information for States on the use of nuclear forensics in response to criminal or other unauthorized acts involving nuclear or other radioactive material based on the guidance provided in IAEA Nuclear Security Series No 2 G Rev 1 Nuclear Forensics in Support of Investigations It is intended for technical and non technical personnel responsible for developing nuclear forensic analytical capabilities within the context of a broader national nuclear forensic programme stemming from national legislation It provides technical information that describes the application of specific methods analytical techniques and technical expertise used for nuclear forensic analysis in support of investigations of criminal or other unauthorized acts involving nuclear or other radioactive material

Nuclear Forensics Gene Aloise,2009 The detonation of a nuclear weapon or radiological dispersal device RDD in the United States or elsewhere would cause decision makers to immediately demand information on the nature of the device including its design the materials used to build it and the materials source as well as the identification of the perpetrators Technical nuclear forensics the analysis of nuclear or radiological materials that are intercepted or the radioactive debris and prompt output signals such as gamma rays produced by a nuclear event can contribute to the identification of the sources of these materials and the processes used to create them Nuclear forensic techniques also could potentially be used to determine the origin of nuclear or radiological materials or devices seized prior to their use in a weapon known as predetonation nuclear forensics The departments of Defense DOD Energy DOE Homeland Security DHS and State State as well as the Federal Bureau of Investigation FBI and the intelligence community would play key roles in a nuclear forensics investigation In this context you asked us to assess the 1 challenges the U S government faces in developing and maintaining

a comprehensive nuclear forensics capability and 2 current and future costs associated with the U S government s nuclear forensics efforts In February 2009 we reported to you on the results of our work in a classified report This letter summarizes certain aspects of our classified report



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