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Efforts on strengthening nucelar security from technology development perspective in JAEA

In 2010, the Japanese Government issued the national statement at Nuclear Security Summit (Washington D.C., USA) to develop technologies related to measurement and detection of nuclear materials and nuclear forensics, and to share them with the international community. In response to this statement, Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) was established in December 2010 in Japan Atomic Energy Agency (JAEA) which is Japan's sole comprehensive research and development institute in the field of nuclear energy. ISCN has been carrying out R&Ds on innovative technology for measurement and detection of nuclear materials and nuclear forensics technical capabilities since Japanese Fiscal Year of 2011. This paper summarized the 10year-efforts on technology development to strengthen nuclear security.

Non-destructive Assay (NDA) methods are an efficient and quick way for detection and quantification of nucelar materials. Main challenges to measure and detect nuclear material are to detect it hidden in heavy-sheilded container and to measure it in high radiation environment and complex compositon. The passive NDA techniques are widly applied in nucelar filed, however they are not applicable to those conditions because emmited radiation is completely shielded and radiation background interfer target spectrum. Active NDA techniques utilize interrogation particles e.g. photons and neutrons inducing nuclear reactions to generate a radiation signature form a sample. Measurement and analysis of the induced differences in radiations and incident particles are used to extract information of nuclear and matrix materials in the sample. These methods are potentially applicable to analysis of high-level radioactive nuclear materials and to detection of nuclear materials in a havy shield. One of the programs to develop active NDA technique is "Development of Nuclear Resonance Fluorescence (NRF) technique"for detection of nuclear materials hidden in heavy-shielded container. This technique utilizes quasi monochromatic gamma-ray beams produced by laser Compton scattering (LCS). The energy of LCS gamma-rays is tuned to a nuclear resonance energy of a nuclide to be found. NRF gamma-rays induced by LCS gamma-rays are observed by gamma-ray detectors. The first part of this program carried out technological development on high-intensity quasi-monochromatic LCS gamma-ray beam production, and then an experiment using an NRF NDA technique will be performed to demonstrate nucelar material detection hidden in a heavy shield in March 2020. Another program is "development of active neutron NDA techniques", in which four techniques are developed in an integrated manner, i.e. Differential Die Away Analysis (DDA), Delayed Gamma-ray Analysis (DGA), Neutron Resonance Transmission Analysis (NRTA), and Prompt Gamma-ray Analysis (PGA). These techniques could be used to complement each other and would be applicable to nuclear security purposes for detection of nucelar material and explosive materials as well as nuclear material accountancy for both low and high level radioactive sample. Basic development of four techniques were carried out and the phase-2 for focusing analysis of high level radioactive sample is currenty under way.
Since initiation of nucelar forensics technology development, the fundamental nuclear forensics analytical capabilities were established for characterization of nuclear materials and prototype nuclear forensics library for interpretation of the analytical results in first three years. ISCN has also engaged in development of advanced technologies for more rapid and precise nuclear forensics analysis and shared the achievements for strengthening international nuclear forensics capabilities. It includes new uranium age dating methods, data analysis methodology for library based on multivariate analysis and image analysis methodology for particle characterization. These technical capabilities have been validated through the joint research with the U.S. national laboratories and Europium Commission Joint Research Center (EC-JRC), and participation in exercises organized by International Technical Working Group. In order to sustain and improve the capability, new technical efforts were recently initiated. The development of post-dispersion event technology covers supporting for detection and recovery of radioactive samples from an event scene, and measurement and signature analysis methodology for post-dispersion samples. As the innovative technology, machine-learning algorism for data analysis on nuclear forensics library, and application of autoradiography for nuclear forensics purpose are being studied.
In order to identify the technical needs to be developed and share our achivements to both domestic and international stakeholders, the international technnical syposiums and workshops were held. Each R&D program was basically conducted for three to five-year basis and was evaluated by international experts at the end of program and the feedback applied to next program. The identified needs from domestic and international community reflect subjects of future program. These communication with stakeholders could also be contributed filling the gap between R&D achievement and implementation in real field, which is one of the most difficult challenges.

The R&D programs on contributing nuclear security in JAEA are being conducted by subsidiarly budget for nucelar security promotion of the Ministry of Education, Culture, Sports, Science and Technology of Japan through collaboration with U.S. Department of Energy and EC-JRC, and Japanese institutes and universities.

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