Nuclear Science

Objective

To increase Member State capabilities in the development and application of nuclear science as a tool for their technological and economic development.

Atomic and Nuclear Data

Accurate and reliable nuclear, atomic and molecular data are vital for generating nuclear energy, whether by fission or fusion, as well as for other nuclear applications in essential fields such as medicine, non-destructive testing and environmental monitoring. These data are provided through on-line databases maintained by the Agency for use by its Member States. In 2013, the servers for the Nuclear Data Services web site[1] were moved to the 'cloud', ensuring increased security and cost savings.

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The number of visitors to the web site averaged 22 700 per month, with about 1.2 terabytes of numerical data, reports and technical documents related to nuclear data downloaded during the year. Parts of the data web site have been 'mirrored' in China and India to ensure greater accessibility to users in those regions.

[1] See: *www-nds.iaea.org*.

LiveChart, which provides users with interactive information on nuclide properties, was developed further in 2013. For example, an enriched visual interface was added, displaying decay chains and gamma intensities. Users can access detailed graphical and tabular information by clicking on a nuclide in the chart (Fig. 1). Data on more than 4000 nuclides are taken from the Evaluated Nuclear Structure Data File (ENSDF) database maintained through the International Network of Nuclear Structure and Decay Data Evaluators (NSDD). An NSDD meeting was held in Kuwait in January to discuss technical issues concerning the compilation, evaluation and dissemination of nuclear structure and decay data. The Experimental Nuclear Reaction Data (EXFOR) database, developed by the International Network of Nuclear Reaction Data Centres (NRDC), reached a major milestone in 2013, having compiled 20 000 original experimental works.

In 2013, a free app was developed for Android tablets and smartphones. The app, called 'Isotope Browser', provides information on the nuclides in ENSDF. Since its launch in July, the app has already been downloaded more than 5000 times.

Four new CRPs were started during the year: One CRP, on material damage due to irradiation, will review the existing displacement per atom (dpa) standard and recommend a replacement. Another CRP focuses on validation of the International Reactor Dosimetry and Fusion File (IRDFF), a dosimetry library containing new reactions extending to 60 MeV. Delayed neutrons accompanying beta decay are of fundamental importance for fission applications and basic science; recent new experiments will be assessed and results incorporated into databases in a third CRP. As part of the series of CRPs studying plasma–wall interactions in fusion devices, a fourth CRP, on irradiated tungsten, will

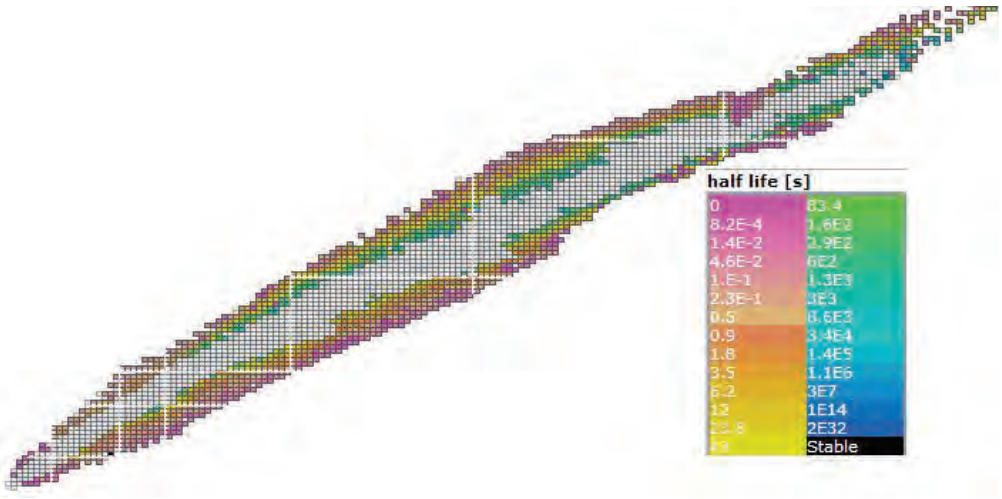

FIG. 1. A LiveChart display of nuclides: each square represents a nuclide; coloured squares represent nuclides discovered in the past 50 years; colours represent nuclide half-life values.

investigate tritium interactions with tungsten, a material important for planned fusion reactors.

The Agency held a number of meetings and workshops on nuclear data and on their application in a variety of fields, including medicine. Nuclei that decay by electron capture are a source of low energy (Auger) electrons that can be used for precisely targeted radiotherapy. An Agency meeting held in May in Vienna brought together experts to review the process and to make recommendations for further compilation of Auger data and high quality measurements. A September Workshop on Nuclear Data for Science and Technology: Medical Applications and another Workshop on Nuclear Data for Analytical Applications, held in October, both jointly organized with the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy, trained 46 participants. Biennial meetings of the International Atomic and Molecular Code Centre Network and the International Atomic and Molecular Data Centre Network held in Vienna in May and September addressed procedures for uncertainty estimates and recommended further emphasis on evaluations of collision cross-section data.

Research Reactors

Improving the utilization of research reactors

More than 30 research reactors worldwide participated in a series of proficiency tests in neutron activation analysis that began in 2010 and culminated in 2013. A majority reported improvement, with the most significant progress observed in Africa. A new series of tests will start in early 2015.

A July Workshop on Development and Implementation of Strategic Plans at Research Reactors, held in Vienna, provided feedback on strategic plan documents from more than 30 research reactor facilities worldwide. The event also provided the reactor facility managers a chance to share their experience related to strategic planning as well as the derived benefits.

Various publications on research reactor applications were issued in 2013, including *Commercial Products and Services of Research Reactors* (IAEA-TECDOC-1715) and *Applications of Research Reactors towards Research on Materials for Nuclear Fusion Technology* (IAEA-TECDOC-1724).

Research reactors in education and training

The Agency continued to support the Group Fellowship Training Programme on Research Reactors, held for the seventh time in 2013. The course, which began in September and took place in Austria and the Czech Republic, covered topics such as research reactor safety, utilization, operation and maintenance. Since it began in 2009, the programme has trained 53 students from Africa, Asia, Europe and Latin America.

A four week training workshop for the initial operating personnel of a newly constructed neutron source facility was completed in November at the Sevastopol National University of Nuclear Energy and Industry in Ukraine. The workshop served as a pilot for developing similar international training programmes.

The first demonstration of remote, Internet based reactor exercises was provided during a side event at the Agency's 57th General Conference. The audience witnessed two experiments broadcast live from a research reactor in France.

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Research reactor infrastructure

The Agency's Research Reactor Database (RRDB) was linked to the Incident and Emergency Centre (IEC) information database, streamlining the IEC's capacity to more effectively communicate and provide timely assistance to research reactor centres in emergency situations. Data for 295 facilities were updated in the RRDB.

The publication *Non-HEU Production Technologies for Molybdenum-99 and Technetium-99m* (IAEA Nuclear Energy Series No. NF-T-5.4), issued in February, served as the basis for small scale medical isotope production support projects in developing countries. Fact finding missions assessing infrastructure and defining production requirements to supply national demand were conducted in Morocco, Peru, Poland and Romania.

Research reactor fuel

The Agency continued to support efforts to minimize civilian use of high enriched uranium (HEU). In 2013, the Czech Republic, Hungary and Viet Nam removed all HEU research reactor fuel from their territories through repatriation operations to the Russian Federation (Fig. 2).

A project and supply agreement (PSA) to facilitate the conversion of a research reactor in Jamaica from HEU to low enriched uranium (LEU) fuel came into force in December. The PSA secured the transfer and export of approximately 9 kg of LEU to Jamaica from the USA for the reactor's continued operation.

At the seventh meeting on lessons learned from the Russian Research Reactor Fuel Return programme, held in June in Sevastopol, Ukraine, over 70 participants from 17 countries shared their experience, contributing to future Agency activities in this area. As in the past, this experience, including identified good practices and

lessons learned, will be incorporated into future projects to optimize their implementation.

FIG. 2. Dual purpose casks (blue) procured by the Agency being loaded into TUK-145/C transport packages for the repatriation of spent HEU fuel at the KFKI Atomic Energy Research Institute research reactor site in Budapest.

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Research reactor operation and maintenance

An Operation and Maintenance Assessments for Research Reactors (OMARR) mission to Pavia, Italy, was completed in March. In November, a follow-up OMARR mission was conducted to the National Institute of Standards and Technology (NIST) reactor in the USA, providing guidance on prioritizing improvements suggested by the experts participating in the mission.

A Workshop on the Implementation of Integrated Management Systems for Research Reactors was held in June in Vienna. Workshop participants shared information and lessons learned on establishing, implementing, assessing and improving management systems for operators.

Through the Agency's technical cooperation programme, and with the support of the US Department of Energy and the European Commission, the modernization of the instrumentation and control system for the WWR-SM research reactor in Uzbekistan was completed. The entire system was accepted for further routine use in July.

Accelerators for Materials Science and Analytical Applications

An International Topical Meeting on Nuclear Applications of Accelerators (AccApp'13), organized jointly by the Belgian Nuclear Research Centre (SCK•CEN), the American Nuclear Society and the Agency, was held in Bruges, Belgium, in August. At the meeting, 174 scientists from 40 countries discussed nuclear applications of particle accelerators, including the production or destruction of radionuclides.

Nuclear Instrumentation and Spectrometry

In 2013, an ultra high vacuum chamber (UHVC) facility integrating various X ray spectrometry techniques was developed at the laboratory of the Federal Institute of Physics and Technology (PTB) in Berlin, in collaboration with the Agency. The Agency installed the UHVC at a beam line at the Elettra Sincrotrone Trieste (EST) in Italy. Thanks to the Agency–EST collaboration agreement, the Agency and its Member States can utilize the new X ray fluorescence beam line 40% of the time to carry out experiments.

Unmanned aerial vehicles (UAVs) provide a low cost, remote platform that can be utilized for a range of different applications. In 2013, as part of the IAEA Action Plan on Nuclear Safety and supported by the Government of Japan, the Agency began developing ultraportable gamma ray radiation sensors and spectrometers for use on customized hexarotor and quadrotor UAVs. Such tools enable emergency responders and decontamination workers to rapidly survey and map medium sized areas (1 km × 1 km) for radiological contamination. UAVs also have other applications ranging from climate studies to crop surveys. The first UAVs were procured and initial flight tests were performed in Fukushima Prefecture, Japan, in December (Fig. 3).

Nuclear Fusion

The second workshop under the demonstration fusion power plant (DEMO) programme, held in December in Vienna, facilitated in-depth discussions among some 90 participants on areas in fusion technology key to the success of the DEMO experiment. Activities within established national roadmaps towards DEMO were presented by several Member States with strong fusion programmes.

A consultants meeting in June in Vienna enabled fusion scientists and engineers and non-proliferation

experts to share their experience with the Agency on non-proliferation aspects of magnetic confinement fusion energy. In particular, areas for enhanced R&D collaboration between the fusion community and the Agency in the area of safeguards activities were identified. In addition, the meeting concluded that it will be necessary to clarify the framework for non-proliferation verification of fusion power systems.

FIG. 3. An Aibotix X6 UAV hovering over a temporary storage site in Fukushima Prefecture in December.