

# 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

The Agency maintains extensive nuclear, atomic and molecular databases that are available to all Member States through on-line and traditional services. The number of International Nuclear Data Committee (INDC) reports on the web has risen from about 1500 in 2008 to more than 1800 in 2009, and important archival material, including the files of standards previously used, has also been made available on-line. There was a significant increase of approximately 12% in the use of on-line sites in 2009.

International collaboration and the development of application specific databases remain at the forefront of the Agency's work, as demonstrated by the prompt adoption by the nuclear industry and research centres of the Agency's contributions, including contributions to the Joint Evaluated Fission and Fusion (JEFF) project for the safe operation of existing reactors and assessment and planning of new reactor concepts, and to a new version of the International Reactor Dosimetry File (IRDF).

At a technical meeting held in Vienna, 22 participants from 15 Member States reviewed the generation of nuclear data using research reactors. The meeting brought together nuclear data experts and reactor managers with the goal of encouraging closer interaction to strengthen the role of research reactors in the provision of nuclear data for a range of applications. Specifically, the discussions focused on the use of research reactors for fission and capture cross-section and decay data measurements, and also for integral experiments to benchmark evaluated data libraries. A significant feature of evaluated databases is that they present non-predictive information and can display complex correlations interactively (Fig. 1). This is important in the analysis of the safety and efficiency of nuclear power plants.

A new graphical interface and retrieval tool for the Evaluated Nuclear Structure Data File (ENSDF) was released in 2009. Known as the 'Live Chart of Nuclides', the tool provides detailed information on nuclide properties.

An important aspect of the Agency's work is to ensure the consistent use of nuclear reaction model codes. In 2009, a report was published covering the past 15 years of work of the Reference Input Parameter Library (RIPL). A new centralized portal for all medical related nuclear data was created and is available at <http://www-nds.iaea.org/medportal/>.

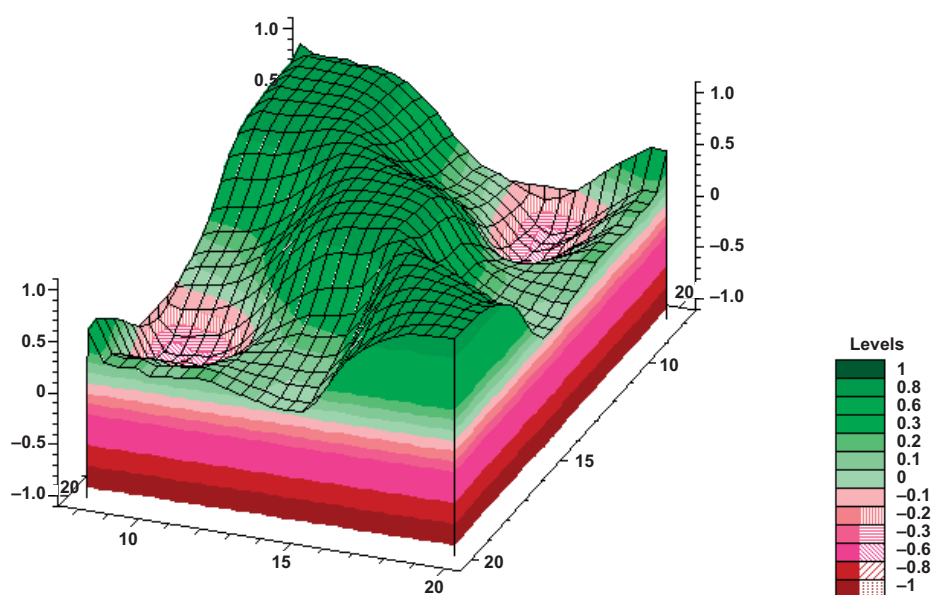


FIG. 1. The correlation matrix for the iridium-193 (n, 2n) iridium-192 reaction showing how cross-section data at different energies are linked.

As part of the Agency's work on atomic and molecular data in support of fusion research, a new CRP was begun, aimed at generating data on excitation, ionization, recombination and heavy particle collision processes for ions and molecules of light elements, which are the dominant impurity species in fusion devices. A new standard for exchange of atomic, molecular and particle-surface interaction data is also being developed.

## Research Reactors

Agency activities in the area of research reactors focused on the challenges of underutilization, ageing/modernization, and the presence of fresh or spent high enriched uranium (HEU) fuel, as well as on issues of safety and security, and on plans by some Member States to build new research reactors. In this connection, more than 20 Member States have approached the Agency regarding the possible construction of new research reactors. In 2009, Agency assistance included the preparation of feasibility studies for Azerbaijan, Jordan, Sudan and the Gulf Cooperation Council (GCC).

The Eastern European Research Reactor Initiative (EERRI), supported by the Agency, organized a group fellowship training course to assist Member States interested in initiating research reactor projects. The course provided training on planning, evaluation, development, construction, commissioning, utilization, operation and maintenance.

Agency supported coalitions and networks of research reactors continued to enhance cooperation among research reactor facility managers, including existing and potential users and other stakeholders. A number of such networks (Table 1) shared research reactor facilities and competencies and collectively offered services to regional and international users, and secured entrepreneurial interest and support for upgrading existing or developing new facilities and improving access to countries without research reactors. During the 6th African Regional Conference on Research Reactor Utilization and Safety, held in Abuja, Nigeria, in November, the African Regional Research Reactor Safety Committee was officially formed and the African Research Reactor Network was initiated.

The Agency supports materials studies for the energy sector using research reactors through CRPs.

TABLE 1. PARTICIPATION OF MEMBER STATES IN RESEARCH REACTOR COALITIONS AND NETWORKS SUPPORTED BY THE AGENCY

Coalition/network	Member States
African Research Reactor Network	Algeria, Democratic Republic of the Congo, Egypt, Ghana, Kenya, Libyan Arab Jamahiriya, Morocco, Niger, Nigeria, South Africa, Sudan, Tunisia, Zambia
Baltic Research Reactor Network	Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russian Federation, Sweden
Caribbean Research Reactor Coalition	Colombia, Jamaica, Mexico
Eurasia Research Reactor Coalition	Czech Republic, Hungary, Kazakhstan, Ukraine, USA, Uzbekistan
Eastern European Research Reactor Initiative	Austria, Czech Republic, Hungary, Poland, Romania, Serbia, Slovenia

Two new CRPs were launched in 2009, one on the application of the large sample neutron activation analysis technique for inhomogeneous bulk archaeological samples and large objects, and the other on characterization and testing of materials of relevance to the nuclear energy sector using neutron beams.

An improved version of the Research Reactor Database (<http://www.iaea.org/worldatom/rrdb/>) showing classification of operational research reactors by geographical distribution, category, features, utilization and applications was circulated to selected users and stakeholders for review and evaluation. The new design will be made available on the web to support the development of strategies for capacity building and effective utilization and management of research reactors on a national, regional and international basis.

## Addressing the Shortage of Molybdenum-99 Supplies

Shutdowns and outage extensions of aged research reactors have significantly reduced global molybdenum-99 supplies since the end of 2007. In

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response, the Agency has been engaged in several initiatives, such as the Eurasia Research Reactor Coalition, set up to expand the number of research reactors involved in molybdenum-99 production. Some of the participating teams (for example, from Poland and Romania) in an ongoing CRP related to the production of molybdenum-99 using low enriched uranium (LEU) targets or neutron activation have offered to provide irradiation services or initiate full scale production of molybdenum-99. A workshop on the assessment of options for enhancing molybdenum-99 production and availability, held in Warsaw in September, and a panel discussion on the reliability of medical isotopes produced in research reactors, held during the Agency's General Conference, highlighted the various issues and challenges to be addressed and the options under consideration by some Member States.

The Agency participated in a number of international meetings and related events aimed at enhancing the reliability of molybdenum-99 supply and sourcing, including an OECD/NEA workshop on the security of supply of medical radioisotopes (held in January 2009), meetings of the OECD/NEA High-level Group on the Security of Supply of Medical Radioisotopes (held in June and December), and a meeting of the Association of Imaging Producers and Equipment Suppliers (in September).

## Research Reactor Operation and Maintenance

Information on ageing related operating experience from research reactors around the world was collected in a database that is available to research reactor operators ([http://www.iaea.org/OurWork/ST/NE/NEFW/rrg\\_operation.html](http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_operation.html)). The Agency also held a technical meeting to share experience in the management of ageing of research reactors.

The Agency published *Research Reactor Modernization and Refurbishment* (IAEA-TECDOC-1625), which includes descriptions of the modernization and refurbishment projects implemented at different research reactors. Written for management teams and stakeholders, the report assumes that individual facilities have developed a five to ten year strategic plan that takes into consideration customer and market trends.

## Research Reactor Fuel

Agency support continued for Member States participating in international programmes to return research reactor fuel to its country of origin. As part of the Russian Research Reactor Fuel Return (RRRFR) programme, 18.9 kg of fresh HEU fuel was moved from Hungary to the Russian Federation under a contract arranged by the Agency. The Agency also assisted in the repatriation to the Russian Federation of spent HEU fuel from Kazakhstan, the Libyan Arab Jamahiriya, Poland and Romania.

An Agency publication, *Good Practices for Qualification of High Density Low Enriched Uranium Research Reactor Fuels* (IAEA Nuclear Energy Series No. NF-T-5.2), provides guidance on ensuring

acceptable performance of high density LEU fuels in a wide variety of research and isotope production reactors to fuel developers, reactor operators planning to use a new fuel, and regulatory bodies considering

issuing licences allowing specific reactors to use a new fuel.

A technical cooperation project on repatriating spent fuel from the RA research reactor at the Vinča Institute in Serbia continues on schedule. During the General Conference in September, delegates from the Russian Federation and Serbia signed the Foreign Trade Contract, a precondition for the spent fuel's envisioned repatriation to the Russian Federation. A further milestone was the initiation of spent fuel repackaging activities. All of the spent fuel will be transported to the Russian Federation in one shipment in 2010.

## Accelerators for Materials Science and Analytical Applications

A topical meeting on 'Nuclear Research Applications and Utilization of Accelerators', held in collaboration with the American Nuclear Society, discussed new trends in this area. The meeting highlighted the importance of continued research into the applications of accelerators for the further development of nuclear power, such as structural materials development and partitioning and transmutation, as well as the role of accelerators into nuclear education, biomedical applications, environmental science and cultural heritage. The participants noted the growing number of practical

applications of accelerators, for example as an analytical tool for environmental issues as well as in industrial practices. The growing interest among developing countries in the adoption of such techniques was also noted.

A series of topical meetings was held by the Agency in 2009 to promote knowledge transfer and networking. In addition, the meetings focused on building capacity in the area of structural materials for fusion and fission applications, high intensity neutron sources, cold neutron sources, synchrotron radiation and utilization of exotic beams.

A new CRP on the application of nuclear methods in microstructural characterization and performance testing of materials for hydrogen fuel cell and storage technologies was launched. Along with another ongoing CRP on Accelerator Simulation and Theoretical Modelling of Radiation Effects (SMORE), the new CRP is focused on addressing materials science issues and developing nuclear technologies to support new energy sources, both nuclear and non-nuclear.

In continuing to strengthen collaboration with other international organizations in 2009, meetings were held with the Joint Research Centre of the European Commission, the IEA and the OECD/NEA. The subjects addressed included advances in materials for fission and fusion reactor systems as well as for hydrogen based energy sources.

A new report on *Ion Beam Applications in Surface and Bulk Modification of Insulators* (IAEA-TECDOC-1607) was published.

## Nuclear Instrumentation and Spectrometry

A CRP on the development of harmonized quality assurance (QA)/quality control (QC) procedures for the maintenance and repair of nuclear instruments was completed in 2009. Seven sets of QA/QC procedures for calibration and maintenance of nuclear instrumentation were developed and four low cost instruments were made available to users in Member States.

The Agency's training programme for building first line maintenance capacity in nuclear instrumentation was modified to better respond to the needs of Member State laboratories. Innovative methods for maintenance — such as using digital signal processing and modern communication tools, including the Internet, for remote diagnostics — and guidelines for modernization of nuclear instruments applied in the fields of food and agriculture and environmental quality management were assessed. The publication, *Signal Processing and Electronics for Nuclear Spectrometry* (IAEA-TECDOC-1634), detailed operational experience in this area and highlighted the latest

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FIG. 2. A participant in the fellowship training programme in the X ray fluorescence laboratory at the Agency's Laboratories, Seibersdorf.

developments in this field. Information on establishing and supporting a quality management system in nuclear instrumentation laboratories was made available to Member States. Ten regional and three national training courses were organized under technical cooperation projects related to nuclear instrumentation support, and 23 participants were trained at the Agency's Laboratories, Seibersdorf, under group and individual fellowship training programmes (Fig. 2).

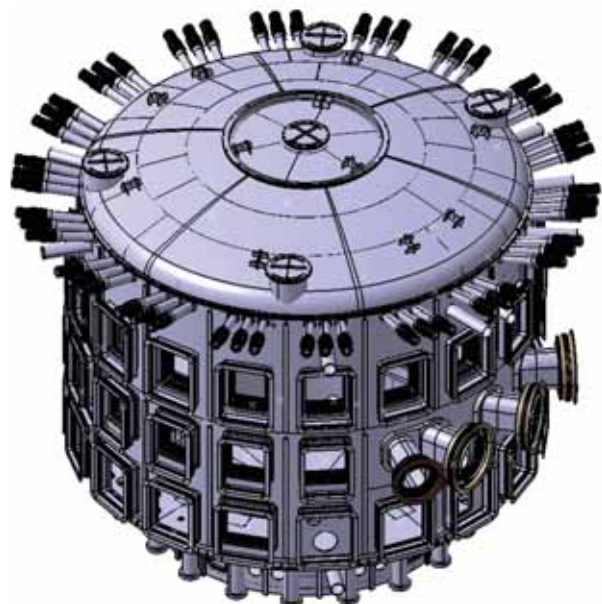
A CRP on unification of nuclear spectrometries that ended in 2009 led to improved analytical practices through a combination of related techniques and by integrating multifunctional instruments. A new CRP on microanalytical techniques based on nuclear spectrometry was initiated with the objective of deploying these techniques for environmental monitoring and materials studies. The Agency's support to Member State laboratories in the field of nuclear spectrometry for environmental pollution monitoring, cultural heritage object analysis and other applications included the organization of seven regional training courses and one national course under technical cooperation projects that included X ray spectrometry aspects. In addition, six Fellows were trained in Seibersdorf in methodology and applications.

## Nuclear Fusion

Agency activities in nuclear fusion focused on improving international collaboration within the plasma physics and fusion community, for example through a joint meeting of the Agency's International Fusion Research Council and the IEA's Fusion Power

Coordinating Committee in February. Further, under the IAEA-ITER cooperation agreement, the Agency and ITER are ensuring reciprocal representation in relevant events for effective exchange of information.

In 2009, over 450 experts attended seven Agency organized technical meetings on nuclear fusion topics. Meeting participants reviewed the latest developments in plasma heating, the theory of particles and plasmas, new designs for possible fusion power plants, and power plant safety (Fig. 3). A joint Agency/European Commission topical meeting on the development of new structural materials for advanced fission and fusion reactor systems reflected the need for a common approach to materials research for these systems.



*FIG. 3. The ITER cryostat (approximately 30 m in diameter) housing the tokamak passed the conceptual design review stage in November.*