

Nuclear Science

Objective

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

Atomic and Nuclear Data

The year 2005 was declared as the “World Year of Physics”, in part to commemorate the 100th anniversary of Albert Einstein’s groundbreaking papers on the theory of relativity, the photoelectric effect and the theory of Brownian motion. To mark this occasion, the Agency examined the contributions of nuclear physics towards sustainable development during the Scientific Forum of the General Conference in September. There was agreement that applications of nuclear science continue to grow. The entire spectrum of nuclear science and technology is deeply rooted in atomic and nuclear physics data, with the Agency being the main source of up to date information in this area. For example, evaluated nuclear reaction data standards and a separate file for thorium-232 have evolved from Agency projects, and have been adopted for the US Evaluated Nuclear Data File (ENDF/B-VII) library. The Agency’s thermal scattering law library for major moderators and the iron-58 resonance evaluation were included in the Joint Evaluated Fission and Fusion (JEFF-3.1) library that was released in 2005. In response to user

requests in Member States, updated libraries were released for reactor lattice calculations in WIMS-D format for neutronics calculations of fusion devices, and a pilot library for accelerator driven systems was also prepared.

Plans to build a code centre network of database resources were formulated after a technical discussion between specialists with extensive expertise in computational methods for the generation of data for atomic and molecular (A+M) physics. The specialists agreed to make their resources available in support of this Agency based fusion research activity. Two CRPs, one on data for molecular processes in edge plasmas and another on plasma diagnostics for fusion research, were also concluded in 2005. Review articles are being published in separate issues of the journal Atomic and Plasma-Material Interaction Data for Fusion, and electronic data files were submitted for inclusion in the Agency’s A+M databases. The new data generated from both of these CRPs have also been used to model fusion plasmas using several internationally developed computer codes.

The Agency provides data users in Member States with cost free access to the most important basic numerical data needed in a wide range of energy and non-energy applications. The strong increase in requests for these nuclear data services continued in 2005 (Fig. 1).

The experimental atomic and nuclear databases obtained from the most recent measurements performed at nuclear physics laboratories

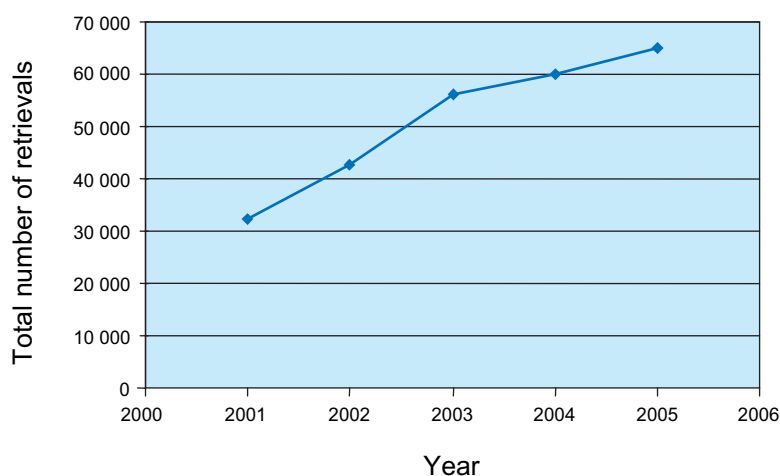


FIG. 1. Requests for the Agency’s nuclear data services, 2001–2005.

worldwide were updated in 2005. This work has been undertaken through direct collaborations with research laboratories, as well as with established networks of nuclear data centres in Europe, Japan, the Russian Federation and the USA. Proper interfaces to these libraries were developed by the Agency and made available to users in Member States.

At the end of May 2005, an upgraded mirror server was commissioned by the Agency at the Instituto de Pesquisas Energéticas e Nucleares, in São Paulo, Brazil. This server hosts the new relational nuclear data services for users in the Latin American region, and is updated automatically every 24 hours from the main server in Vienna. Considerable work was also undertaken to optimize the retrieval codes for the major nuclear structure and decay data files to improve services to users in Member States. A framework was developed in conjunction with the National Institute of Standards and Technology and the Oak Ridge National Laboratory in the USA encompassing data representation methods for structure properties, such as energy levels, coupling schemes and radiative properties, and for particle collisions including excitation and ionization processes. This framework can also be used for A+M processes and is now evolving into a global structure for A+M data, which is of direct interest to the astrophysics community.

Training activities organized by the Agency included workshops on nuclear data for neutron activation analysis, on nuclear structure and decay data and on nuclear data processing for Monte Carlo particle transport calculations. One of these workshops also provided the impetus for the induction of newly trained scientists into the International Nuclear Structure and Decay Data Evaluators' Network at a crucial time when the number of qualified staff has been in decline.

Research Reactors

The Agency's main focus of activities during the year in the field of research reactors was on promoting regional collaboration and networking as part of efforts to strengthen the development of strategic utilization plans. The first phase was initiated by providing guidance through regional workshops. In the second phase, technical and consultants meetings were organized to cover the Mediterranean, Southeast Asia and the Pacific, and Latin America to facilitate discussions among the

stakeholders of the participating Member States. Three areas for collaboration were identified: radioisotope production, education and training, and neutron beam applications. The preliminary plan aims at facilitating collaboration among countries with research reactors and associated facilities and those which do not have such facilities.

Critical facilities have played an important role in testing reactor physics codes, modelling, teaching and training. At a meeting of reactor designers and critical assembly experts, the modalities of using critical facilities to facilitate the development of specific innovative reactor designs were discussed. There was also agreement that information needed to be shared between various experimental groups in the interests of preserving knowledge for the future. In addition, the feasibility of using LEU instead of high enriched uranium for the sub-critical core of accelerator driven systems was explored.

In 2005, the Agency continued to support Member States, at their request, in returning research reactor fuel to the country of origin. Within the framework of the Russian Research Reactor Fuel Return Programme, fresh fuel was shipped to the Russian Federation from the Czech Republic and Latvia.

The number of requests for Agency assistance in relation to research reactor conversion increased considerably in 2005. At present, the Agency's technical cooperation programme is managing research reactor conversion projects in Bulgaria, Kazakhstan, the Libyan Arab Jamahiriya, Portugal, Romania, Ukraine and Uzbekistan. A project for the production and qualification of LEU fuel elements was completed, allowing the conversion of the La Reina Research Reactor in Chile. In addition, new conversion project proposals were presented for Jamaica and Poland.

On the issue of the adoption of low enriched uranium (LEU) targets for molybdenum-99 production, the Agency organized a workshop in Buenos Aires. A CRP was also initiated to assist countries interested in the small scale production of molybdenum-99 using LEU targets or neutron activation to meet local requirements.

Accelerators

Another activity organized in conjunction with the World Year of Physics in 2005 was a course on pulsed neutron sources, held in cooperation with the Abdus Salam ICTP in Trieste. One of the goals was to impart to young scientists the

technology and potential of pulsed neutron sources in materials science, and to make them aware of the complementary nature of the various accelerator generated probes.

At an Agency symposium on the utilization of accelerators, scientists from developing countries were brought together to acquire and share knowledge across a broad spectrum of research interests, from basic and applied nuclear physics research to analytical applications, to radiation processing, and to accelerator driven systems. The increasing use of accelerators for material characterization and modification and multi-disciplinary efforts of several accelerator centres were notable features of the papers discussed at this symposium.

To enhance the exchange of information and knowledge, the Agency organized thematic technical meetings during the year. Experts on applications that utilize accelerator based technologies and techniques were brought together to present the latest results and innovations. The need to promote and foster networks of accelerator facilities was highlighted with the aim of enabling Member States to increase their participation in accelerator based science and technology. Areas identified included high energy accelerators for the production of special radioisotopes and accelerator driven neutron source facilities.

An example of regional collaboration was the Agency assistance in 2005 through its technical cooperation programme to Nigeria in establishing an accelerator facility at the Centre of Energy Research and Development in Ile-Ife. The facility will be used for research and training and for the promotion of nuclear science and technology in various key areas such as health, agriculture, environment, mineral development and oil production.

Collaboration with research institutions in Austria, Croatia, Germany and South Africa resulted in the development of a new portable X ray fluorescence instrument and a micro-beam X ray scanning spectrometer, as well as new methodologies and applications of X ray micro-fluorescence and micro-tomography based on synchrotron sources. These instruments are intended to support research in environmental pollution monitoring, the study of cultural heritage objects, entomology and human health.

Thirteen fellows received training in methodology and applications of X ray spectrometry at the Agency's Laboratories, Seibersdorf. Four regional training courses on applications of nuclear analytical

techniques for air pollution monitoring and the study of cultural heritage objects were organized in Member States under various technical cooperation projects.

Member States require suitable software for accelerator based nuclear analytical techniques and for ensuring the accuracy of the outputs. An intercomparison and validation exercise of all available software was completed, establishing that the underlying system was sound and capable of producing reliable and accurate results. In this connection, an updated database of accelerator based analytical techniques (<http://www-naweb.iaea.org/napc/physics/AccelSurv/index.html>) was developed and distributed to Member States.

Nuclear Instrumentation

Nuclear instrumentation is indispensable for the development and application of nuclear techniques. In 2005, a number of national and regional activities were completed to improve the capacity of laboratories in developing countries to utilize, maintain and repair nuclear instruments. A CRP on the development of harmonized quality assurance and quality control procedures for the maintenance and repair of nuclear instruments was initiated to build and strengthen capacity in developing Member States.

New instruments continue to enter the marketplace, making older instruments obsolete and unserviceable in a relatively short time. Member States and their technical work force need to keep abreast of these changes. To support them, interactive distance learning modules and training tools for nuclear instrument maintenance were developed and made available through regional training courses. In particular, more than 250 training kits for nuclear instrumentation were distributed to fellows trained at the Agency's Laboratories, Seibersdorf, and in Member States. Training efforts included instruction to 20 fellows in nuclear instrumentation, and two regional and two national training courses in nuclear instrumentation under various technical cooperation projects.

Nuclear Fusion Research

A major step forward in the path to the future use of fusion energy was taken on 28 June 2005 with the signing of a joint declaration of all parties to the



FIG. 2. Signing of the ITER declaration in June.

International Thermonuclear Experimental Reactor (ITER) (Fig. 2).¹ The partners agreed on future arrangements and on the construction of ITER at Cadarache, in France.

Agency activities in the area of nuclear fusion focus on promoting international collaboration and facilitating the exchange of information. In this regard, 11 technical meetings were held on plasma physics and fusion research. Altogether, 735 scientists from some 40 countries and international organizations participated in these meetings. The

¹ The ITER partners are China, the European Union and Switzerland (represented by Euratom), India, Japan, the Republic of Korea, the Russian Federation, and the United States of America.

proceedings have either been published by the Agency or have been submitted to international journals. A course on plasma physics was conducted at the Abdus Salam ICTP to review the experimental observations and theoretical descriptions of plasma instabilities.

The tokamak is the main device used to demonstrate the phenomenon of nuclear fusion. As part of a CRP on research using small tokamaks, the Agency – through the Abdus Salam ICTP – helped to coordinate a plasma physics experiment at the Institute of Plasma Physics, in Prague. Involving 25 scientists from 10 States, the objective was to promote a networking culture within the small tokamak community, thereby enhancing their contribution to mainstream fusion research. ■