JRC Information Events in Bulgaria

Information Event with Researchers in Sofia

Sofia, 19 April 2005, Sofia University St. Kliment Ohridski

INRNE – JRC Conference – Informational Days,

Sofia, 19-22 February 2003, Hotel Moscow, Kiev conf. room

Nuclear Science for Sustainable Environment and Security

JRC and INRNE Joint Activities

Recent Results

Excellence, Sustainability, Integration

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Contents

Editorial

The collaboration between INRNE and JRC institutes started in 1993 and was essentially developed and improved after the NUSES FP5 project (INRNE – JRC Conference – Informational Days "Nuclear Science for Sustainable Environment and Security") event in 2003 in Sofia, aiming the further integration between JRC and INRNE.

The exchange and implementation of good practices, advanced technologies and reference science by joint projects and cooperative activities are necessary to reach synergetic, diversification and long-term effect.
Moreover after the NUSES event in Sofia the substantial deepening and diversification of the joint JRC – INRNE activities were reached covering regional and global aspects and obtaining the sustainable development.

During the last two years were started successfully: 5 new EURATOM projects,
1 ITU – INRNE project (GAMDETEC), 1 FP6 project (BEOBAL) and several other activities between INRNE, ITU, IRMM, IE and IES.

In this connection we would like to thank one more time the JRC leadership personally the Acting Director General, Dr. Roland Schenkel, Dr.h.c.; the Enlargement Officer Dr. Jiri Burianek; Dr. Giancarlo Caratti, Head of Unit, Enlargement and Associated Initiatives; Dr. Pierre Frigola, JRC, Directorate General and many colleagues from different JRC institutes as: Dr. Maria Betti, Dr. Klaus Lützenkirchen, Dr. Peter Rullhuzen, Dr. Philip Taylor, Dr. Uve Wätjen, Dr. Marc de Cort, Dr. Arwyng Jones, Ms. Doris Florian, Mr. Victor Esteban Gran, etc.

Taking into account the obtained results, we strongly believe in the future development and success of the JRC – INRNE joint activities in the frame of the NUSES work programme.

Sofia, 19 April 2005

Prof. D.Sc. Jordan Stamenov
Director of INRNE
NUSES Co-coordinator
BEOBAL Coordinator

Assist. Prof. Dr. Boyko Vachev
Head of INRNE Department of European projects
NUSES Co-coordinator
BEOBAL Sub coordinator

Top quality neutron data for new concepts in nuclear technology

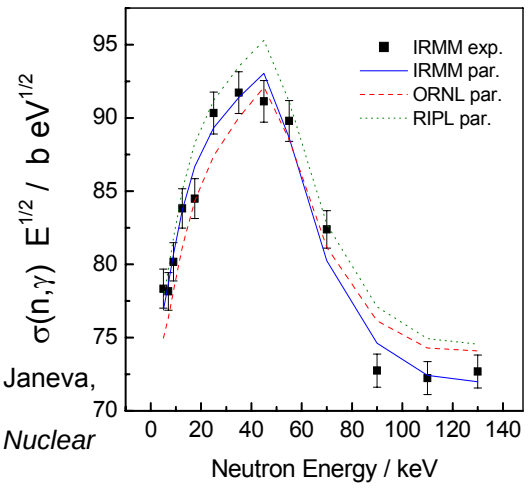
The JRC has an active program in the measurement for basic neutron data, data for application in nuclear safety, advanced fuel cycles and waste management strategies like transmutation, accelerator driven systems and the possible use of Thorium fuel cycle. The Neutron Data Laboratory of INRNE is developing collaboration with IRMM-JRC Institute that is a major contributor of neutron data, important for various sciences (physics, medicine, astrophysics, etc.) and technology.

The neutron cross sections investigations

The thorium-uranium fuel cycle is very appealing because the natural resources of thorium considerably exceed those of uranium and because this cycle limits the build-up of highly radioactive trans-uranium nuclides. Accelerator – Driven - Systems (ADS), based on the Th – U fuel cycle, are also studied to incinerate the waste of the first generation of nuclear power plants. Recently, the need of improved nuclear data initiated a Coordinated Research Project (CRP) "Evaluated Nuclear Data for the Th-U Fuel Cycle" organized by the International Nuclear Data Committee (INDC) of the IAEA in Vienna.

To improve the total and capture cross section data for ^{232}Th, in both the Resolved (RRR) and Unresolved Resonance Regions (URR), high-resolution total and capture cross-section measurements were performed at GELINA at different flight paths. One of the major effects which may cause erroneous measurement results are capture events which were caused by neutron scattering in the sample. These corrections of measured neutron capture yield have been done on an evaluation of different approaches: analytical expressions and Monte Carlo simulations. The uncertainty of the measured neutron capture yield due to these effects is less than 1% between 4 keV and 140 keV.

Using the statistical models, implemented in the codes SAMMY/FITACS and HARFOR the average resonance parameters for ^{232}Th in the URR have been derived. The obtained evaluated average resonance parameters are consistent with the resolved resonance parameters from RRR. The calculated total cross section with the evaluated average resonance parameters have been used for determination of the Optical Model parameters. Also the self-shielding factors calculated with the pre-processing code NJOY and the code HARFOR have been compared.



Janeva, N. Koyumdjieva, N. Lukyanov, A.A. Lukyanov, Determination of the ^{232}Th(n,γ) Cross Section from 4 to 140 keV at GELINA, *Nuclear Science and Engineering*.

Neutron activation cross section measurements

During 2004 both Institute for Nuclear Research and Nuclear Energy and Institute of Experimental Physics have participated in the subgroupe 19 of the Working Party on international Evaluation Co-operation of the NEA Nuclear Science Committee.

Accurate knowledge of neutron-induced activation cross sections is of interest to many fields of nuclear science. These cross sections are of interest in estimating radiation levels and decay heat of materials that have been exposed to radiation fields with strong neutron component. Other prominent direct applications concern reactor, environmental and space dosimetry, material analysis and isotope production.

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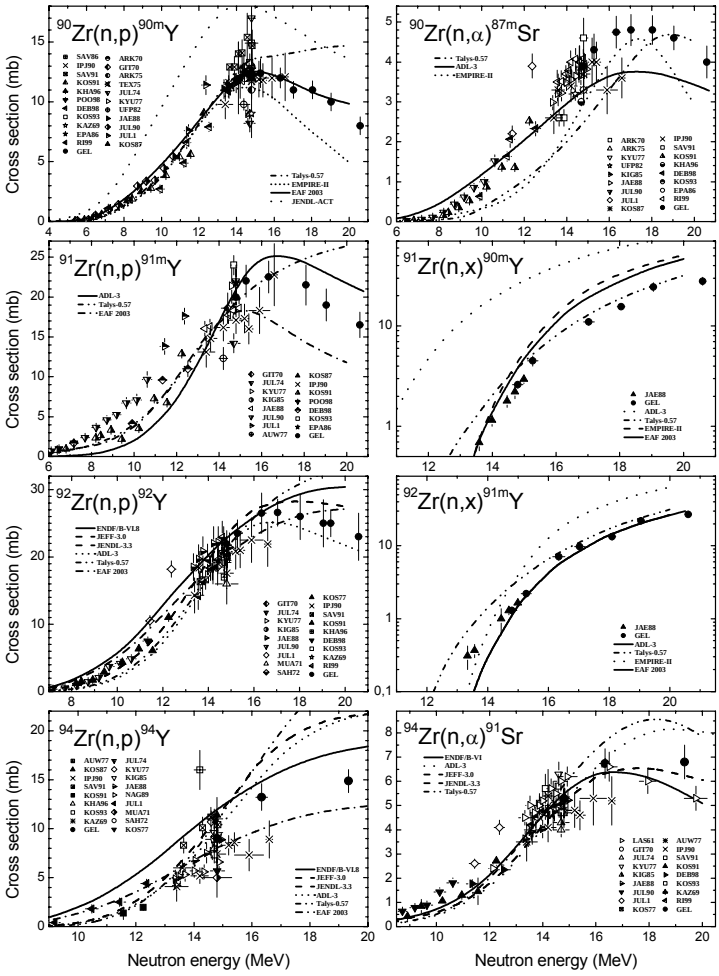
NUSIS 2 Years later
FP5 Project

A new set of activation cross sections has been measured by the members of the Subgroupe 19 for the incident neutron energy from the threshold to 20 MeV. The emphasis is on mass regions of Si to Zn (structural materials), and Pb (moderator/coolant shielding material). The measured data have been compared with the data from Evaluated Nuclear Data Files (ENDF/B-VI, JEFF-3.0, JENDL-3.3, EAF2003, IRDF) and nuclear model calculations.



A.J.M. Plompen, P. Reimer, A. Fessler, D.L. Smith, V. Semkova, S.M. Qaim, A.J. Koning, M. Baba, K. Shibata, P. Oblozinsky, M. Herman, M. Avrigeanu, V. Avrigeanu, G. Csikai, F. Cserpak, R. Doczi, S. Sudar, R. Forrest, J. Kopecky, R. Capote-Noy, Neutron Activation Cross Section Measurements for the Validation of Nuclear Models and their Parameters, NEA/WPEC-XX, Nuclear Energy Agency, Organisation for Economic Co-operation and Development, in press

Bulgarian scientists in IRMM-JRC, Neutron Physics Unit, 2004 – 2005

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Ivan Sirakov – national expert
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$^{10}B(n,\alpha)$ standard reaction

$^{10}B(n,\alpha_0)/^{10}B(n,\alpha_i\gamma)$ branching ratio and angular distribution of the α-emission up to 2MeV

Most of the neutron cross-section measurements are made relative to so called neutron cross- section standards. That is why it is of utmost importance to have a reliable and up-to-date standards cross-section library.
The new IAEA Coordinated Research Project (CRP) [1] on the improvement of the neutron cross-section standards database has been started in 2002. The CRP's aim is to produce a new standards file and to investigate the problems e.g. the available ^{10}B experimental data (cross-sections and branching ratios) caused in the R-matrix model fits in the last evaluation.
Meanwhile, significant improvement has been made for the $^{10}B(n,\alpha)$ standard reaction. But, the most recent investigations of the branching ratio by Weston and Todd [2] showed quite some deviation of up to 30% to the ENDF/B-VI standards evaluation in the incident neutron energy range from 100 to 600keV.

IRMM has been asked by the standards subgroup of the Working Party of Evaluation Cooperation (WPEC) of the NEA/OECD to perform similar measurements of the branching ratio as a function of incident neutron energy up to 1MeV.
The first experiment (at a GELINA flight-path L~30m) has been finalized and accomplished by another measurement of the branching ratio at L~60m **[3]**.

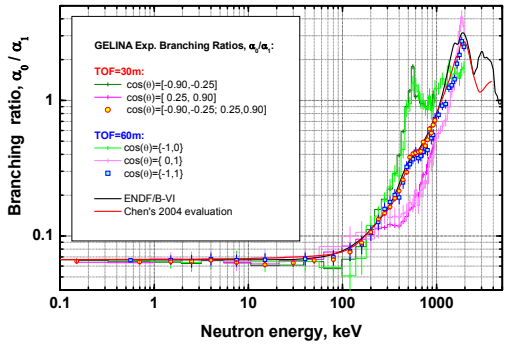

Fig.1 Branching ratios (forward, backward and total) as a function of the incident neutron energy obtained from the two measurements at L ~30m and L ~ 60m.

In **Fig.1** the branching ratios of both runs are shown (by the symbols) up to 2MeV. The histograms with error bars show the forward and backward hemisphere branching ratios. It is seen that the branching ratio values show very different behavior for both hemisphere from ~200keV onwards. The evaluated data from ENDF/B-VI are given as the thick black line and a new evaluation made by Chen Zhenpeng **[4],** in the frame of the IAEA CRP, by the thinner red line. The two evaluations differ from about 1.1MeV onwards and the new evaluation follows the branching ratios determined in this work from about 1MeV onwards.
In **Fig. 2** the comparison is made to the data of Ref.**[2]**. Above ~ 80keV the data of Weston and Todd [2] deviate from the present results and only around 1MeV within the error bars both dataset overlap again.

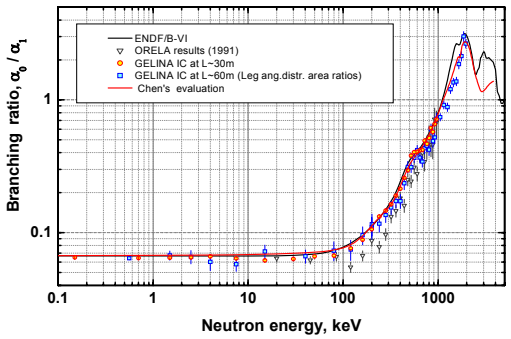

Fig. 2 Comparison of the results from the branching ratio measurements with the data of Weston and Todd [2].

It is presently not clear why the data of Ref. **[2]** are lower, but it might be due to the fact, that the statistics in these measurements was rather poor and the analysis was done only based on the full energy information and did not take into account any angular information as in the present work..

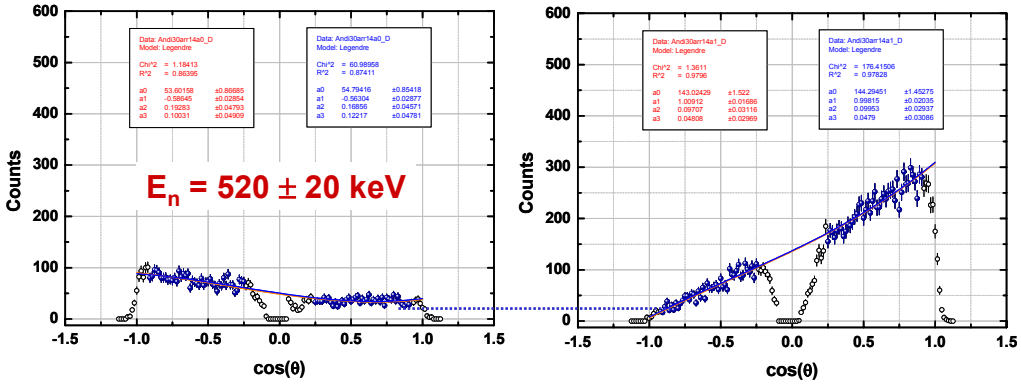

Fig. 3 Angular distribution for E_n ~ 520keV. *Left part*: for the ground state transition and *right part*: for the first excited state transition. The lines represent different Legendre polynomial fits.

Fig. 3 shows the angular distribution at E_n~520keV for both forward and backward hemispheres. The angular distribution shows a strong anisotropy both for the alpha branch to the ground state (left part of **Fig. 3**) and to the first excited state (right part of **Fig. 3**). This anisotropy has even an opposite behavior for the ground state transition (higher yields at backward angles) compared to the first excited state transition (higher yield at forward angles). The different lines in the figure reveal Legendre polynomial fits to the experimental data to be able to cover also the range of cos(θ) values which we were unable to measure (angles close to the sample region). The branching ratios were calculated for several scenarios, namely only using the experimental points with the cos(θ) range from [-0.9, -0.25, 0,25, 0.9] and compared to the results from the Lengendre fit, which covered the full cos(θ) range.

In order to improve the accuracy for the data above 1MeV and to obtain the reaction cross-section, new measurements with a modified ionization chamber are under preparation.

This way it will be possible to obtain all the important data characterizing the disintegration of ^{10}B by neutrons with energies from thermal up to 2.5-3MeV.

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[1]http://www.iaea.org/programmes/ripc/nd/crps/standcrosect_of_lightelem.htm
[2] L. W. Weston and J. H. Todd, Nucl. Sci. Eng. **109**, (1991) 113.
[3] F.-J. Hambsch, H. Bax, NP. Sci. Report 2001, EUR 20412 EN, ISBN 92-894-4152-6 (2002) 64.
[4] Chen Zhenpeng, Private communication, 2004.

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Neutron Techniques Standardization for Structural Integrity
NET SAFELIFE project

The INRNE is a partner in the European Network on Neutron Techniques Standardization for Structural Integrity (NET), which is operated by JRC – IE in Petten. The main objective of the NET European Network is performance and safety enhancement of European Nuclear Power production by supporting the structural integrity and the safe operation of ageing reactors. The Network aims at the development and standardization of novel experimental (e.g., neutron diffraction, Small Angle Neutron Scattering) techniques and advanced numerical modelling methods for the investigation of residual stress and defects in welded structural components. NET supports CEN & ISO standardization activities, interacts with other nuclear Networks under the JRC-IE institutional project SAFELIFE, and supports NET related competitive activities concerning investigations of materials ageing, structural integrity and NDE for welded RPV internals and primary piping joints.

These methods include Neutron Diffraction measurements and predicative Finite Element Modelling (including real-time distribution and post-welding state) of stresses in materials used in the power installations. Among the others experimental methods Small Angle Neutron Scattering is developed as very prospective for study of microstructure changes and evolution of defects caused by various heat/mechanical - treatments.

During the past period INRNE specialists - Kiril Krezhov and Pavlin Groudev took participation in NET workshops in Warsaw (7-8 June 2004), Polland and Petten (1-2 December 2004), Holland. Further, a young scientist – Dimitar Neov was enlisted to work on post-doctoral grant in the Neutron methods group in IE. His work in this group comprises investigations of internal residual stress distribution in pre- and post-heat treated welds (including multi-pass, repair welds) and pipes by neutron diffraction as a non-destructive tool for stress evaluation. The group activities include also non-destructive measurements of stress state in radioactive specimens like sections of nuclear power plant subjected to heavy irradiation.

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REDOS
Reactor Dosimetry: Accurate Determination and Benchmarking of Radiation Field Parameters, Relevant for Reactors Pressure Vessel Monitoring

RPV benchmarks were developed on the base of Mock-ups created on the critical assembly LR0, INR (Rez, Czech Republic). They simulated the irradiation conditions of VVER-440 and VVER-1000 (Fig.1) vessels and were used for validation and improving the methodology for RPV neutron fluence evaluation.(**REDOS FP5 EURATOM project**).

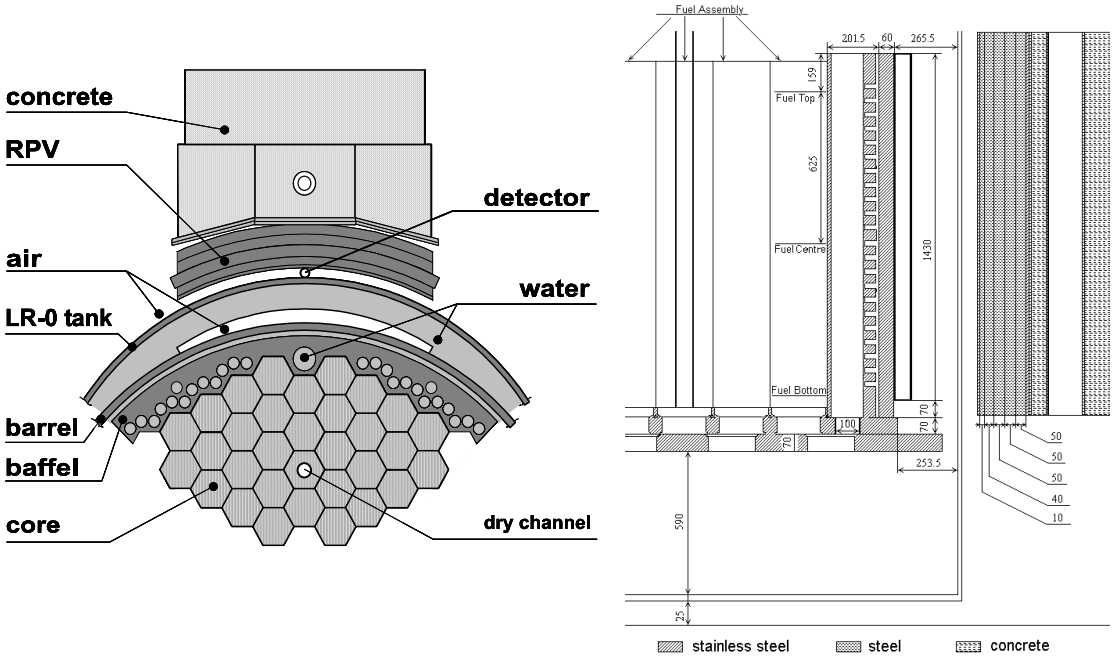

Fig. 1 VVER-1000 Mock-up

The main conclusions of REDOS project are:

- A good consistency between the experimental and calculational results was demonstrated. All calculational methods applied by the participants are applicable for neutron fluence evaluation.
- The created VVER-440 and VVER-1000 benchmarks could be used in licensing process as well as for education and training of young specialists.
- The sources of uncertainties in neutron fluence and RPV lifetime determination were estimated.
- The application of ex-vessel (behind the RPV) activation detectors for verification/validation of NPP neutron fluence calculation has been approved
- The neutron and gamma fluxes' calculation by MCNP code was revised, benchmarked, and verified.

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SARNET NoE
Network of Excellence
for a Sustainable Integration
of European Research
on Severe Accident Phenomenology

SARNET is constituted by most of the research capacities and expertise in severe accident from 49 organizations, coming from 16 Member States, 2 Candidate Countries and from Switzerland, plus the JRC of the EC.

Objectives

Since April 2004, 49 organisations are networking in **SARNET** their capacities of research in order to resolve the most important remaining uncertainties and safety issues for enhancing, in regard of Severe Accidents (SA), the safety of existing and future Nuclear Power Plants (NPPs) towards:

- to optimise the use of the available means and to constitute sustainable research groups. SARNET tackles the fragmentation that exists between the different R&D national programmes, notably in defining common research programmes and developing common computer tools and methodologies for safety assessment.
- the critical mass of competence for performing experiments needed in the SA domain, analysing them, developing models and integrating them into ASTEC (integral computer code used to predict the NPP behaviour during a postulated SA) is achieved for most types of NPPs in Europe.

To reach these objectives, all the organizations networked in SARNET contribute to a joint programme of activities, which can be broken in several elements:

- Implementing an advanced communication tool for fostering exchange of information;
- Harmonizing and re-orienting the research programmes, and defining commonly new ones;
- Analysing commonly the experimental results provided by research programmes in order to elaborate a common understanding of concerned phenomena;
- Developing ASTEC, which capitalizes in terms of models the knowledge produced within SARNET;
- Developing Scientific Databases, in which all the results of research programmes are stored;
- Developing a common methodology for Probabilistic Safety Assessment (PSA) of NNPs;
- Developing educational courses and text (source) books;
- Promoting personnel mobility between the various European organisations.

SARNET provides an appropriate frame for achieving within a couple of years a sustainable integration of the European research capacities on SA. By capitalizing the acquired knowledge in ASTEC and in Scientific Databases, SARNET produces necessary conditions for preserving the knowledge produced by thousands of men-years and diffusing it to a large number of end-users. By fostering collaborative work on developing and validating ASTEC, SARNET makes this code as the European reference for any kind of water-cooled NPP existing in Europe. By fostering collaborative work in the domain of code development and

PSA, SARNET creates the necessary conditions for harmonizing the approaches and making Europe a leader in SA computer code and risk assessment methodology. Through a periodic review of priorities and co-programming of work amongst organisations, SARNET allows a more efficient use of available means and budget. Through an education and training programme addressing young scientists, SARNET consolidates on the long term the European excellence in the SA domain.

A preliminary analysis of ASTEC capabilities for application to VVER 1000 reactor type has started in INRNE in close collaboration with our partners for VVER reactors and IRSN. Validation progress was good. The ASTEC analyses are compared to MELCOR analyses performed by INRNE specialists. The results received by INRNE using ASDTEC and MELCOR codes for analysing SBLOCA have been reported during the 1st ASTEC Users' Club, held in Köln from 21 to 24 February 2005.

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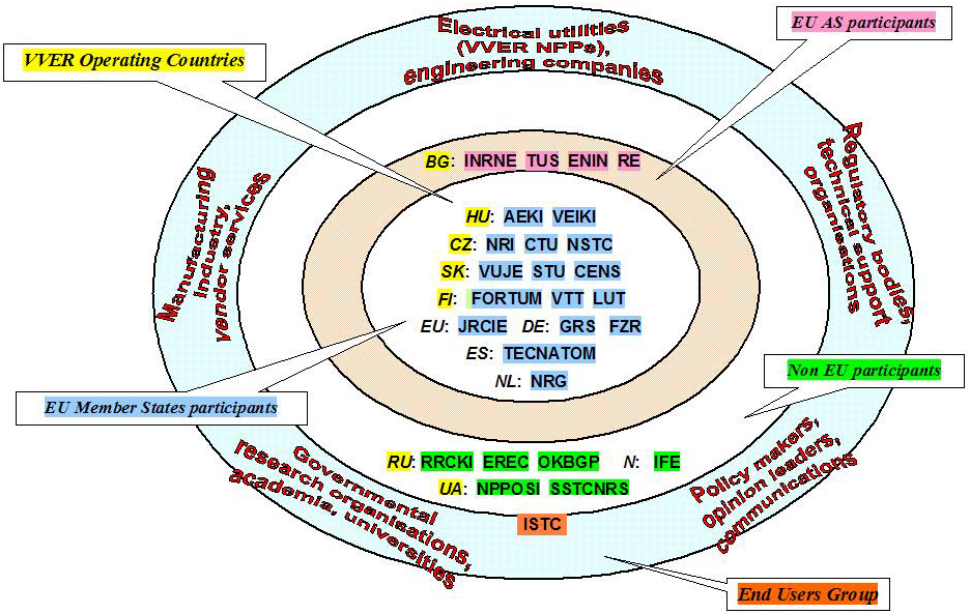
COVERS
Coordination Action "VVER Safety Research"

The objective of the **COVERS** EURATOM FP6 project is to improve professional and communication environment important for ensuring a continuing safe and efficient operation of nuclear power plants with VVER-440 and VVER-1000 reactors.

Co-ordination activities will cover such important areas as Operational Safety, Factors of Materials and Equipment Ageing, Information and Knowledge Management so that the shared information will contribute also to the enhancement of NPPs operational efficiency.

A consortium of organisations, which have many years of experience with the nuclear power plants of VVER type operational safety evaluation and assurance, as well as with their material specifics, is established as a tool for fulfilling COVERS project objectives.

Effective experience and information exchange between the participating organisations and end users will be based on the appropriate communication tools. Significant attention will be paid to such issue as the integration of obtained resulting information with that accumulated in the countries outside of the EU operating VVER reactors. The viable organisation form of the RTD structure shall enable the synergic utilisation of parallel activities in the research and industrial applications even after the project will be finalised.



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NUSIM 2 Years later FP5 Project

Licensing Fuel in Bulgaria
Research and Development

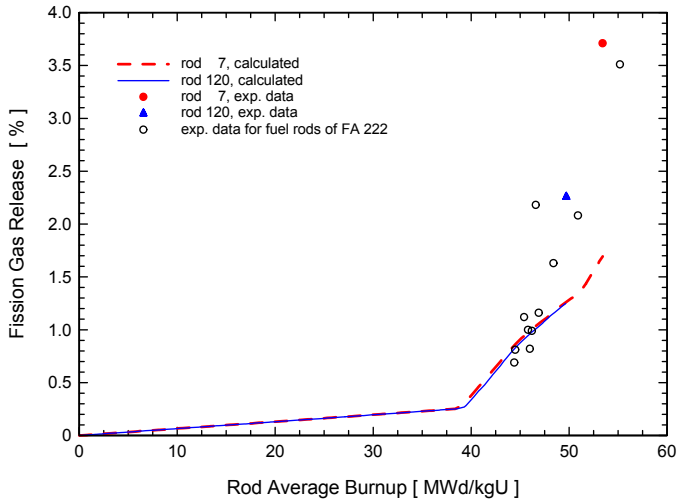
The goal of this study, is to prove the applicability of the TRANSURANUS-VVER version code to the safety analyses, performed at the NPP-Kozloduy. This work is a continuation of an existing collaboration between ITU – Karlsruhe, Germany and, manifested, up to now, in three projects – FERONIA PHARE project (1996 – 1998), bilateral ITU – INRNE project, 1999 and a four-country collaboration comprising research institutes from Germany (EC ITU – Karlsruhe), Bulgaria (INRNE – Sofia), Hungary (AEKI/KFKI – Budapest) and Slovakia (VUJE – Trnava) – project PECO–1, 2001 – 2002.

- **Institute for Nuclear Research and Nuclear Energy;**
- **Nuclear Regulatory Agency;**
- **Nuclear Power Pland "Kozloduy";**
- **Physics Department of the Sofia University;**
- **Technical University of Sofia.**

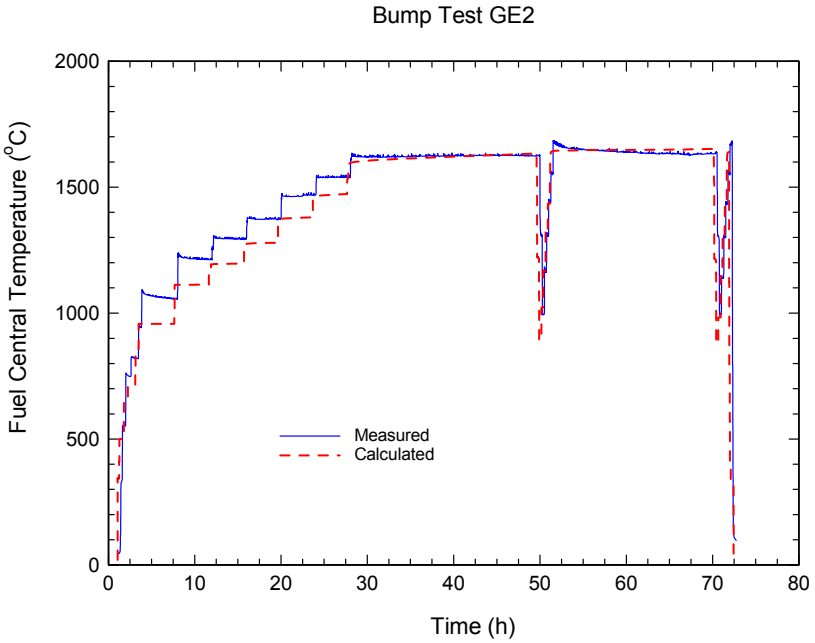
The licensing procedure of commercial nuclear fuel requires utilisation of sophisticated and reliable codes to predict the fuel rod behaviour. The TRANSURANUS code, developed at the ITU of the Joint Research Centre of the European Commission, proved to be promising for assessing the fuel performance in VVER's operated in the East European countries.
The present project aims at helping Bulgaria in reforming activities related to the nuclear fuel cycle in the country. More precisely, the goal is to assist Bulgaria in improving a fuel licensing process in line with European standards. Essential in this process are fuel performance codes used for assessing the behaviour of nuclear fuel rods both during operation in the reactor as well as for the interim storage of spent fuel elements.
The main objects of interest were:

- fission gas release (FGR);
- geometrical changes of the fuel;
- internal pin pressure;
- fuel–to–cladding gap, etc.

Some results from the modelling these fuel parameters by the TRANSURANUS are shown in the figures below:



Calculated FGR for Russian VVER–440 fuel - comparison with experimental data



Calculated by TRANSURANUS temperature of the fuel in the centre of the fuel rod, for Western type of PWR fuel.

Expected scientific results

Two types of resuts are planned as main achievements of the contract:

- verification of the TRANSURANUS-VVER v1m2j03 version against the IFPE-OECD/NEA-IAEA Data base. It can be shown, that the code prediction for most fuel behaviour parameters coincide with the experimental data within ± 5 %, which has to be estimated as an excellent achievement of the code;
- the TRANSURANUS Verification Data Base (TUVDB) for data storage of a given verification procedure will be enlarged with data for both Russian (VVER–440 and VVER–1000) and Western type of fuel;

On this basis, projects like the reported here, are important for further development of the collaboration in this area, for studying fuel behaviour, especially in the field of:

- Fuel behaviour modelling as a part of reactor material research;
- Fuel performance modelling as a component of fuel design;
- Fuel modelling as a component of commercial fuel licensing;
- Fuel modelling for NPP's operational needs and decision making;
- Training of research and operational NPP staff for fuel licensing by using TRANSURANUS code.

Moreover, recently, Bulgarian side declared, on behalf of the Nuclear Regulatory Agency, the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences and the Nuclear Power Plant "Kozloduy", that the results, obtained in the frames of such projects, serve the national needs in the field of the radiation safety, safe operation of the NPP and the reactor physics science.

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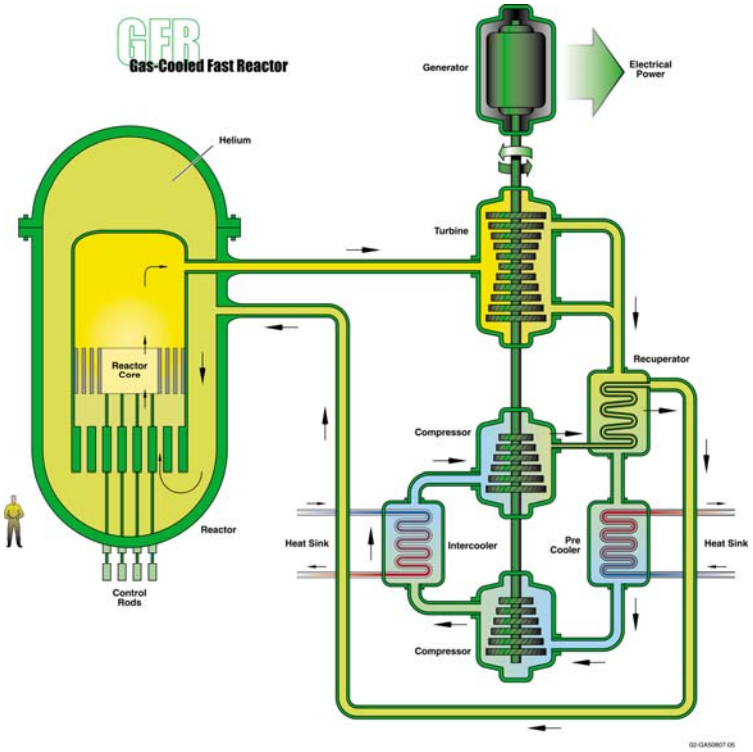
Generation IV
Future Nuclear Energy Systems

Generation IV is an international initiative aimed at developing nuclear energy systems that can supply future worldwide need for electricity, hydrogen and other energy products. These systems are to be deployable no later than 2030, for providing competitively priced energy products while satisfactorily addressing nuclear safety, waste, proliferation, and physical protection concerns. To enable nuclear energy to fulfill an expanded worldwide role, many countries have been cooperating within the framework of the Generation IV International Forum to advance this new generation of nuclear energy systems.

The Reactor Physics Laboratory at INRNE has taken initial steps in seeking opportunities for joining the Generation IV international initiative. First contacts with the correspondent European experts in this direction were obtained last year by Prof. J. Stamenov. Following this idea representatives of the Reactor Physics Laboratory have recently gained relevant knowledge through participation in international meetings, including a Summer School on Generation IV Reactors, Fuels and Fuel Cycles, held in Cadarache, France, and an International Workshop on Nuclear Data Needs for Generation IV Nuclear Energy Systems, held in Antwerp, Belgium. The experience gained by the Reactor Physics Laboratory in the research of materials, processes and parameters of currently operating nuclear systems, under international cooperation with the Atomic Energy Research as well as with institutes from Russia, France, etc., can be used in collaborative efforts on the viability and performance demonstration of the Generation IV systems.



The Reactor Physics Laboratory is mainly interested in collaborations aimed at advancing the Gas-Cooled Fast Reactor (GFR) system. This system employs helium gas as coolant and features a fast neutron spectrum core and closed fuel cycle. The GFR is primarily envisioned for missions in electricity production and actinide management, although it may be able to economically support hydrogen production. The Reactor Physics Laboratory recognizes the importance of establishing international collaborations with partner research centers in the European Union in order to effectively participate in the research and development of the Generation IV systems.

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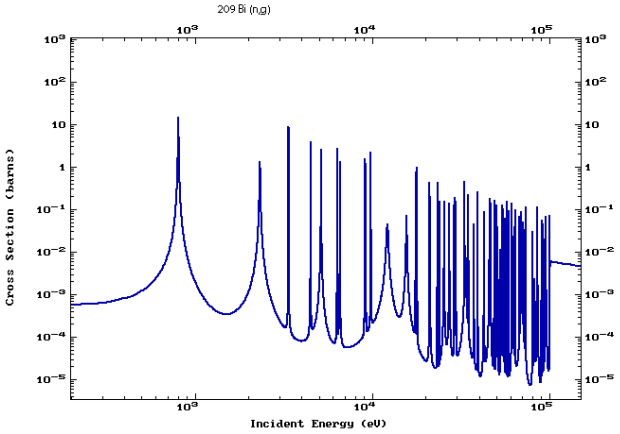
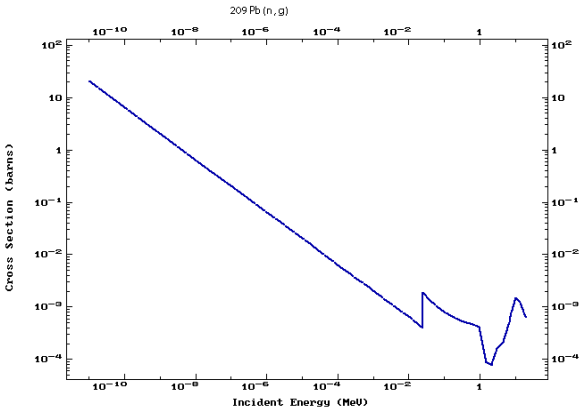
IP EUROTRANS

European Research Programme for Transmutation of High Level Nuclear Waste in Accelerator driven System

The large reduction of long term radioactivity and radiotoxicity of spent fuel and high level nuclear waste can contribute for the future of nuclear energy and its acceptance by public that heavily dependent on a solution for the safe disposal of the nuclear waste and the operation of final geological repositories. In this context, the strategy - transmutation of the high-level nuclear wastes is of foremost priority. The strategic objective of research in this area is to work towards a European Transmutation Demonstration (ETD) in a step-wise manner. The aim of this 4-year FP6 project EUROTRANS (total budget of 42.3 M€, including 23 M€ of EC contribution) is to carry out a first advanced design of an approximately 50 to 100 MWth experimental facility (realisation in a short-term, say about 10 years) demonstrating the technical feasibility of Transmutation in an Accelerator Driven System (XT-ADS), as well as to accomplish a generic conceptual design (several 100 MWth) of a modular European Facility for Industrial Transmutation (EFIT) (realisation in the long-term).

The scientists from INRNE of Bulgarian Academy of Sciences as participant No 20 will take part in Domain5 NUDATRA. The objective is the improvement of the simulation tools for ADS transmuters and its associated advanced fuels. This includes improving the evaluated nuclear data libraries and reaction models for materials in transmutation fuels, coolants, spallation targets, internal structures and reactor and accelerator shielding. The neutron cross section of minor actinides, lead, bismuth will be studied for the needs of the design. On the figures the neutron radiative capture cross section for ^{209}Bi and ^{206}Pb is presented. The data are taken from ENDF/B-6 data library. Two students from Sofia University are working on their graduation thesis about accelerator driven systems and nuclear data needed for those. One of the students Boyan Rossmanov started his work with nuclear data libraries preparing these figures.





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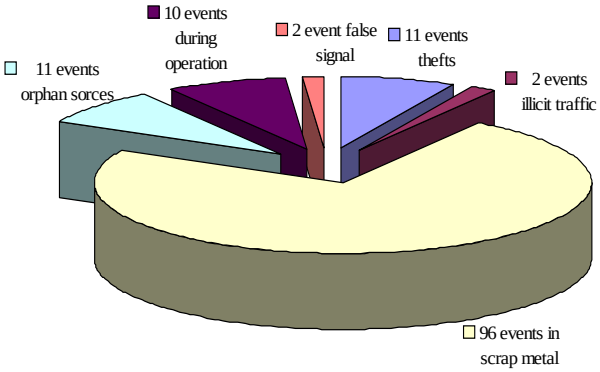
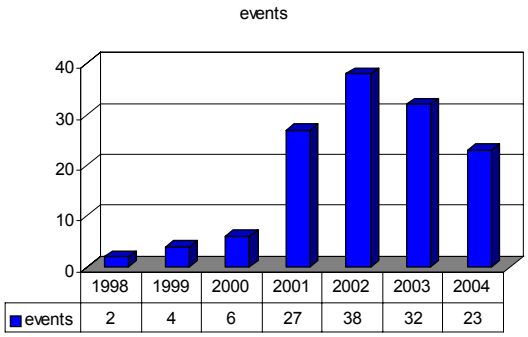
NUSES 2 Years later FP6 Project

GAMDETEC
Combating Illicit Trafficking of Nuclear Materials

The European Commision has taken a decision for cooperation between the European states for combating illicit traffic of nuclear materials and aplication of mutual efforts by the police, cistoms, law-inforcement etc. authorities of the countries that are subjected to such traffic. Terrorists may also attempt to acquire radioactive materials.

The Bulgarian Nuclear Regulatory Agency (BNRA) is the regulatory authority of works in co-operation with the other state structures - Ministry of Health, Ministry of Environment and Water, Ministry of Finance (Customs), Ministry of Transport and Communications, Ministry of Agriculture and Forestry and law enforcement organisations as Ministry of Interior, Ministry of Defense etc. BNRA co-operates also with scientific organizations as Bulgarian Academy of Science (BAS) especially with the Institute of Nuclear research and Nuclear Energy (INRNE), Sofia University etc.
The Institute for Nuclear Research and Nuclear Energy - Bulgarian Academy of Science (INRNE-BAS) is the largest Bulgarian scientific institute in the field of nuclear science. It has equipment and qualified personnel for combating illicit traffic of nuclear and radioactive materials in Bulgaria which is a new and important issue and is addressed with greatest concern and highest priority. INRNE has established collaboration with the responsible authorities from the Bulgarian police and customs for analysis of nonfissile nuclear materials of illicit traffic.
The illicit cases are illustrated on the following diagrams:





The **GAMDETEC** INRNE – ITU project objectives

- to further improve the capacities for gamma analysis of nuclear samples in Bulgaria
- to exchange technical experience related to the treatment and analysis of vagabonding materials

The main objective of this project is a transfer of equipment - supply of ORTEC Detective system, with a Stirling-cooled HPGe detector.

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NUSIS 2 years later
FP5 Project

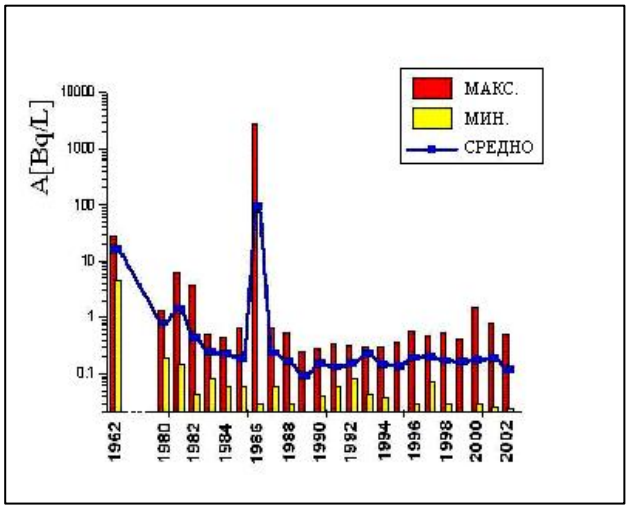
Environmental Radiation Monitoring

JRC Project "Harmonization of techniques and methodologies for sampling and measuring radioactivity in the environment"

The Control Laboratory for Radiation Protection (CLRP) is directly responsible now for the environmental monitoring, but by far this is not the only unit of INRNE involved in this research field. CLRP is involved in the interactions and collaborations in the framework of the BEO Moussala and BEO Centre of Excellence. This permits on specific occasions to mobilize in the field of radiation monitoring considerable human resource, comprising between fifty and sixty specialists and technical staff.

Specific research agenda consists of:

1. Analysis of samples from soil, water, plants, fallout, aerosols, small mammals and fishes etc. - total beta-activity, gamma-spectrometry, determination of ^{90}Sr content, determination of Pu content using radiochemical technique, electrochemical deposition and alpha-spectrometry
2. Gamma-background monitoring by means of thermoluminescent dosimeters (TLD);
3. Development of the technique for measurement of radon in soil gas using TLDs and SSNTDs.
4. Monitoring of the cosmic neutrons at BEO Moussala.

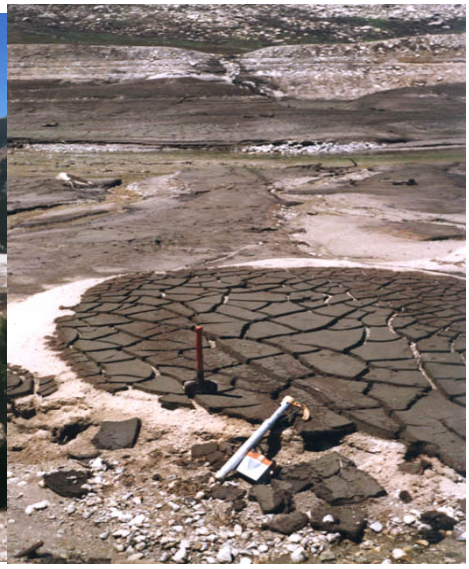


Total beta-activity of wet fallout, INRNE area

A good example is the complex investigation of the pollution in the catching area of "Beli Iskar" dam in collaboration with the Institute of Geography – BAS, IRE – Belgium and NPI, Prague.

The Beli Iskar dam lake – one of the lakes, supplying Sofia with drinking water, is situated at 1900 m altitude in Rila Mountain. The dam was built in the first quarter of the former century. In the summer of 2002 the lake was drained for repair of the barrage. This presented a unique opportunity for a direct access, immediately in situ measurement and sampling of the bottom depositions. Two sampling expeditions were carried out in 2002 and about 150 sediment, water and plant samples were taken. In situ measurements of the radiation background and the chemical characteristics of the affluent water were performed. The laboratory analysis started in 2003 with the total beta determination of all samples. Limited number of sediment samples was analyzed concerning the content of radionuclides (including Pu), heavy metals and toxic elements. The techniques developed and validated in the frame of the JRC Project will permit more comprehensive analysis – more radionuclides - actinides, Sr etc. as well as the activity depth distribution and consequently – dating of the sedimants.

Regarding the responsibilities, mentioned above, a very important stage of the laboratory development started with our integration with the EC JRC activities, joining in 2003 the project "Harmonization of techniques and methodologies for sampling and measuring radioactivity in the environment", 2003-2005.
Participants: ITU, Karlsruhe and laboratories from Hungary, Romania, Bulgaria, Slovenia, Poland, Turkey, Slovakia;

Objectives:

- Organization of inter-laboratories exercises
- Harmonization of procedures for different ecosystems and matrices
- Training on analytical procedures and techniques
- Development of protocols for harmonized procedures for the measurement of radioactivity in different ecosystems
- Creation of a network of Nuclear Environmental Safeguards in Candidate Countries and initiation of an "enlarged" European Research Area for Measurement of Radioactivity in the Environment
- Development of a data base of validated analytical procedures accessible to all Candidate Countries.

During 2003 and 2004 four meetings of experts were carried out in ITU. The problems discussed were connected mainly with harmonization of the sampling procedures. A sampling [illegible] 005.

Sampling of sediments from the bottom of the "Beli Iskar" dam lake

We expect in the frame of the project to validate our procedures for analyzing alpha-emitters and Sr and to get able to perform more sophisticated and "deep" environmental analysis of some areas of particular interest.

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BEO Centre of Excellence

BEO Moussala

HIMONTONET FP5 project

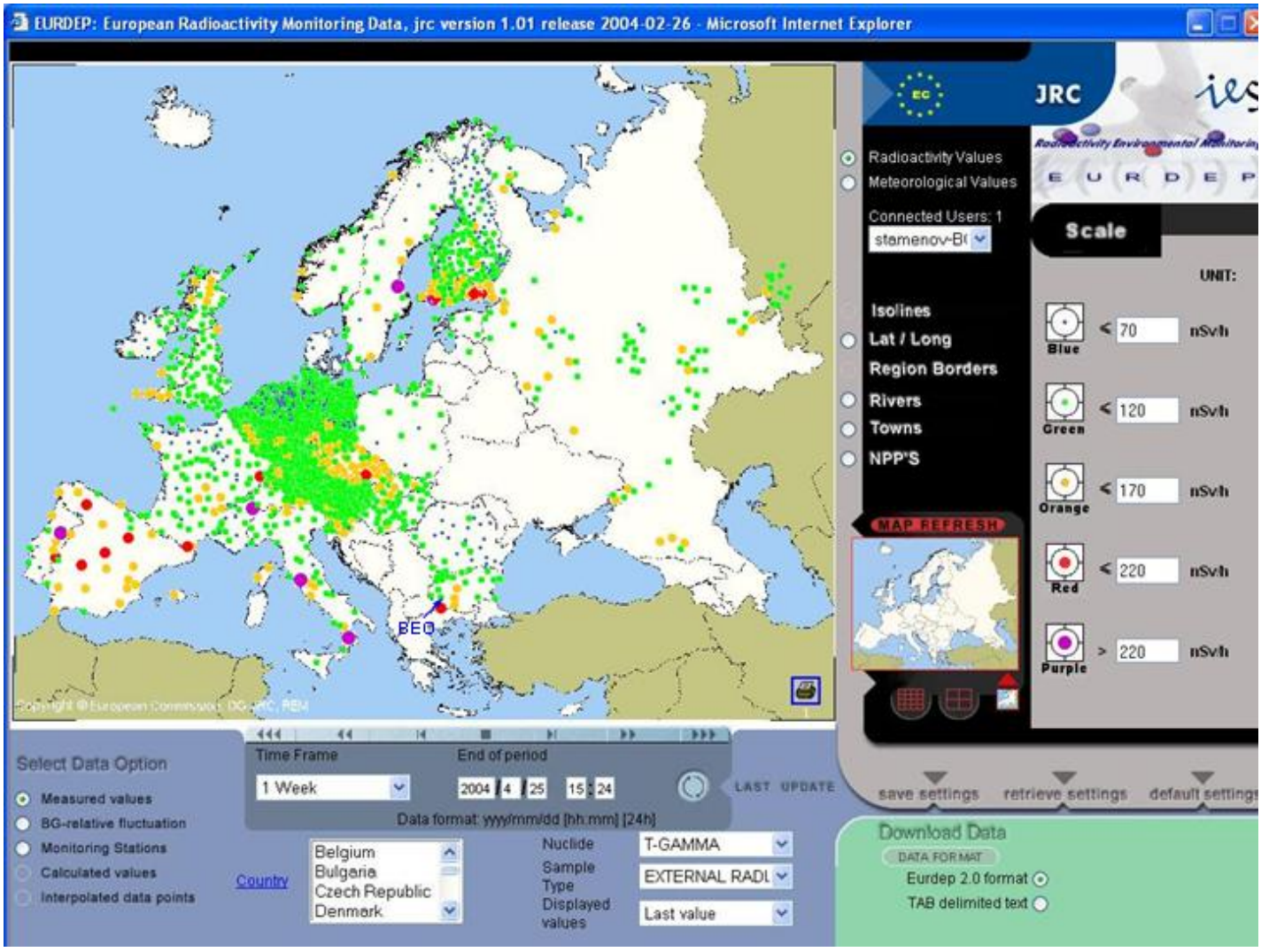
Global Change and Climate Research, Natural Hazards and Technogenic Risks, Aerospace and Terrestrial Environment

European Radioactivity Monitoring
REM - EURDEP

http://www.beo.inrne.bas.bg

http://beo-db.inrne.bas.bg

JRC, IES, Ispra



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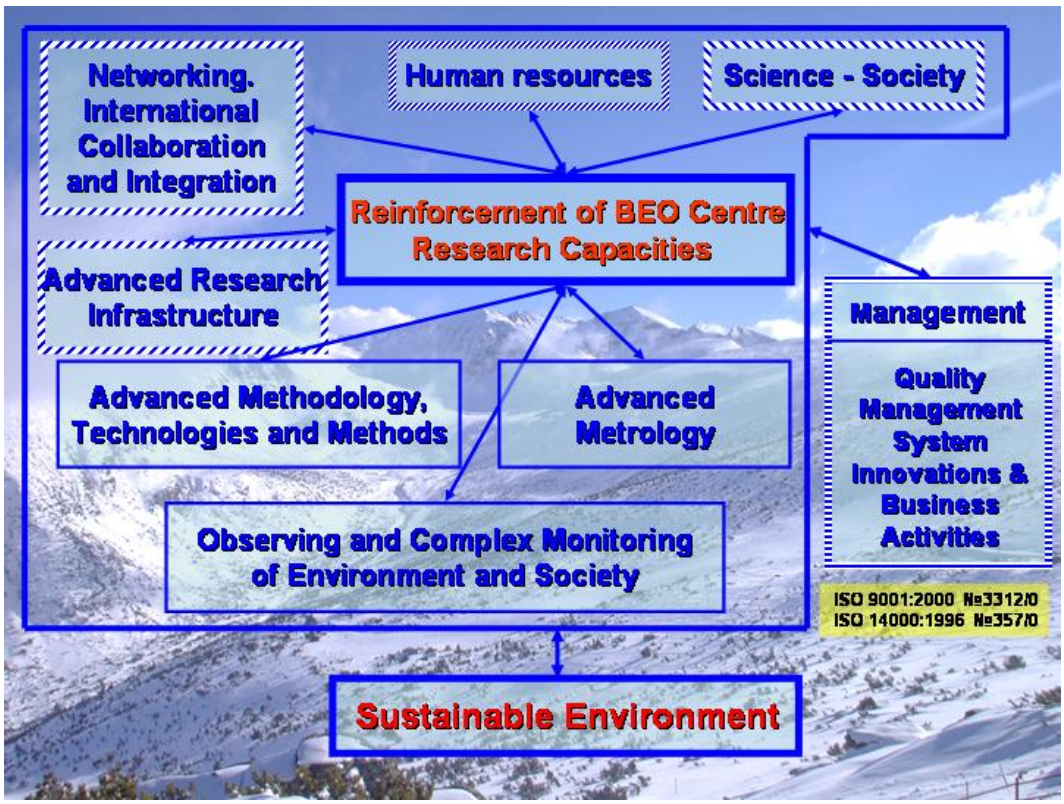
NUSES 2 years later
2 FP5 Project

BEOBAL

BEO Centre of Excellence Research Capacity Improvement for Sustainable Environment and Advanced Integration into ERA

The **BEOBAL FP6 project** is devoted to **Reinforcement of the BEO Centre of Excellence Research Capacities,** and by this way the respective S&T potential of INRNE and Bulgaria for advanced **Sustainable Environment** studies, devoted to the main Global change and ecosystems observing problems, using sophisticated information technologies and advanced **Integration in ERA**, in their institutional, national, regional and European aspects



The main project goal is decomposed in **4 operational goals:**

A. The Networking, International Collaboration & Integration and Reinforced Research Infrastructure contains of:

1. ***Diversification, broadening and enhancement of international collaboration and cooperation*** towards to reach real European integration first of all with big

European and world institutions like JRC, CERN, IAEA, WMO, IIASA, UNESCO with accent on correspondent European centres of excellence, joining European and world importance networks and especially improving the level of the regional collaboration.

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NUSIS
2 Years later
FP5 Project

2. Reinforcement of S&T equipment and systems of BEO CoE directed to ***enhancement of the research infrastructure*** of European importance, connected with: global change observing, ecosystems monitoring, technological and natural risks (study, early detection and control) widely using new information technologies and platforms. The improving of systems for ***observing and complex monitoring*** in attempt to realize adequate management towards to reach sustainable environment. ***Joining of BEO Moussala to WMO/ GAW*** *(Global Atmosphere Watch Programme)* ***as a regional GAW station***, creating and improving by this way South - East European part of this network.

3. All above is directed to ***implementation and development of advanced methodology, technology, methods and advanced metrology*** in the field of Global change and ecosystems and their regional and European projections and components including: impact and mechanisms of greenhouse gas emissions and atmospheric pollutants from all sources on climate, ozone depletion and carbon skins, towards to improve predictions and forecasts; operational forecasting and modeling, global change observing systems; especially environmental radioactivity, monitoring and assessment of technological and natural hazard and risks. All these activities will be performed using advanced information systems and applying the already created in INRNE computer farm (in collaboration with CERN IT division), based on the modern GRID technology, towards to reach adequate solution of all above listed tasks.

B. Improvement of Human Resources ***includes advanced Human Resources long-term management*** reaching and preserving European qualification level and creating the best home for young scientist, additionally attracting young scientist from other countries

C. Advanced Science – Society Interaction policy towards to reach not only dissemination of the obtained research results but to succeed in the active science communication and dialogue with the public organisations, government and NGOs.

D. Application and development of **advanced Management system** directed to a sophisticated and pragmatic complex approach to all above mentioned aspects (objectives A, B, C) management - from Quality and Environment management ISO certified system and a new, active and aggressive business approach to scientific research and applications, to the regional aspects of technology and innovation generation, transfer, implementation and complex use of all available and new financial instruments.

These objectives will be archived by the set of SSA activities in the areas of networking, improvement of human resources, exchange of personnel, visiting fellows for teaching and short training of Ph.D. students and Post Docs, a special programme for hearing young researchers, broad and regular improvement of collaborative activities and joint projects, all in the framework of continuously enhancening and development of INRNE integration with JRC, European high mountain observatories and other leading international institutions and centres of excellence. Several JRC institutes are included with joint activities in BEOBAL project – ITU, IRMM and IES.

The realisation of BEOBAL objectives will contribute the objectives of the sub priority “Global Change and Ecosystems” of 6th thematic priority, ERA development and reinforcement of Bulgaria RTD capacity

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NUSES Work Programme

Main goal: **Integration between JRC and INRNE**

Other aims:

1) to exchange and implement good practices, advanced technologies and reference science by joint projects and other activities towards reaching synergetic multiplication and long-term effects;
2) diversification and deepening the joint JRC – INRNE activities covering regional and global aspects work programme
3) to reach sustainability

The programme results after 2 years:

- **5 new joint EURATOM projects**
- **1 FP6 project – BEOBAL**
- **1 INRNE – ITU project – GAMDETEC**
- **joining Generation IV JRC EURATOM initiative**
- **extremely active personal exchanging and training in JRC institutes ITU, IRMM and IE**
- **very useful results obtaining after Brussels meeting with JRC leadership in Summer 2004**

Good joint practices:

1) leadership coordination meetings
2) development of joint project proposals
3) regular estimation of the work programme progress using express survey questionnaires

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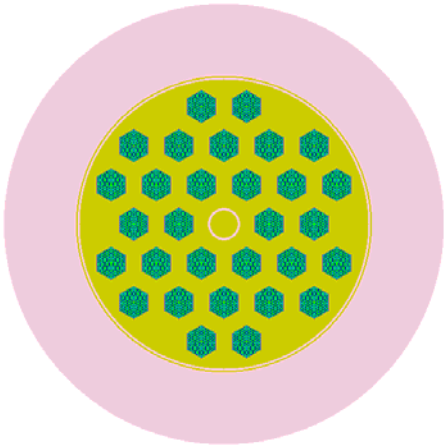
Hot Projects, New Ideas

Safety Analysis for VVER Spent Fuel Facilities

Calculatonal analyses of the spent fuel storage and transportation facilities are needed for substantiation of their nuclear and radiation safety. Continuous improvement of models and calculational methods has been carried out in Reactor Physics Laboratory.
The main analysis tools used are the SCALE system developed by the Computational Physics and Engineering Division at Oak Ridge National Laboratory in the US, the MCNP code developed at Los Alamos National Laboratory in the US.



Radial Model of Transport Cask for 30 VVER-440 Spent Fuel Assemblies

The SCALE system is intended for performing standardized computer analyses for licensing evaluation of nuclear systems and includes a number of selected data libraries, as well as various calculational modules (code's sequences interfaced with data libraries) for performing depletion, criticality, shielding, and heat transfer analyses. The MCNP code is a general purpose particle transport code used worldwide basically for reference calculation.

The parameters, important for safety assurance of NPP Kozloduy spent fuel storage and transportation facilities, have been evaluated on the basis of results calculated by the SCALE modular code system. Criticality safety assessment has been made in compliance with the design criteria for all operational conditions. The neutron and gamma fluxes and dose rates for transport technological equipment and for the spent fuel storage have been calculated. Verification of the obtained results has been performed. The analysis of both comparison between experimental and SCALE calculated results and comparison between MCNP and SCALE calculated results shows good agreement in the limits, approved in the international practice.

The further VVER SCALE applicability aspects discussion is planed to be performed in the frames of WP3 "Operational safety" of the project COVERS FP6 EURATOM project.

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Radioecotoxicological studies

Impact assessment of environmental global changes on the living organisms and water

In a study of global atmospheric changes one of the main task is the evaluation of the adverse factors influence on the life.

The performance of radioecotoxicological studies enable the investigation of the correlations between the harmful disturbing environmental factors and the specific response of the organisms. A special attention is given to the pollution influence on the water structure as the most wide spread part and center of biological systems.

In order to evaluate the environmental impact on the organisms the investigations of the influence of complex harmful factors - chemical elements (Cu,Cd etc.) and radioactivity on plant communities, as an example for the estimation of the global change on the biota is performed, because the additional input from anthropogenic origin have the potential to disrupt the delicate balance attained within the ecosystems.

Another way of the influence of the environmental parameters variations on the living organisms is via the changes in the water intramolecular energy spectrum. The fluctuations of the water energy spectrum as a consequence of the action of chemical and physical factors leads up to a change in the activity of the biomacromolecules due to the exchange of water molecules between the hydrated water layer around the molecule and the volume of water.

This complex approach enables the more accurate evaluation of the influence of global changes on the biota in order to protect and save the life on our planet.

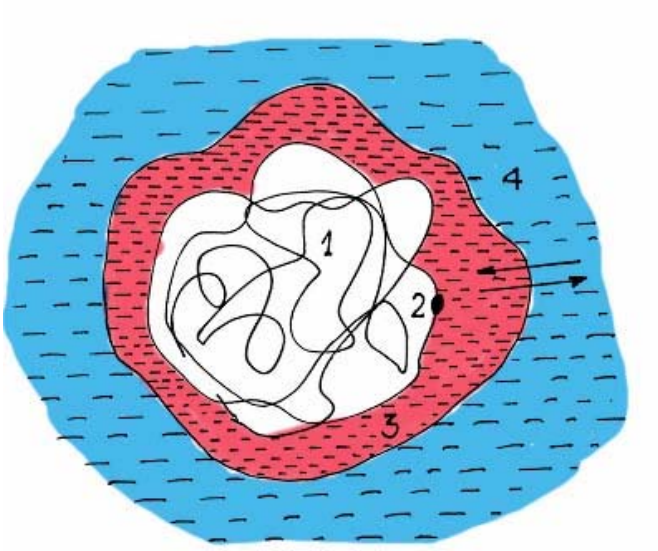

Illustration of the influence of water structure changes on the bio-macromolecule activity.
1 - bio-macromolecule; **2** – center of activity; **3** – hydrated layer; **4** – volume of water

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