



# European Working Group “Hot Laboratories and Remote Handling”

Plenary Meeting 2007, Bucharest, Romania, September 20 – 21, 2007

## PROCEEDINGS

### Opening

Marin Ciocanescu, “[\*Overview of R&D Program in Romanian Institute for Nuclear Research\*](#)”, RAAN-SCN, Romania

### Session 1: Hot cell facilities: Infrastructure, Refurbishment, Decommissioning

Wouter Klopper, Willie van Greunen, et al, “[\*Overview of hot cell facilities in South Africa\*](#)”, NESCA, South Africa

Adam B. Robinson\*, R. Paul Lind, Daniel M. Wachs, “[\*Overview of the Idaho National Laboratory Hot Fuel Examination Facility\*](#)”, Idaho National Laboratory, USA

Mark Huntelaar, Renate de Vos, Lars Roobol, “[\*License to build\*](#)”, NRG, The Netherlands (Abstract)

### Session 2: Waste, transport, safety and remote handling issues

Laurent Breton, Marc Masson, Bernard Vignau, “[\*The irradiated elements cell at PHENIX\*](#)”, CEA, France

Jung Won Lee, Kiho Kim, Geunil Park, Myungseung Yang, Keechan Song, “[\*Development of remote equipment for DUPIC fuel fabrication at KAERI\*](#)”, KAERI, Korea

Robert Zubler, Johannes Bertsch, Peter Heimgartner, “[\*Aspects of working with manipulators and small samples in an  \$\alpha\beta\gamma\$ -box\*](#)”, PSI, Switzerland

Rik-Wouter Bosch, Willy Claes, “[\*Handling and safety of polonium contaminated lead-bismuth capsules in a hot cell\*](#)”, SCK•CEN, Belgium

Roberto Covini, Paolo Iorio, “[\*The GIOCONDA experience of the Joint Research Centre Ispra: analysis of the experimental assemblies finalized to their safe recovery and dismantling\*](#)”, ISPRA, Italy

### Session 3: Post-Irradiation Examination techniques

Marcel Parvan, Ana Matei, Marin Mincu, Octavian Uta, Steve Palleck, John Montin, Shaun Abbas, “[\*PIE of a CANDU fuel element irradiated for a load following test in the INR TRIGA reactor\*](#)”, RAAN-SCN, Romania

Atsushi Onozawa, Akio Harada, Junichi Honda, Ryo Yasuda, Masahito Nakata, Hiroyuki Kanazawa, Yasuharu Nishino, “[\*Improved technique to measure hydrogen concentration in the cross section of the fuel cladding\*](#)”, JAEA, Japan

Yury Goncharenko, Gennady Kobylansky, Andrew Novoselov, “[\*Adaptation of the pole figure measurement to the irradiated items from zirconium alloys\*](#)”, SSC RF RIAR, Russia

Daniel Kuster, H. Wiese, P. Poerschke, V. Boutellier, “[\*Fuel rod profilometry with a laser scan micrometer\*](#)”, PSI,

Switzerland

Lionel Gosmain, S. Sorieul, Aurore Michaux, Guy-Marc Decroix, "[\*Raman spectroscopy, a new facility at LECI laboratory to investigate neutron damage in irradiated materials\*](#)", CEA, France

Boris Meunier, Yves Pontillon, Sidonie Clement, Jacqueline Debarge, Julien Piquemal, Marina Pontillon, Guillaume Volle, Sebastien Bernard, "[\*Fission product and He release from irradiated nuclear fuels: MERARG 2 capabilities\*](#)", CEA, France

Didier Gavillet, "[\*Analysis of complex nuclear materials with the PSI shielded analytical instruments\*](#)", PSI, Switzerland (Abstract)

J.P. Coad, D. Janney: "[\*Summary of session 3\*](#)"

## Poster session

Alain Hanssens, Magali Benchikhoun Ranchoux, "[\*Presentation of CETAMA activities \(CEA analytic group\)\*](#)", CEA, France

Jung Yang-Hong, "[\*Analysis of a metallic precipitates in an irradiated simulated fuel\*](#)", KAERI, Korea

J. Paul Coad, Anna Widdowson, Daniel Farcage, Jari Likonen, William Parsons, Tommi Renvall, Alexander Semerok, P.-Y. Thro and JET-EFDA Contributors, "[\*Detritiation of tiles from tokamaks by laser cleaning\*](#)", EURATOM/UKAEA, UK

Jean-Paul Grandjean, Bernard Autran, Jean-Yves Blanc, "[\*Experience feedback on the refurbishment of the LECA hot laboratory at Cadarache\*](#)", CEA, France (Abstract)

Christophe Valot, Thierry Blay, Laurent Caillot, Marie Pierre Ferroud-Plattet, "[\*New device for X-ray diffraction analyses of irradiated materials\*](#)", CEA, France

Silviu Ionescu, Octavian Uta, "[\*Tensile testings and metallographic examination on irradiated CANDU pressure tube specimens\*](#)", RAAN-SCN, Romania

Ana Matei, Marin Mincu, Ion Man, "[\*Separation and determination of actinides from spent nuclear fuel solution by alpha spectrometry\*](#)", RAAN-SCN, Romania

Gabriela Androne, Ana Matei, "[\*Experiments for separation and purification of <sup>99</sup>Mo from uranium solutions with fission products as tracers\*](#)", RAAN-SCN, Romania

Quentin Auzoux, Xavier Averty, Jean-François Lecot, Gérard Pinte, Cédric Dumas, "[\*Iodine induced stress corrosion cracking and axial creep: 2 new cladding testing facilities at Leci laboratory\*](#)", CEA, France

Pierrick Menegon, Nathalie Herlet, Yves Pontillon, Gilles Ferlay, Jean-Philippe Dancausse, "[\*Development of a gas trapping system for fission products xenon and krypton throughout dissolution of irradiated targets and fuels in hot cells\*](#)", CEA, France

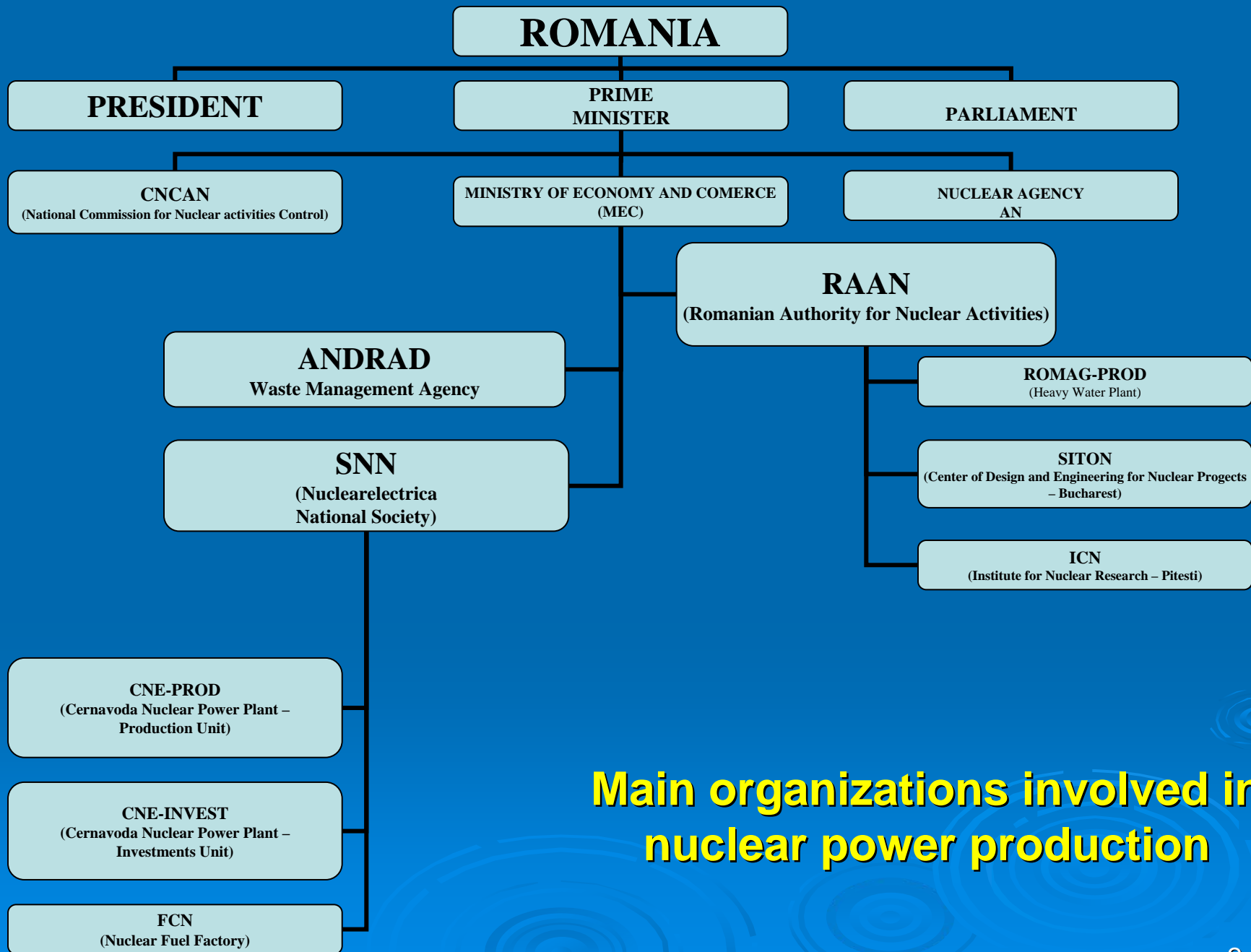
Dawn E. Janney, Thomas P. O'Holleran, Adam Robinson, "[\*Post-irradiation-examination of irradiated fuel outside the hot cell\*](#)", Idaho National Laboratory, USA

## Home

# Overview of research potential of Institute for Nuclear Research – Pitesti



*European Working Group*  
**"Hot Laboratories and Remote Handling"**  
*Plenary Meeting*  
*20 - 21 September 2007, Bucharest, ROMANIA*



**Main organizations involved in  
nuclear power production**



# Romania Map



# Main R&D Organizations

- **INR, Institute for Nuclear Research, Pitesti**  
*Major R&D Nuclear Facilities (TRIGA Reactor, Hot Cells), Material Laboratories, Nuclear Fuel, Nuclear Safety....*
- **CITON, Center for Nuclear Objectives Engineering, Bucharest**  
*R&D studies related to Nuclear Installations, Nuclear Safety, Waste management...*
- **ICIT, National Institute for cryogenics and isotope technologies, Rm Valcea.**  
*R&D devoted to heavy water technologies*
- **IFIN, Institute for nuclear physics and engineering, Bucharest**  
*Atomic Energy Applications*
- **University research (Politechnical University Bucharest, University of Pitesti, etc.)**
- **Other research centers and laboratories**

# INR activity outline and staff

## Activity outline

- Nuclear Power Research as a scientific and technical support for the Romanian nuclear power programme
- Mainly dedicated to the existing NPP in the country (CANDU)
- Focused with priority on:
  - Nuclear Safety (behavior of plant materials, components, installations during accident conditions and integrity investigations);
  - Radioactive Waste Management
  - Radioprotection
- Product and services supply for NPP

## INR Staff

- 320 – R&D qualified and experienced staff
- 240 – devices and prototype workshops and site support activities
- 90 - administration

# INR ORGANIZATION

**Director**  
**Mr. Constantin PAUNOIU**

**Nuclear Safety Deputy Director**  
**Mr. Marin CIOCANESCU**

**Scientific Deputy Director**  
**Mr. Ilie TURCU**

**Financial Director**  
**Mrs. Mariana NITA**

**Quality Management Group**  
**Mr. Cristian PATTICU**

**Reactor Physics and Nuclear Safety**  
**Dr. Csaba ROTH**

**Operation and Utilization of TRIGA  
Reactor**  
**Dr. Marin PREDA**

**Nuclear Materials and Corrosion**  
**Dr. Dumitru OHAI**

**Nuclear Fuel Performance**  
**Dr. Grigore HORHOIANU**

**Post Irradiation Examination**  
**Mr. Marcel PARVAN**

**Electronics**  
**Mr. Gheorghe RADU**

**Out of Pile Testing**  
**Mr. Constantin IORGA**

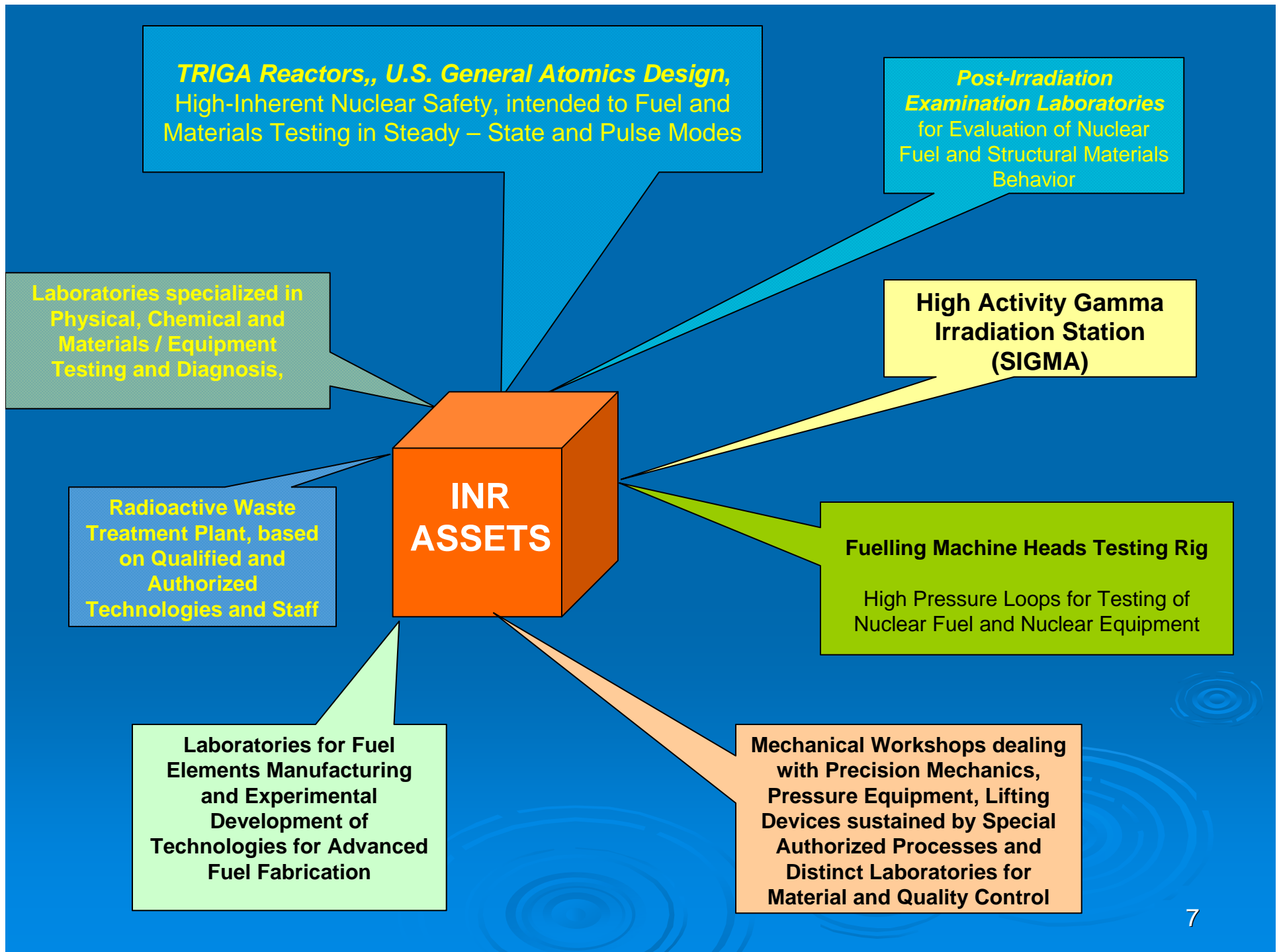
**Radioactive Waste Treatment**  
**Mr. Ion POPESCU**

**Health and Physics/Radioprotection**  
**Mr. Alexandru TOMA**

**Reliability and Testing**  
**Dr. Gheorghe VIERU**

**Administrative and Support Activities**  
**Human resources, Accounting,  
Procurement, Planning and Contracting,  
Library, etc.**





# **Institute for Nuclear Research – Pitesti**

## **Main Fields of Activity**



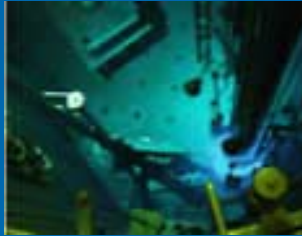
**Reliability  
and testing**



**Radiation  
protection**



**Post irradiation  
examination**



**Reactor  
physics**



**Corrosion**



**Electronics**



**Radioactive  
wastes**



**Metrology**



**Out-of-pile  
testing**



**TRIGA  
reactor**



**Design**



**Fuel  
performance**

# Reactor Physics and Nuclear Safety Department

## Objective:

Continuous improvement of the nuclear installation safety through nuclear safety analysis upgrading, development of models and, computer codes.

## Activities:

- Reactor Physics Analysis
- Thermalhydraulic Analysis
- Reactor Physics Computer Methods and Codes Development
- Nuclear Safety Analysis for NPP
- Safety Assessment for Radioactive Wastes Repositories
- Experimental Methods for Reactor Physics
- Neutronic Design of In-Pile Irradiation of Romanian CANDU Type Fuel in TRIGA Reactor
- Probabilistic Safety Analysis for Cernavoda NPP, research reactors and conventional installations.

## Experimental Facilities:

- Reference Neutron Spectrum Devices for Thermal and Epithermal Energies (to be Assessed as a Neutron Flux Density Etalon)
- Neutron Source Graphite Pile for Low Neutron Flux Measurements
- High Resolution Gamma Spectrometry Chain

# TRIGA reactor

## Objectives:

- Technical support for irradiation tests on structural materials and nuclear fuel for CANDU type nuclear power plants.
- Irradiated and non-irradiated nuclear fuel behavior analysis in transient regime.
- Radioisotopes and irradiated materials production with applications in health, industry and environment areas

## Activities:

### Nuclear fuel irradiation tests

- Irradiation tests on TRIGA, experimental CANDU SEU-43 fuel type, etc.
  - Cernavoda NPP fuel tests in accident conditions – LOCA, RIA
  - Structural materials irradiation in inactive environment (Helium)
- Power cycling tests with technical conditions specified by the beneficiary







Design, validation and authorization for new devices used in irradiation tests on nuclear fuel and structural materials.  
TRIGA reactor operation and management  
Reactor utilization for radioisotope production and neutron beam applications

### **Experimental Facilities:**

In core irradiation devices for experimental fuel and materials

SIGMA facility for gamma irradiations

High resolution neutron diffractometer for structural analysis on nuclear materials

Neutronography installation for quantitative and qualitative analysis on nuclear fuel

Prompt gamma spectrometry installation

Thermal column for thermal and intermediary neutron flux experiments.

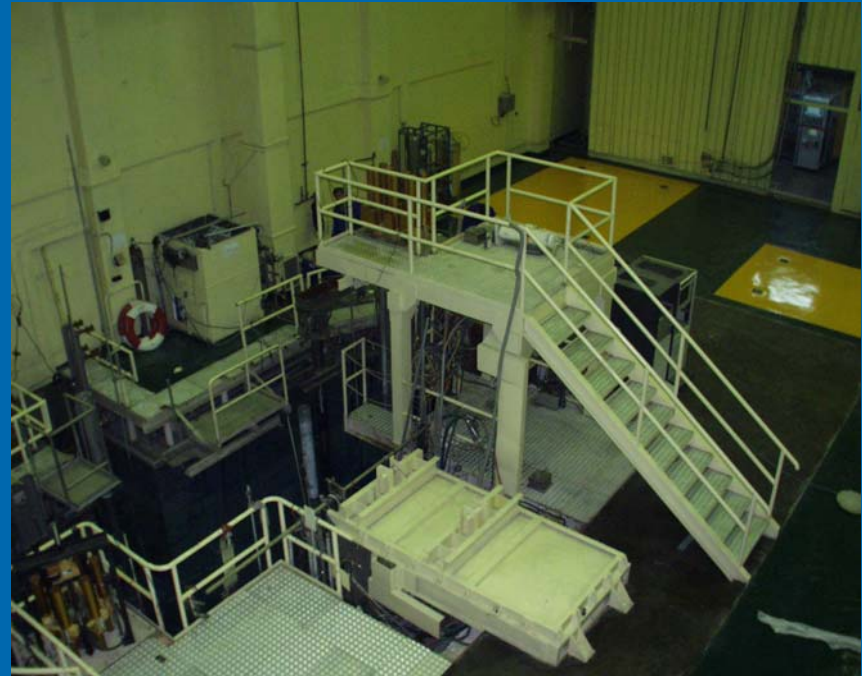




# TRIGA reactor – cont'd

## Strategic plan 2005-2010

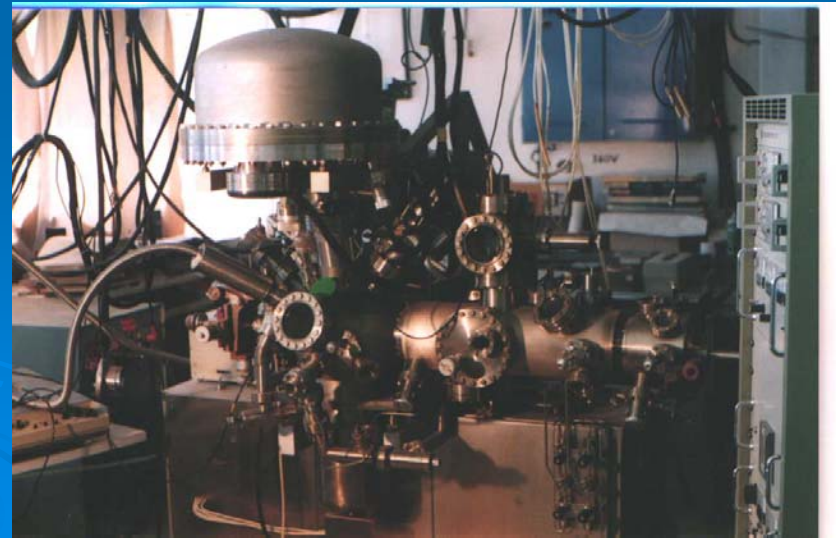
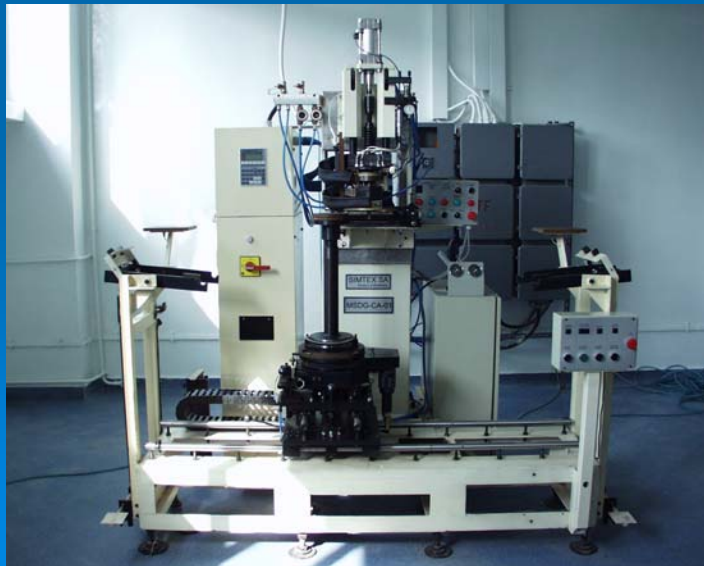
- Maintenance of operational status of the reactor;
- Continuing TRIGA SSR 14MW conversion from HEU to LEU;
- Activities to ensure higher thermal flux for experimental channels;
- SEU 43 type experimental fuel elements testing according to specifications;
- RIA type test in ACPR, on pre-irradiated fuel;
- Alternate/multiple use of neutron flux in the reactor core and from horizontal beam tubes;
- Radioisotope production for pharmaceutical applications.



# Nuclear Materials and Corrosion Department

## Objectives:

- Nuclear materials behaviors study in NPP's, under normal, abnormal and severe accident conditions.
- Manufacturing and control technologies for advanced nuclear fuels development





### Activities:

- Thermo-mechanical testing of metallic and ceramic materials under different state of stress and environment conditions;
- investigation of degradation mechanisms acting in the NPP systems/components materials;
- Reception tests on half-finished alloys;
- Fracture mechanical analysis;
- Zirconium alloys and UO<sub>2</sub> pellets behavior under sever accident conditions;

Microstructural and fracture surfaces analysis;

Micro- and nanostructural analysis;

DRX and texture analysis;

Decontamination technologies for of NPP components and equipments;

Development of technologies for UO<sub>2</sub> sinterable powders;

Development of technologies for UO<sub>2</sub> sintered pellets with controlled microstructure;

Technologies for Zr alloy welding concerning experimental fuel assembly;



# Nuclear Fuel Engineering Laboratory

## Objectives:

- design, analysis and performance evaluation of fuel elements and fuel bundles in operation at Cernavoda NPP;
- in reactor testing of the CANDU type fuel elements and fuel bundles.

## Activities:

### Fuel behavior modeling:

- UO<sub>2</sub> fission gas release, fuel swelling, thermal and mechanical behavior swelling and grain size;
- Pellet-cladding interaction; cladding thermal - mechanical behavior;
- Stress corrosion- cracking (SCC).

### Computer codes development and validation:

- Computer Codes for fuel behavior under normal conditions;
- Computer Codes for fuel behavior under accident conditions;
- Finite element computer codes. Probabilistic computer codes;

### Fuel engineering:

- Fuel design optimization and evaluation;
- Fuel performance analyses using computer codes;
- Defective fuel analysis;
- Fuel bundle structural analyses; Heat transfer analyses;

### Fuel safety analysis

# Post-Irradiation Examination Laboratory

## Objectives:

- CANDU fuel and structural materials behavior investigation after irradiation in Cernavoda Nuclear Power Plant (NPP) or in Romanian TRIGA research reactor.
- Manufacturing and sale of sealed nuclear radiation sources and radioisotopes used in industry, agriculture and medicine.
- Radioactive waste characterization and treatment.





## **Activities:**

### **Non-destructive Post-Irradiation Examination**

- Visual Inspection and Photography
- Profilometry and Length Measurement
- Gamma Scanning and Tomography
- Eddy Current Testing to check the fuel rod cladding integrity after irradiation.

### **Destructive PIE**

- Puncture Test
- Optical Microscopy
- Mass Spectrometry
- High Performance Liquid Chromatography (HPLC) with UV-Vis detector
- Tensile Testing and Creep Testing

### **Sealed Nuclear Radiation Sources**

- Manufacturing of sealed  $^{192}\text{Ir}$  and  $^{60}\text{Co}$  sources for industrial radiography.

### **Radioactive Waste**

- Radionuclide characterization



# OUT-OF-PILE-TESTING Department

## Objectives:

- design, manufacturing and test of the equipment, facilities, nuclear and non-nuclear materials in operation in the Out –of - Pile Testing Department
- design, manufacturing and operation of the specialized unique devices for out-of-pile testing on nuclear fuel



**Activities: oriented for Cernavoda NPP**

**Fuel bundle out-of-pile testing:**

- test assembly for the impact test
- test assembly for pressure drop tests
- test assembly for wear and endurance tests

**Testing of Fuelling Machine (F/M) heads No.4 and 5 for Cernavoda NPP- Unit 2 (performed between 2001 and 2005) - first head No.4 delivered to Cernavoda NPP in August 2005.**

**Qualification technologies have been developed (for fuel channel closures); there have also been designed and manufactured:**

**maintenance tools for the NPP (garter springs repositioning, plugging of steam generator pipe)  
installation for testing F/M rams  
F/M mechanical and electric simulator**

**Test rigs used for nuclear fuel qualification:**

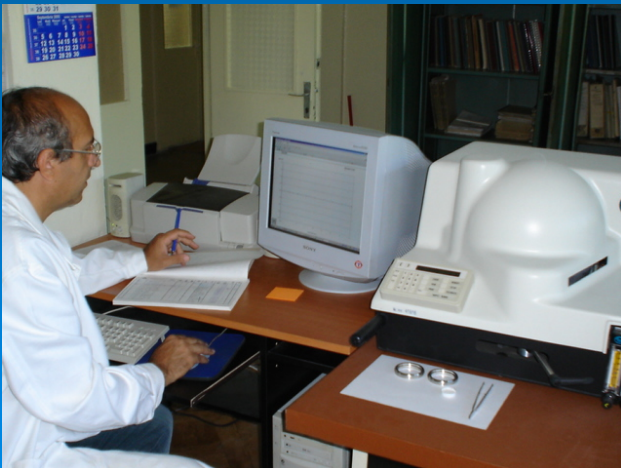
- test rig for fuel elements
- test rig for the Fuelling Machine heads
- test rig for channel closure
- test rig for reactivity control mechanisms
- test rig for vibrations
- test rig for spare ram assembly
- test rig for explosion panels



# Radiation Protection, Environmental Protection and Civil Protection Department

## Objectives:

- implementation of radiation and environment protection plan for ICN nuclear facilities
- R&D program destined to increase proficiency in human and environment protection against radiation-associated risks.



# Radiation Protection, Environmental Protection and Civil Protection Department

## Activities:

- Radioecological studies of radioactive contamination transfer for agricultural and aquatic ecosystems.
- Development of radiation measurement methods for radiation protection purposes: Monte Carlo methods for efficiency calibration of spectrometric and dosimetric devices
- Developing of radionuclide environmental dispersion models (AQUARAD)



- Derived emission limits for nuclear reactors for gaseous and liquid effluents
- Method and techniques for rapid sampling of tritium from atmosphere for concentration measurements.
- Testing of individual protection equipment for radioactive contaminated working environments.
- Scientific, methodological and practical support development for emergency planning and preparedness



# Radioactive Wastes Management Department

## Objectives:

- treatment and conditioning of radioactive wastes resulted from the TRIGA reactor and other research laboratories of the site, the Nuclear Fuel Factory (FCN), the Cernavoda NPP, Institute for Nuclear Physics and Engineering (IFIN-HH).
- design and manufacturing of equipment and tools for the assay and measurement of radioactive samples from the environment and from working areas, which imply radioactive sources.



### Activities:

Implementation of new equipments and technologies in the management of radwaste.

- Treatment technology by evaporation of liquid effluents resulted from the TRIGA reactor and conditioning of the yielded concentrate, in view of its final disposal.

- Treatment technology for liquid wastes contaminated with natural uranium, followed by uranium recovery.

- Conditioning technology for  $\beta$ - $\gamma$  low active solid wastes, in view of their final disposal. Qualification of packages for the storage of solid and liquid radwaste from NPP:

- Stainless Steel Packages for storage of low and medium active wastes from NPP operation

- Stainless Steel Packages for storage of liquid radwaste from NPP operation/decontamination.



# ELECTRONICS

## Objectives:

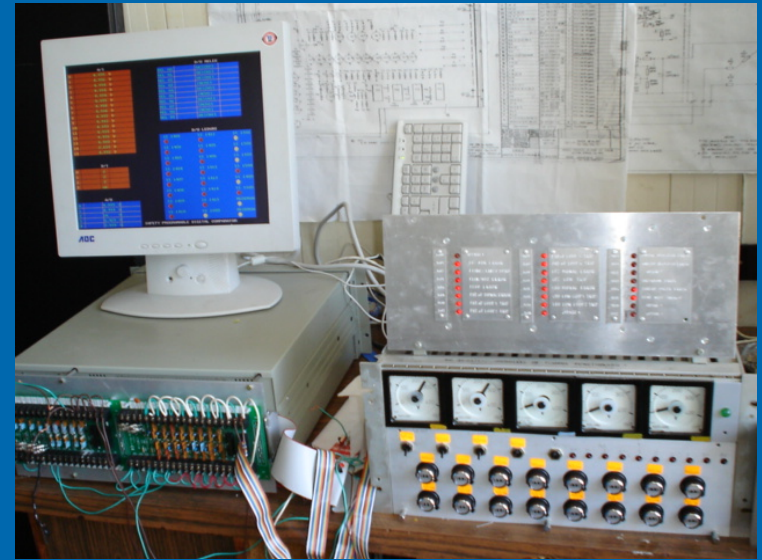
- research and development of dedicated electronic instrumentation and equipment, mainly for nuclear applications
- an R&D program for development of radiation field measurement devices
- software development for process control and data processing





### **Activities:**

- design and manufacturing of equipment for CANDU 600 NPP, ranging from electronic instrumentation like Ionization Chamber Amplifier for reactor control with trip comparator for fast shutdown system, In-Core Flux Detector Amplifier or Dynamic Compensation Module, to computer based system control like Failed Fuel Location System (delivered to Cernavoda NPP Unit 1 in 1991 and for Unit 2 in 2005), Gaseous Fission Product Monitor (delivered to Cernavoda NPP Unit 1 in 1991 and for Unit 2 in 2005), Area Monitors.



- design and manufacturing of equipment for our research facilities, like Safety and Control System for Irradiation Devices, Radiation Dose Data Acquisition System, Meteorological Data Collector and Processing System for nuclear facilities.

# DESIGN SERVICES

## Objectives:

- design of nuclear equipment, pressure vessel and laboratory devices.



## Activities:

- Design of investment objectives: pre-feasibility and feasibility studies, technical designs;
- Design of research equipment and installations
- Design of equipment related to CANDU type nuclear fuel manufacturing
- Design of pressure vessels, piping and hoisting units within nuclear or classic objectives.





# RELIABILITY AND TESTING

## Objectives:

➤ qualification and production tests and certification of the equipment and instrumentation manufactured in our institute or manufactured by licensed suppliers

## Activities:

- tests and certification for Cernavoda NPP equipments, such as: Failed Fuel Location System, Heat Transfer System Radiation Monitoring, Ion Chamber Amplifier, Dynamic Compensation Module, etc.
- test and certification of type A and B packages used for temporary storage and transportation of radioactive wastes.



# QUALITY MANAGEMENT

## Objective:

- Development, implementation and maintenance of a quality management system according to ISO 9001:2000 and to applicable statutory and regulatory requirements

## Activities:

- Quality engineering activities for quality management system documentation;
- Quality survey activities for design and manufacturing of products for nuclear installations and conventional applications;
- Quality survey activities for nuclear installations operation;
- Quality assurance training of personnel;
- Quality management systems internal and external auditing.

## Main achievements:

- INR quality management system certification by LRQA (Approval certificate No. 170254);
- INR quality management system authorization by CNCAN for research, design, manufacturing and operation activities related to the nuclear field.

# IAEA Assistance and Co-operation

## 35 years of technical assistance and support

Establishment of the Institute for Nuclear Technologies following IAEA recommendations and significant IAEA assistance with the objective to provide the necessary technical and scientific support for the Romanian Nuclear Power Programme (1971).

Institute development with the continuous support of IAEA (fellowships, equipments, expert mission) including:

Regular Projects with INR as the main recipient:

- Development and testing of locally made fuel elements
- Building Nuclear Safety capabilities
- Development of the Cernavoda Probabilistic Safety Evaluation Studies
- Plant commissioning requirements and training
- Radiological protection
- Licensing of test facilities for CANDU 600 fuelling machine
- Full conversion of TRIGA 14-Mw Core from HEU to LEU



# IAEA Assistance and Co-operation

35 years of cooperation

## Regional projects

Training courses, scientific visits, expert missions, etc.

Ex: RER/9/076 Strengthening Safety and Reliability of Nuclear Fuel and Materials in Nuclear Power Plants: Upgrading the Hot Cells at INR Pitesti and development of the CANDU spent fuel examination and surveillance programme.



## Others co-operation forms:

- Research contracts
- INR contribution to the IAEA activities (development of standards, experts)

# IAEA Assistance and Co-operation

## 2007-2008

### Regular Project

- ROM/4/024 Full Conversion of TRIGA 14-MW Core from HEU to LEU Fuel

### Regional Projects

- RER017-Human Resource Development, Nuclear Technology Support and Regional Programme Review; Dumitru DOBREA, CP
- RER002-Strategic Planning for Management, Self-reliance, and Sustainability of National Institutions; Constantin PAUNOIU, CP
- RER033- Strengthening Capabilities for Nuclear Knowledge Preservation; Marin CONSTANTIN, CP
- RER008 – Strengthening Safety Assessment Capabilities; Ilie TURCU, CP
- RER014 – Upgrading National Capabilities in Controlling Public Exposure; Alexandru TOMA, CP
- RER022 – Support in Planning of Decommissioning of Nuclear Power Plants and Research Reactors; Csaba ROTH, CP
- RER003 – Repatriation, Management and Disposition of Fresh and/or Spent Fuel from Research Reactors; Marin CIOCANESCU, CP
- RER017 – Nuclear Techniques for the Protection of Cultural Heritage Artefacts in the Mediterranean Region; Maria IONILA, CP

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