Science and the Nuclear Industry in Bulgaria

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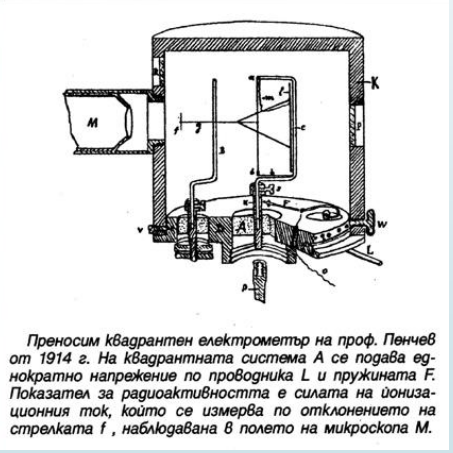
INRNE-BAS TODAY

The Bulgarian complex centre for scientific and application research in the fields of:

- Nuclear physics
- Nuclear energy, nuclear methods and technologies
- High energy physics
- Radiation environment and ecology
- Theoretical and mathematical physics
- The research reactor of the INRNE-BAS
- Basic environmental observatory at peak Moussala
- Cyclotron laboratory
- World recognized results of the INRNE notified during the European Science Foundation evaluation of the Bulgarian Academy of Sciences

Prof. Pavel Penchev (1873-1956)
Pioneer of the Radioactivity Research in Bulgaria



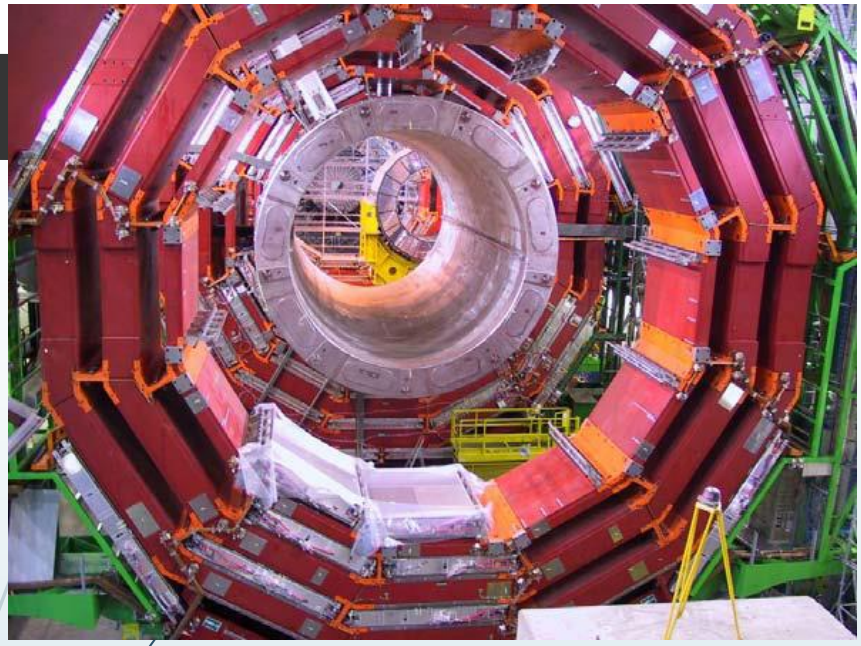
Преносим квадрантен електрометър на проф. Пенчев от 1914 г. На квадрантната система А се подава еднократно напрежение по проводника L и пружината F. Показател за радиоактивността е силата на йонизационния ток, който се измерва по отклонението на стрелката f , наблюдавана в полето на микроскопа М.

Pavel Penchev specialised in radioactivity under supervision by Pierre Curie. He constructed an advanced electrometer and was the first to investigate the radioactivity of Bulgarian mineral water.

Prof. Elisaveta Karamihailova (1897-1969)
Pioneer of the Experimental Nuclear Physics in Bulgaria

The group of Acad.

W. Andrejtscheff is the world leader in the field of the lifetimes of the excited nuclear states measurements!

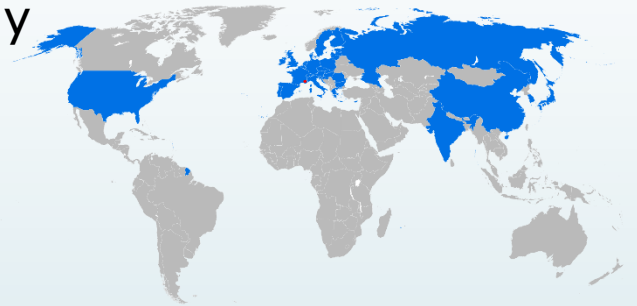


Bulgaria since 1999 Member State of CERN

Member of CMS since 1991, CMS MoU signed in 1999

We shall finish what we started together

- Council Conclusions on a reformed ITER project - the way forward



ITER, means „passage” from latin – the aims are to contribute to a much faster realization of the prospect that most of our electricity needs will be covered by fusion.

- Extension of the EURATOM Programme for research and training during 2019-2020

eu2018bg.bg
Bulgarian Presidency of the Council of the European Union

United We Stand Strong

THOMSON REUTERS

Thomson Reuters awards INRNE with the first place for **Essential Science Indicators for highly cited, top and hot papers**.

The beginning

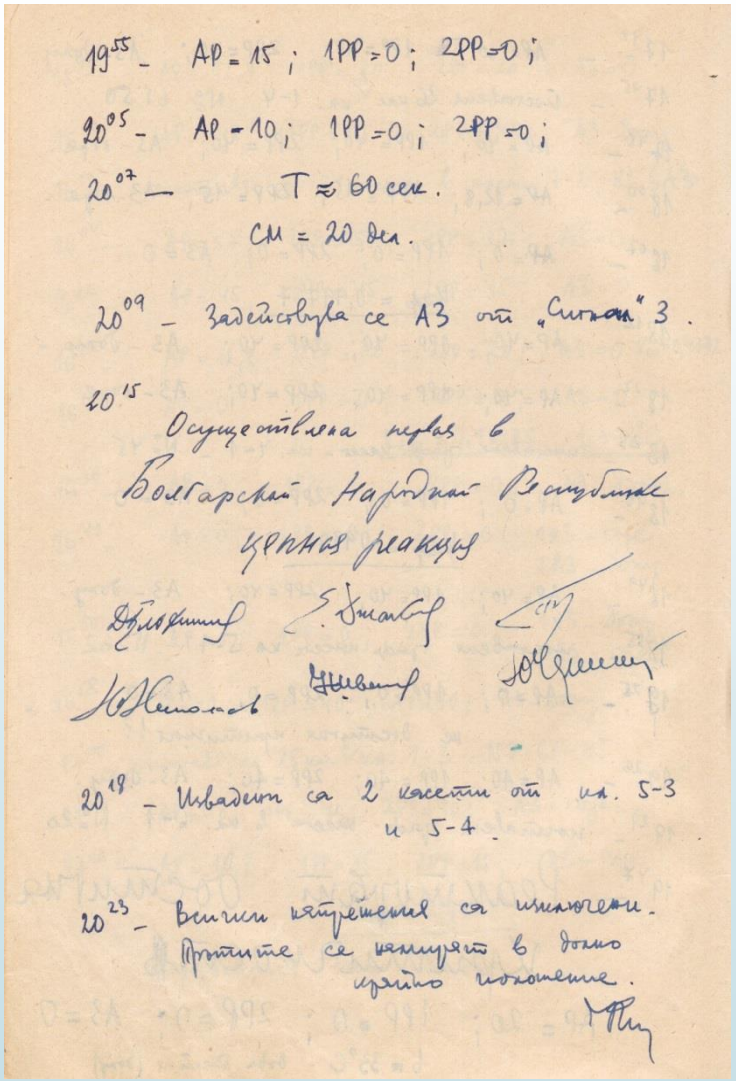
- 1956-1957 – training of group Bulgarian scientists and engineers in operation of IRT in Kurchatov Institute , Moskow: Simeon Ruskov, Vasil Hristov, Nikolay Buchvarov, Anton Markov, Ilija Mishev, Krikor Sakalijan and Dimitar Vatev.

Before the Reactor construction, 1956

The Reactor under construction

Start of Nuclear energy project in Bulgaria

- Construction – started 1956
- Physical start-up – **September 18, 1961**, **Prof.D.I. Blohintsev**, State Committee of Atomic Energy, ex-USSR, wrote in the reactor diary this fact: **"Today at 20,15h the first chain reaction in the People's Republic of Bulgaria has been accomplished"**
- Official opening – November 9, 1961



IRT- 2000

- Pool type, light water cooled and moderated reactor;
- Up to 48 fuel and graphite assemblies in the core - 14, 15, or 16 fuel rods in the assembly.
- Fuel assemblies - EK-10 type (10% enrichment), C-36 (36% enrichment). Reflector- 13 graphite blocks.
- Cooling system - 3 pumps, special ejector pipe, max. flow rate 540m^3, 2 heat exchangers, ion exchange and mechanical filters.
- Storage pool - maximum capacity- 112 fuel assemblies, connections to reactor pool and hot cell laboratories, 73 spent fuel assemblies were stored up to July 2008.
- Experimental channels - 11 horizontal and 12 vertical, maximum neutron flux on 2MW thermal power- 2.10^{13} n/cm^2sec

IRT-2000 Mission

- **EDUCATION**
  - Nuclear energy, technology and investigations
  - Dosimetry, radiation protection
  - Physics, radiochemistry and radiobiology
  - Nuclear safety
- **Applications**
  - Neutron activation analysis
  - Production of isotopes
  - Radio-pharmacy
  - Nanotechnology
  - Neutron radiography
  - New materials
  - Metrology

First stage of the construction and commissioning of the Kozloduy NPP

- **1970 – 1975 г. – construction of 1 and 2 unit with**
- **pressurized water reactors type WWER-440, model V-230.**

30.06.1974 – Start up of unit 1

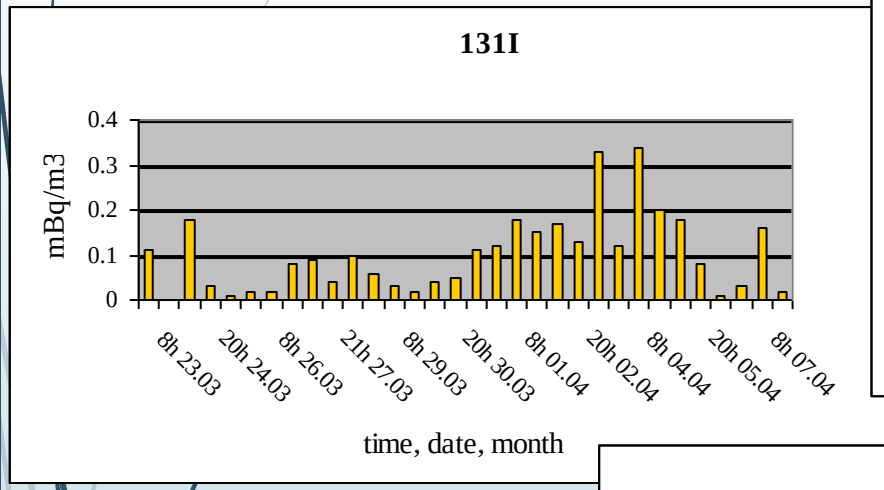
22.08.1975 – Start up of unit 2

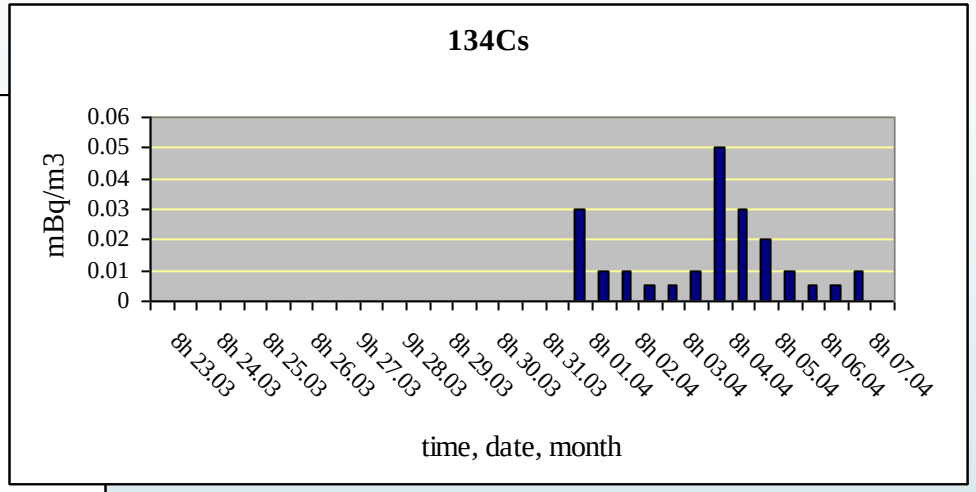
The official opening of KNPP was on 4-th of September 1974

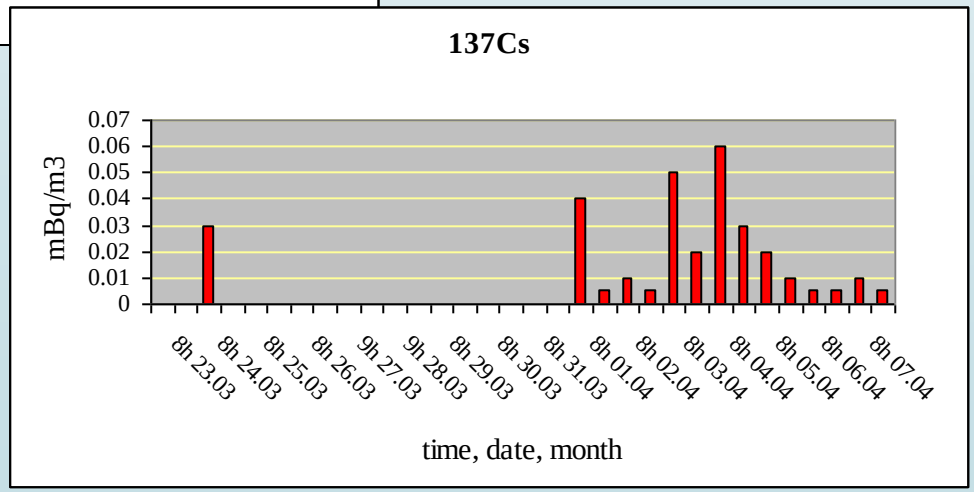
The State Enterprise Radioactive Waste started the construction of National Disposal Facility for Low- and Intermediate Level Radioactive Waste - 29.08.2017

Basic environmental observatory Peak Moussala-2928 m.

Radioactive transsborder transfer: Fukushima







Bulgarian Nuclear Future

Bulgaria has nuclear ambitions. We plan to use effectively and what is more important safely new nuclear reactors. The main tasks:

-To continue to use safely the 5-th and 6-th unit at KNPP;
- New nuclear reactors – 7-th and 8-th unit at KNPP;
- Safely use of fuel from different manufacturers;
- New repository for radioactive waste;
- To continue to be a strong member of nuclear energy community worldwide;
- To educate new generation in the fields of Nuclear Physics and Nuclear Energy;

INRNE
PhD STUDENTS ON SUBJECTS RELATED TO NUCLEAR REACTORS
in the last 10 years

PhD theses defended

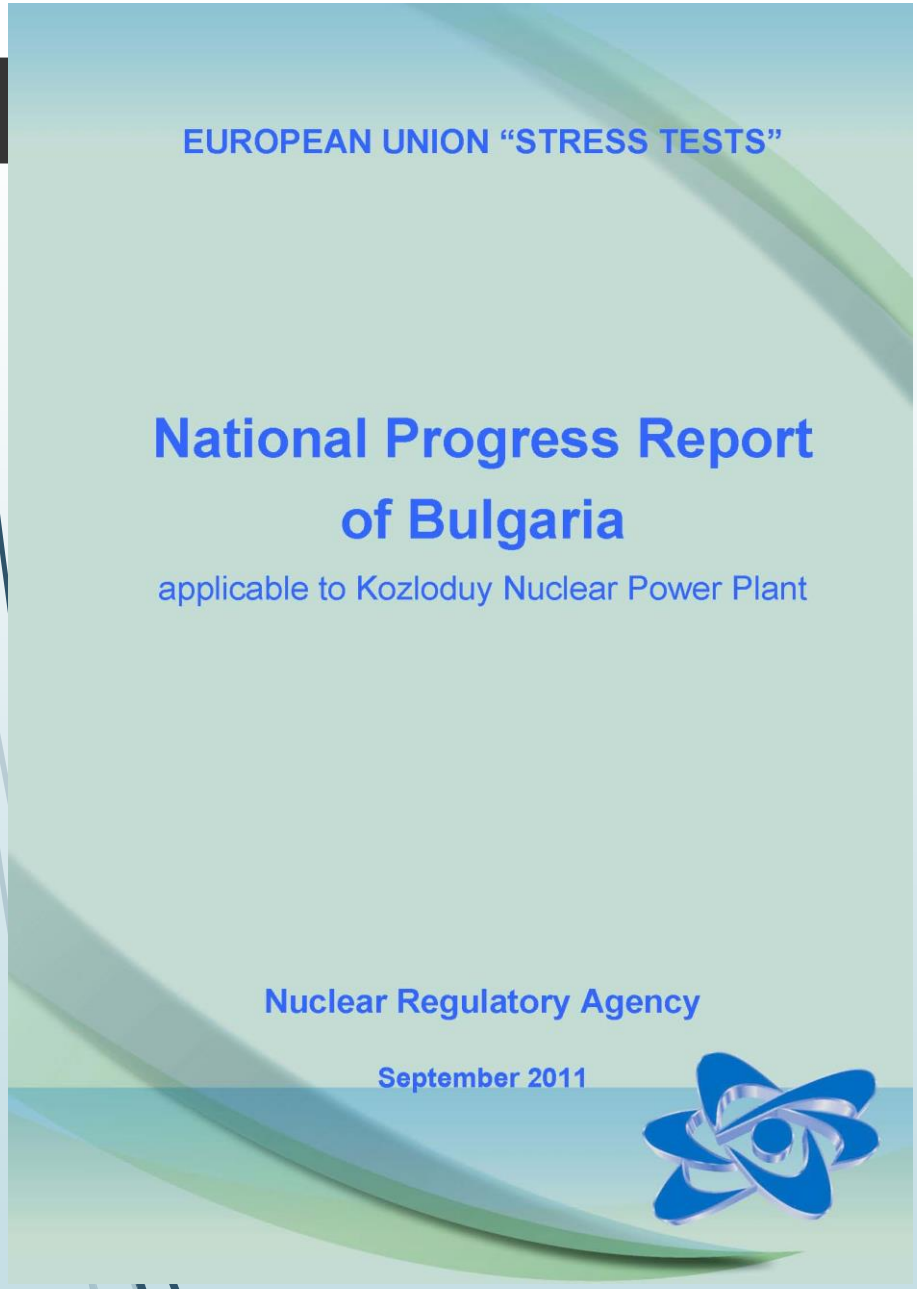
PhD students in process of theses defence

PhD students in process of theses preparation

Total number - 34

The biggest project in the field of education of PhD students between an academic organization and industry is between INRNE-BAS and NPP Kozloduy.

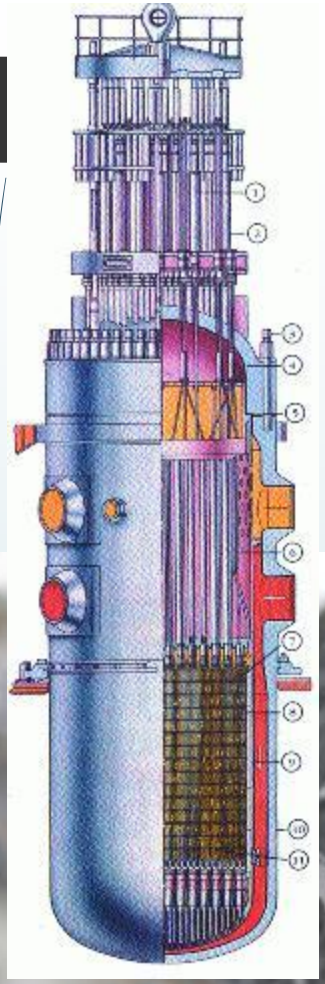
New scientific program in the field of Nuclear energy was signed by the INRNE-BAS, Technical university Sofia and Sofia university. It is just started now.

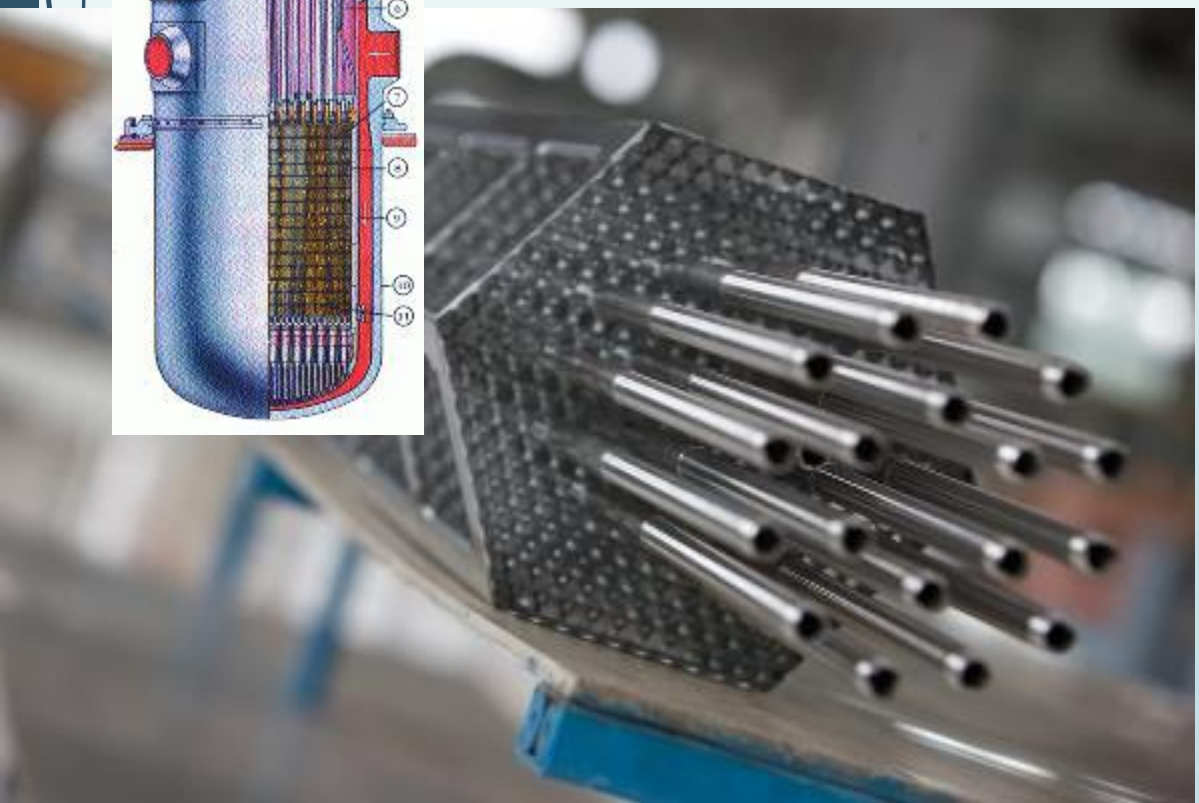


INRNE and Stress-tests of the NPP "Kozloduy"

"Extreme external climate conditions"

Optimization of nuclear fuel behavior for WWER-1000





АЕЦ КОЗЛОДУЙ

Activities related to the assessment of the NPP's Safety at INRNE-BAS

Projects with participation of INRNE in the field of NPPs Safety

SASPAM-SA (Safety Analysis of SMR with PAssive Mitigation strategies - Severe Accident).

Key Objective of SASPAM-SA: to investigate the applicability and transfer of the operating large-LWR reactor knowledge and know-how to the near-term deployment of integral PWR (iPWR), in the view of Severe Accident (SA) and Emergency Planning Zone (EPZ) European licensing analyses needs.

Key Outcome of SASPAM-SA : to be supportive for the iPWR licensing process by bringing up key elements of the safety demonstration needed; to speed up the licensing and siting process of iPWRs in Europe.

Funded by EC in the frame of HORIZON-EURATOM-2021-NRT-01-01, "Safety of operating nuclear power plants and research reactors". Implementation period: 2022-2026.

Activities related to the assessment of the safety of NPPs at INRNE-BAS

IAEA Colaborative Research Project (CRP): Developing a Phenomena Identification and Ranking Table (PIRT) and a Validation Matrix, and Performing a Benchmark for In-Vessel Melt Retention.

Main project features: The goal of the project is an analysis of the applicability and technical feasibility of the IVMR strategy to high power reactors.

The main outcomes of the project are: Developing of a PIRT and a Validation Matrix for IVMR. Relevant assumptions and scenarios to estimate the maximum heat load on the vessel wall, improved numerical tools for the analysis of IVMR issues and a harmonized methodology on the IVMR. Performing the integral and self alone safety analyses concerning assessment of the RV and bottom head cooling possibility for severe accident management.

Funded by IAEA, Done in period 2000-2024.

Activities related to the assessment of the safety of NPP'sat INRNE-BAS

CAMIVVER (Codes and Methods Improvements for VVER comprehensive safety assessment).

Main project features: CAMIVVER promotes the use of multi-disciplinary deterministic methodologies to describe the interaction between thermal hydraulics and neutronics and the validation against high fidelity calculations such as Monte Carlo and CFD. It is based on new generation codes presently under continuous development.

The main objectives are: progressing in the development of industrial codes and methods dedicated to VVERs.

Funded by EC. Implementation period: 2020-2023.

Activities related to the assessment of the safety of NPPs at INRNE-BAS

MUSA (Management and Uncertainties of Severe Accidents)

Main project features: MUSA characterizes the uncertainties in severe accidents analyses, including some SAM actions.

The goal of the project is to support assessments and improvement of NPPs' safety based on results of simulation codes, use of experimental data and estimate of risks to increase safety margins of power plants under operation. Using the uncertainty quantification methodologies for estimating source term in safety analysis (accident analysis, periodic safety evaluations, etc.). Performing of the uncertainty analyses in respect to the fission product release and transport in the reactor circuit and the containment.

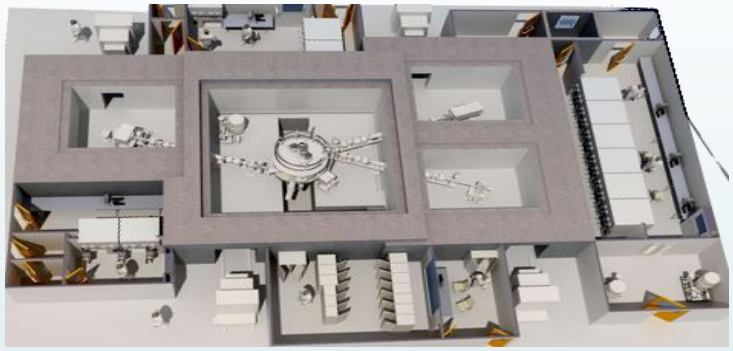
Funded by EC in the frame of H2020. Done in period 2019-2023.

Expert activity

Scientific Support for Nuclear Energy, Research and expertise for BNRA, NPP "Kozloduy“, Ministry of energy, National electric company, State Enterprise Radioactive Waste, and others.

The Cyclotron Laboratory at INRNE-BAS

The aim is to establish a center for:



Applied Research

R&D in Radiopharmacy

Production of Radiopharmaceuticals

Fundamental Science – Chemistry, Biology, Physics

Training and Education in:

Nuclear Energy;

Radiochemistry;

Radiopharmacy;

Nuclear Physics;

Radiation Protection.

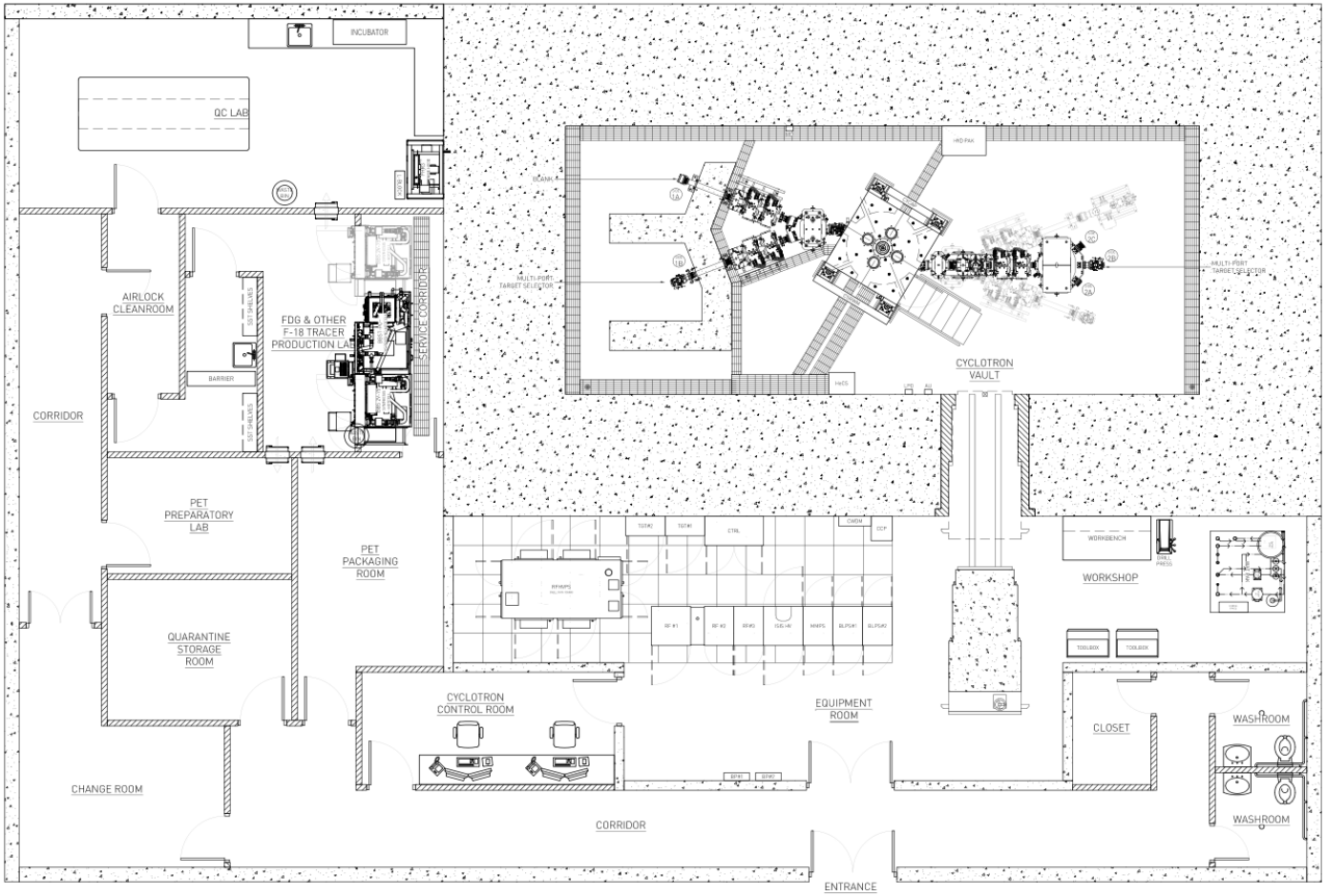
TR-24, ACSI(EBCO), Vancouver, Canada

- Accelerates H- ions
- Extraction by stripping foils
- Beam Energy: 15 – 24 MeV
- Beam Current: 400 μA
- Upgradeable to 1 mA
- Dual Beam Extraction
- External CUSP ion source
- Turbomolecular and cryo vacuum pumps
- Vacuum:5.10-7 – 10-6 Torr

PET: 11C, 13N, 15O, 18F, 124I, 64Cu, 68Ge

SPECT: 123I, 111In, 67Ga, 57Co, 99mTc

Cyclotron Vault Layout



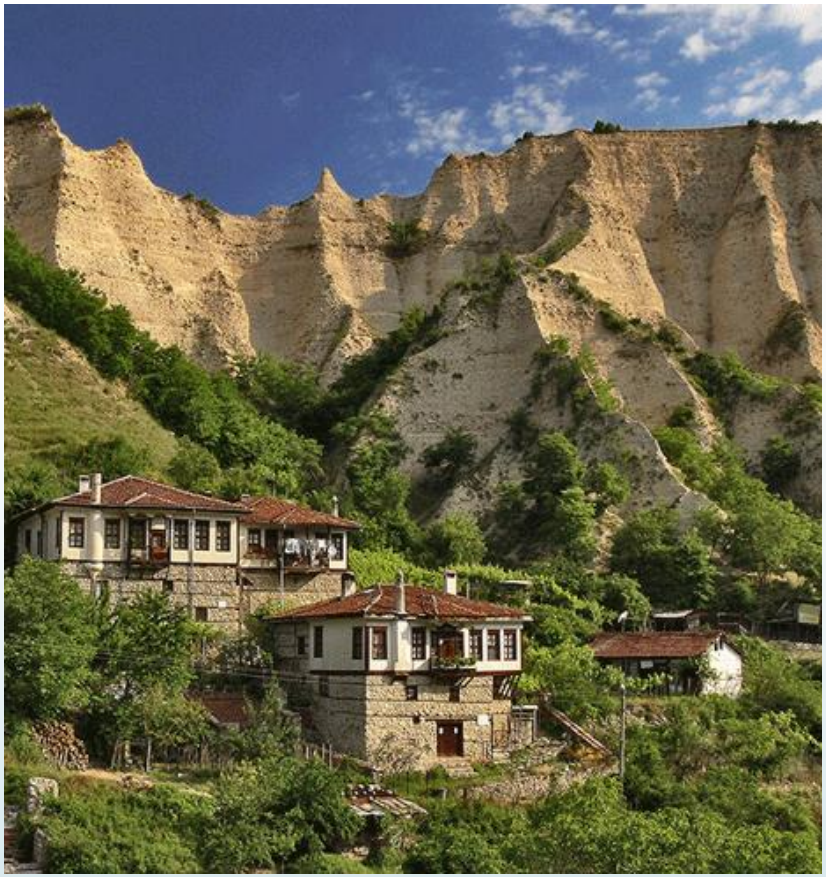
ADVANCED CYCLOTRON SYSTEMS, INC.

BULGARIA
TR-24 CYCLOTRON AND RADIOPHARMACY
PROPOSED LAYOUT

AS SHOWN | BU | A3 | 1 / 1 | BU-00xx | A

International Young Naturalists Tournament

INRNE-BAS is strongly involved in the education of new generation physicist. At every tournament they win some of the first plces.



Thank you!
Merci!
Благодаря!

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