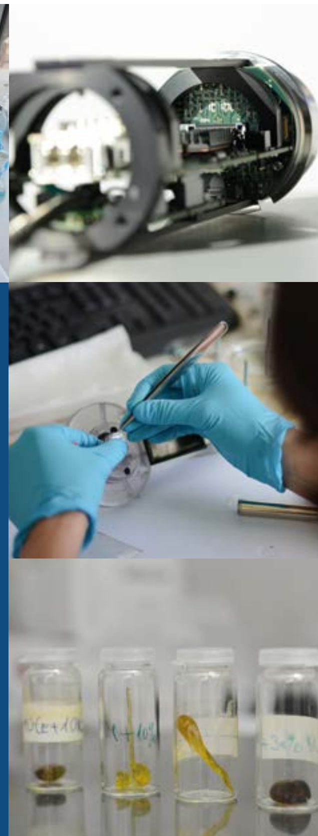
ek.hun-ren.hu



HUN-REN Centre for Energy Research

HUN REN

Research. Innovation. Impact.

Table of Content

Welcome

Dear Reader,

Hereby we would like to present our booklet which provides a brief overview of our research centre.

The Centre for Energy Research was established in January 2012 on the basis of two former independent institutions, the Atomic Energy Research Institute and the Institute of Isotopes. In 2015 Institute of Technical Physics and Materials Science became part of the EK.

The Centre for Energy Research is part of the Eötvös Loránd Research Network.

The aim of the Centre for Energy Research (EK) is to carry out basic, applied and developmental scientific research of international standard in the fields of nuclear energy, functional materials and nanosystems, environmental protection, energy efficiency and energy security.

Director General:
Dr. Horváth Ákos

Target areas:

- basic, applied and development research in accordance with the provisions of the Atomic Energy Act
- safety analysis of nuclear power plants,
- basic, applied and development research in the field of renewable energy sources
- environmental protection systems
- research on functional materials
- operation of the Budapest Research Reactor

Mission statement

- Research and development in the field of nuclear science and technology for facilitating the adoption and the safe use of nuclear technology in Hungary
- To participate in international research effort aiming at establishing a new generation of nuclear power plants and closing the fuel cycle
- Maintaining and improving competence in nuclear science and technology, especially in the field of nuclear safety, security, health physics, nuclear and isotope chemistry
- Developing plasma physics understanding and technology for controlled nuclear fusion
- To guarantee the safe operation of Budapest Research Reactor (BRR), and to ensure the accessibility of the research facilities around the reactor
- Research activities to improve nuclear analytical and imaging methods and their applications for energy and materials science
- Perform studies in the field of environmental physics related to energy generation, renewable energies, energy storage, and their impact on public health, and environmental safety
- Research and development in the field of low carbon energy technologies and of energy saving in industrial technologies
- Interdisciplinary research on complex functional materials and nanometer-scale structures, exploration of physical , chemical , and biological principles, their exploitation in integrated micro- and nanosystems, and in the development of characterization techniques
- Dissemination of the results in international programs, education, industrial research and to the general public

Board director:

Dr. Attila Imre

The Internal Advisory Board of the Research Centre (KUTTA) is an internal advisory body of the General Director of the Centre, delivering opinions and giving advice related to scientific matters. The KUTTA is the widest scientific forum of the Research Centre. The KUTTA performs various tasks related to its competence and defined by related laws and other regulations. The members of the KUTTA are the Chiefs of the Institutional Scientific Councils (ITT) and the General Chief of the KUTTA, appointed by the General Director.

The primary duties of the KUTTA are:

- deliver opinions and advice concerning the goals, scientific concept and main research areas of the Centre, the Centre
- periodically review all main research topics of the Centre; provide its statement concerning expansion, modification or cancellation, expansion, modification or cancellation,
- delivers opinion concerning issues related to scientific education; ascertains the originality of PhD theses written in the Centre, theses written in the Centre,
- reviews research proposal; suggests their support from the central budget,
- reviews research topics and evaluate their results,
- give opinions about matters related to the scientific work of the institutes, including scientific qualification of researchers
- offer opinions about the promotion of researchers,
- advise the General Director in questions in various research-related topics upon request,
- evaluate the progress of junior researchers.

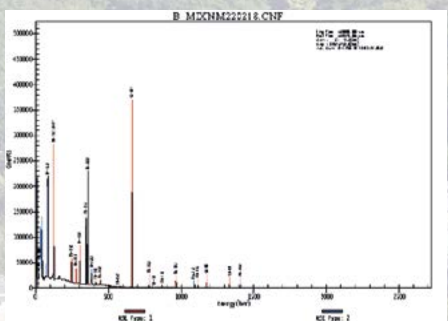
Some of the functions of the KUTTA related to a given institute can be passed to the responsible ITT.

Environmental Protection Service

Head of Service:
Gáborné Endrődi

The Environmental Protection Services of the Energy Research Centre is responsible for the nuclear environmental monitoring and partly for the radiation protection and personal dosimetry of the KFKI campus. Radiation protection and environmental monitoring have more than 50 years tradition at the campus. The continuous monitoring of the radiation levels at the campus are performed by 16 GM probes placed at different points of the campus, especially near to the entrances and those facilities, where emission of radiation may occur. These probes are on-line connected to the data-centre of the Service, where continuous duty is provided. There are 4 environmental monitoring stations at the KFKI Campus, where aerosol sampling and fall-out sampling devices are operated. The wastewater emissions are checked at the only exit point of the campus, near to the main entrance.

The collected samples at the listed stations are measured by beta and gamma spectroscopy. In the case of emission the radionuclide-selective analysis provides the identification of the source, and the performing of preventive measures. The laboratory of the service is equipped with low level beta and gamma



detectors and several other radiation monitoring instruments. The personal dosimetry is performed by thermoluminescent dosimeters (TLD). Workers of the campus exposed to the risk of internal radioactive incorporation are regularly checked by a low-level whole-body counter. The Service operates the Central Radioisotope Storage Facility of the KFKI Campus, where the actually not used radioisotopes are stored. An irradiating pavilion is operated by the service. Different gamma and neutron sources are available, which are used mainly for calibration and testing of dosimeters. A mobile laboratory is also available, which is equipped with all necessary instruments to perform different kinds of environmental measurements in the field.

Quality control manager:
Réka Makai-Lengyel

In order to achieve the highest quality of research, development, design, condition monitoring and valuation, engineering, contracting and managing in design, production, implementation and inspection – the Atomic Energy Research Institute introduced its quality management (QM) system by ISO 9001 standard in 1994.

Maintaining the system, it has been continuously upgraded to ISO 9001:2015 valid in the whole Research Centre since 2017.


KIVÁLÓSÁGI TANÚSÍTVÁNY


Minősítő lap

AZ MVM PAKSI ATOMERŐMŰ ZRT. IGAZOLJA, HOGY KÖVETELMÉNYEINEK AZ

ENERGIATUDOMÁNYI KUTATÓKÖZPONT

MINŐSÉGIRÁNYÍTÁSI RENDSZERE

MEGFELEL.

MINŐSÍTETT TERÜLET:

A MINŐSÍTÉS ÉRVÉNYESSÉGI IDEJE: 2023.07.31.

A MINŐSÍTÉS SZÁMA: KM 67/2020

EZEN MINŐSÍTŐ LAP A MELLÉKLETTEL EGYÜTT ÉRVÉNYES.

Paks, 2020. július 31.

PUSKÁS LÁSZLÓ
főosztályvezető

HORVÁTH GYÖRGY
osztályvezető

The QM system is certified by the Hungarian Standards Institution, member of IQNet, since 1999. The Research Center's QM system ability was proven by seven recertification, releasing the actual certificates (Figures 1 and 2).

One of our main contracting partners, the MVM Paks Nuclear Power Plant has also achieved a recertification audit, and released the conformance labelling (Figure 3), which is one of the basic preconditions for contracting.

MAGYAR SZABVÁNYÜGYI TESTÜLET
HUNGARIAN STANDARDS INSTITUTION

TANÚSÍTÁSI OKIRAT
CERTIFICATE

Tanúsítjuk, hogy a
We certify that the Management System of

Energiatudományi Kutatóközpont
(kivéve az MFA és a Reaktorüzem)
H-1121 Budapest, Konkoly-Thege Miklós út 29-33.

MSZ EN ISO 9001:2015 (ISO 9001:2015)

Educational activities

Although the Centre for Energy Research is not an educational institution, it is intensively involved in higher education.

The most significant segment is PhD training. The centre's researchers are involved in the activities of almost all the major Hungarian universities' doctoral schools (in the natural sciences and engineering) as supervisors, lecturers and core members. Our PhD students formally belong to these schools, but their research is carried out at the Research Centre. The number of students varies, usually between 30 and 50. That is about 10% of our total research staff.

There is also intensive participation in BSc and MSc level education. One of the forms of this is thesis and dissertation supervision and consultation; these students come to us mostly from universities in Budapest (BME, ELTE, Óbuda University), but we have students from almost all universities in Hungary.

In addition, a significant number of EC researchers also regularly teach at these universities. Some of them do it as external lecturers, but several of them have part-time university status, mostly as associate professors or full professors.

The Centre also has a number of internship programmes for students aimed at „attracting" BSc or MSc students to write their thesis or dissertation here. The students are involved in an interesting research project, and if both parties are satisfied, the research can lead to a thesis, a dissertation or possibly a PhD thesis. One such programme, for example, is „Energy Research at the Energy Research Centre" (EK2), now in its fifth year.

Also, as part of our educational activities, the Centre participate in international educational programmes, mainly those of the International Atomic Energy Agency (e.g. radiation protection training).

Budapest Neutron Centre

Head of BNC useroffice:
Dr. Rózsa Baranyainé Fliszár

BNC coordinates the use of the reactor and provides scientific infrastructure for the international user community. Currently 16 experimental stations are offered in the user programme. A major step in the instrument development programme was the installation of the cold neutron source (CNS) facility in 2000. The commissioning of the CNS was followed by the replacement of the former neutron guides by new supermirror guides in both the in-pile and out-of pile sections. In the following years the focus of development gradually shifted towards the improvement of quality and reliability of the experiments and of the sample environment.

The mission of BNC is to provide research opportunities for - according to an ENSA survey - about 500 potential neutron users in the Central-European region. BNC maintains an open access user programmethrough a peer-reviewed proposal system advised by an International Scientific Council.BNC has participated in several EU-supported programmes like NMI3 (Integratedas Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy), SINE2020 (Science and Innovation with Neutrons in Europe in 2020), BrightnESS (Building a Research Infrastructure and Synergies for Highest Scientific Impact on ESS), CERIC (Central European Research Infrastructure Consortium), IPERION CH (Integrated Platform for the European Research Infrastructure ON Cultural Heritage) and ERINDA (European Research Infrastructures for Nuclear Data ApplicHeritage

The BRR and BNC are strongly committed to train the future generation of professionals. In cooperation with Hungarian universities (Budapest University of Technology and Economics, Roland Eötvös Uni-

versity of Sciences, Budapest, the University of Pannonia, Veszprém), BNC accommodates students for laboratory practices in studies of nuclear science and technology. In collaboration with IAEA, BNC organizes nuclear science and technology oriented training courses for international students on a regular basis. The Budapest Research Reactor is open to tours by the general public

Budapest Neutron Centre (BNC) consortium was founded by three research institutes (KFKI Atomic Energy Research Institute, the Research Institute for Solid State Physics and Optics, and the Institute of Isotopes) of the Hungarian Academy of Sciences in 1993 to co-ordinate research activities associated with the Budapest Research Reactor (BRR) on the KFKI science campus. In 2005, a fourth institute, the Research Institute for Particle and Nuclear Physics joint the consortium. With the reorganization of the Hungarian research network, BNC is now a consortium of the Centre for Energy Research (CER) and the Wigner Research Centre for Physics (Wigner CRP). BNC is legally represented by the CER.

Website of BNC: www.bnc.hu


CERTIFICATE of RECOGNITION

This is to certify that

Budapest Neutron Centre

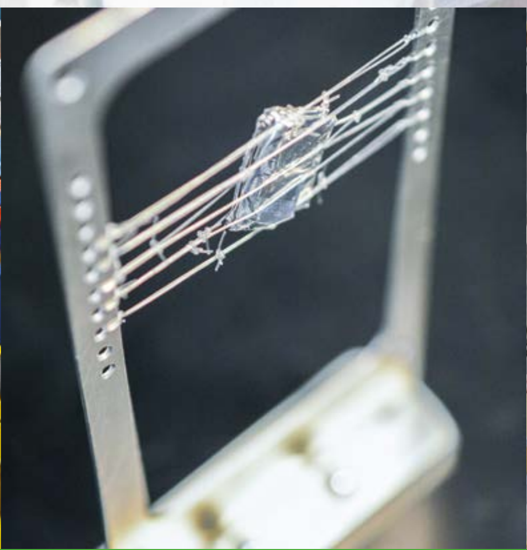
is recognized as an

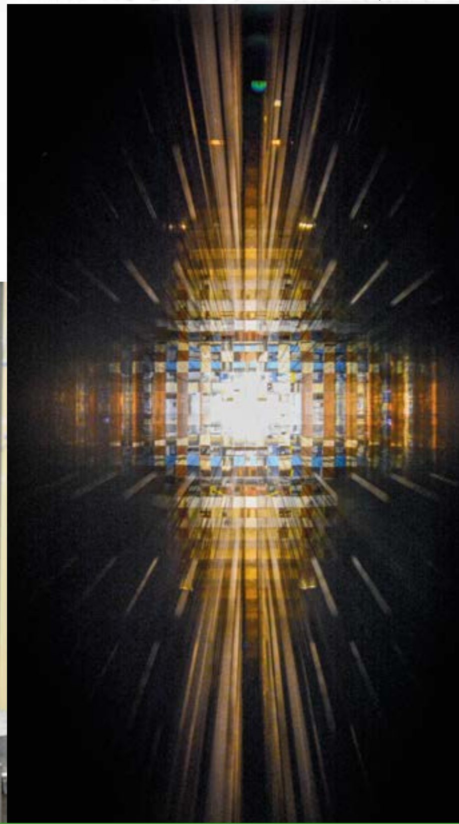
EXCELLENT RESEARCH INFRASTRUCTURE in HUNGARY

in terms of its scientific performance and international collaboration.

Awarded by

the National Research, Development and Innovation Office Budapest, Hungary





Budapest Research Reactor

Head of the Reactor Department:
Péter Juhász

The Budapest Research Reactor (BRR) is a VVR-type (water-cooled, water-moderated) Soviet design reactor. It went critical in 1959. The initial thermal power was 2 MW. The second reconstruction was a full-scale upgrade project started in 1986, and finished in December 1992. The upgraded 10 MW reactor received the operation license in November 1993.

After restarting the reconstructed reactor was operated around 2500-3000 hours on annual average.

The reactor license is still valid until December 2023. That's why we have begun preparing the lifetime extension according to legislation and guidelines

Utilization:

Since its initial criticality, the BRR has been utilized as a neutron source for research and various industrial and medical applications.

The scientific utilization of the research reactor is coordinated and managed by the Budapest Neutron Centre, which is a consortium founded by four academic institutions in 1993. Under the guidance of the BNC, the 15 measuring sites opened a possibility for BRR to be a regional centre. BNC participates in several EU supported programmes : www.bnc.hu In the framework of these programmes European scientists can get access to the BRR experimental facilities.

The reactor will be utilized not only scientifically but also as a service provider.

The production of radioactive isotopes for use in healthcare and industry is the most important, but irradiations of various structural materials is also significant..

Safety and security policy

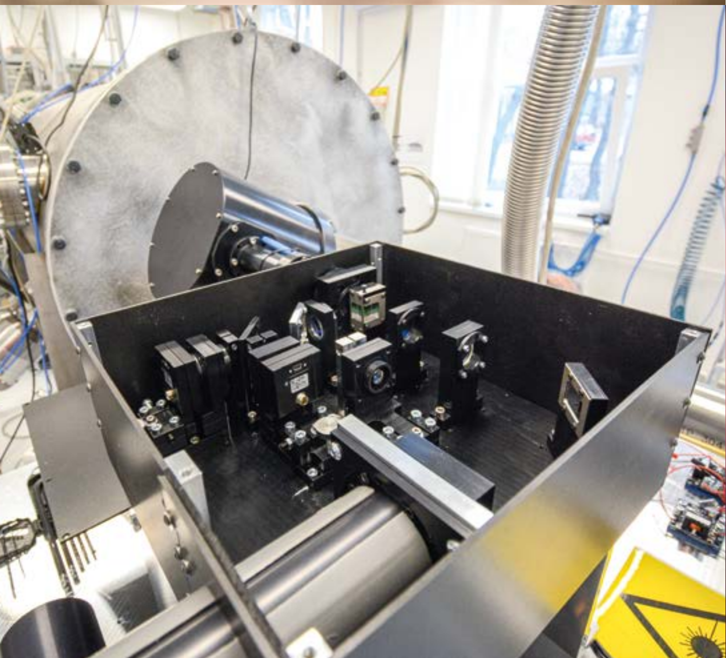
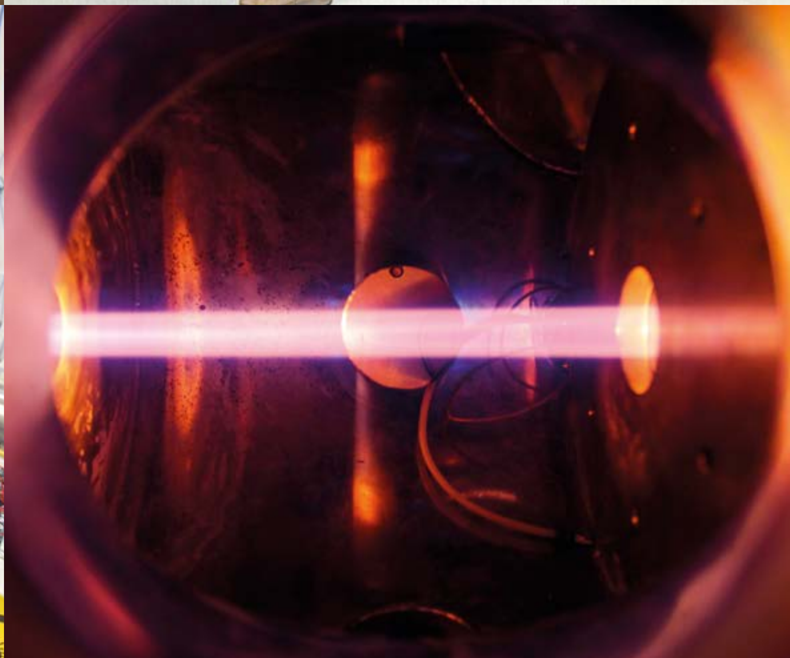
Since the commissioning of the reactor in 1959, a very strict and consistently advocated approach has prevailed in the research reactor safety policy, according to which safety is the first and foremost requirement in the operation of the reactor.

The transparency is part of our safety and security policy.

Therefore traditionally, now for more than twenty years, the reactor can be visited with a professional presentation or guidance, after a pre-registration.

The reactor can be visited with a simple entry permit application.. The visit can be organized at a pre-arranged time.



Institute for Atomic Energy Research

Director:
Dr. Ákos Horváth

The state-of-the-art is connected to the basic and applied research in the fields of reactor physics and nuclear reactors, reactor core simulations, safety assessments of nuclear power plants, safety aspects of transportation and storage of nuclear materials, radiation damage, as defined in the Law on the application of nuclear energy.

Main points are:

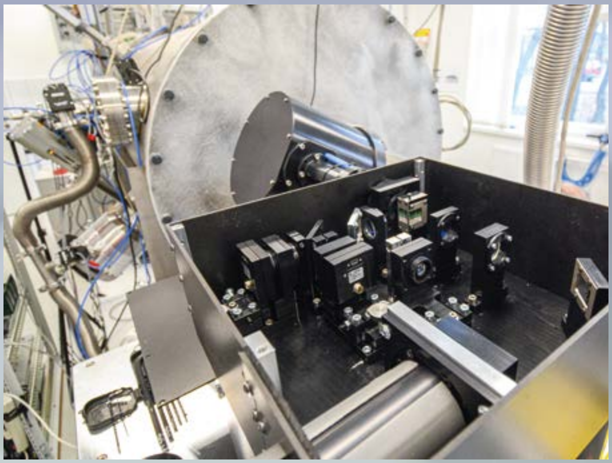
- development of multi-physics modeling and advanced numerical simulation tools
- research on reactor materials
- research related to fuel cycle modernization and radioactive waste management
- Generation IV reactor systems
- research related to nuclear power plant technology
- radiation protection, biological effects of radiation
- nuclear security and nuclear forensics (IAEA Collaborating Centre)
- space science
- fusion energy research
- development and utilization of the 10MW Research Reactor infrastructure

Departments:

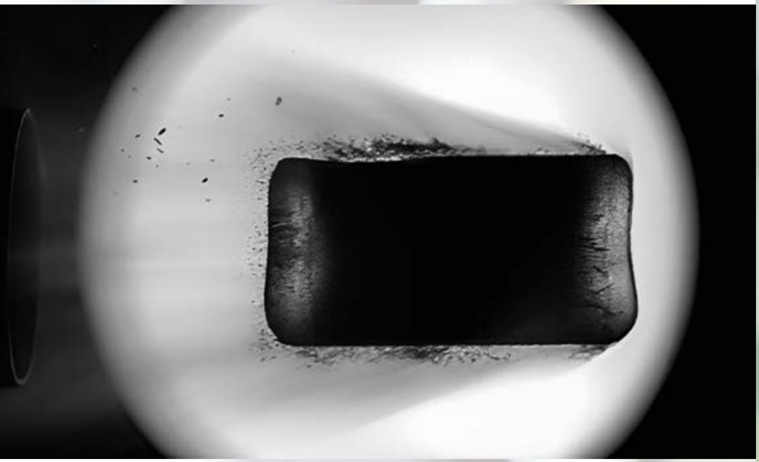
- Fusion Plasma Physics Department
- Fusion Technology Department
- Fuel and Reactor Materials Department
- Nuclear Safety Department
- Reactor Monitoring and Simulator Department
- Nuclear Security Department
- Radiation Protection Department
- Space Research Department

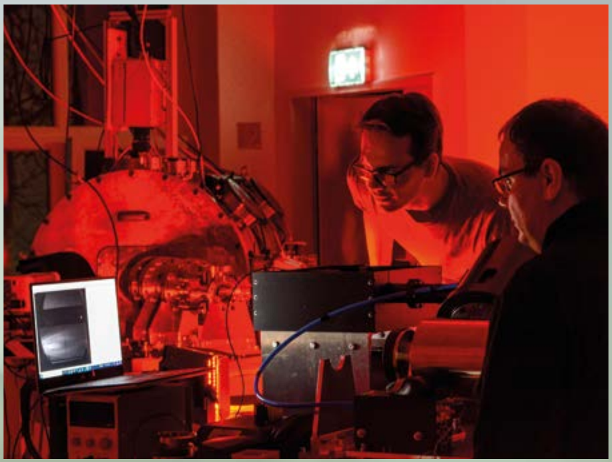
Fusion Plasma Physics Department

Head of Department:
Dr. Sándor Zoletnik

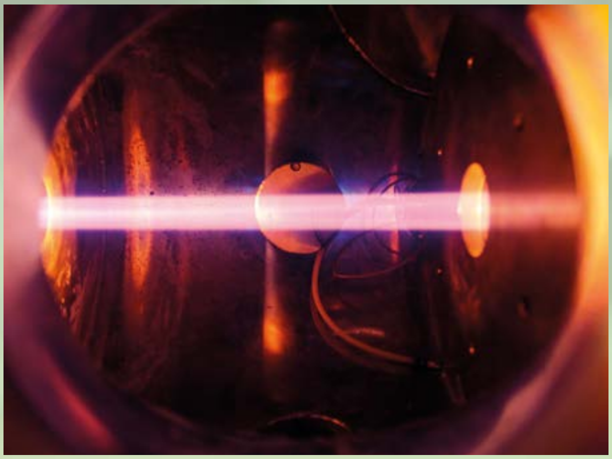


The research field of the department is controlled fusion energy production and related technologies. It builds and operates plasma diagnostic systems for the world's largest present-day magnetic fusion experiments. These diagnostics utilize original technologies developed at the department: special real-time processing video cameras, alkali beam accelerators, high-speed

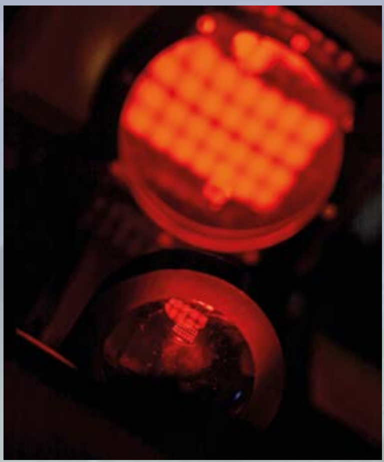




and high sensitivity light detection setups. For future devices it participates in the design of the DONES fusion materials testing facility, development of Shattered Pellet Injector technology for ITER and engineering solutions for the European DEMO fusion reactor.

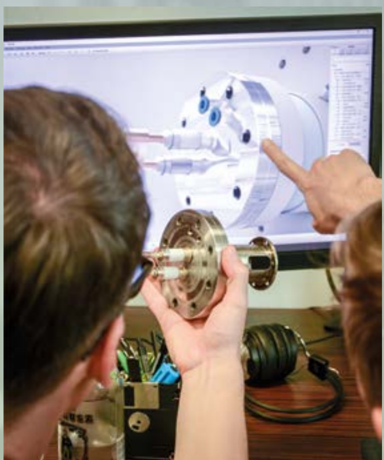


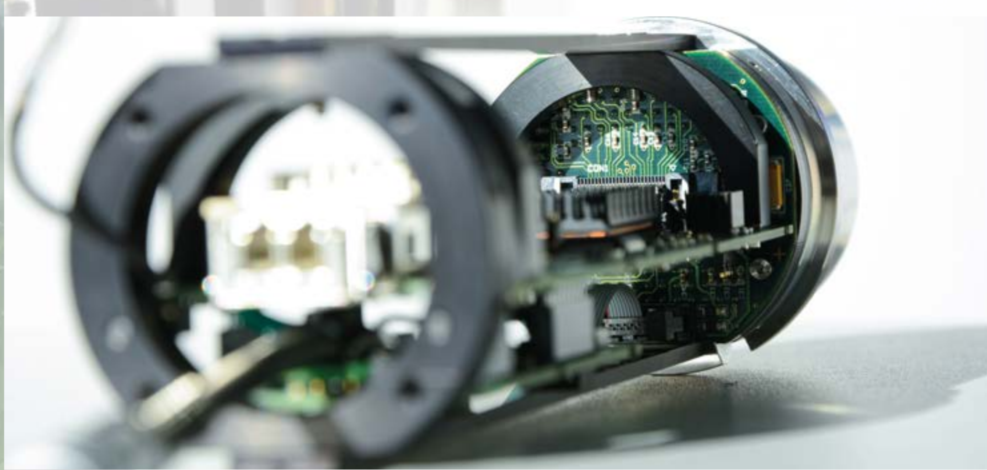
Most of the diagnostics developed for large international fusion experiments are operated by researchers of the laboratory in order to study phenomena in these high temperature plasmas. For data analysis various statistical evaluation



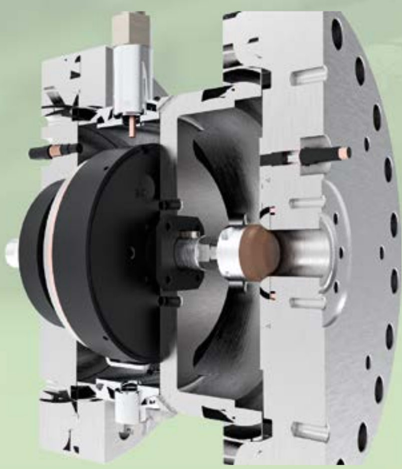
methods and modelling codes developed. The physics results are published in leading scientific journals of the field.

During its research the department collaborates with a large number of fusion laboratories around the world and participates in the following experiments: JET(EU), MAST-Upgrade (UK), ASDEX Upgrade, Wendelstein 7-X (Germany), COMPASS (Czech Republic), KSTAR (South Korea), EAST (China), JT-60SA (Japan). Most of the work is performed in the framework of the EUROfusion consortium with support of the European Union. The Hungarian Eurofusion participation is coordinated by the department.



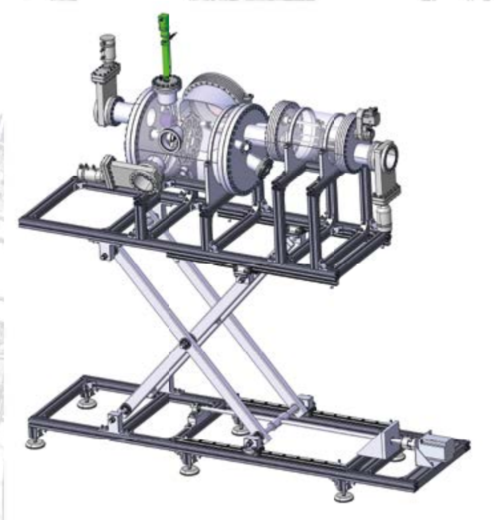


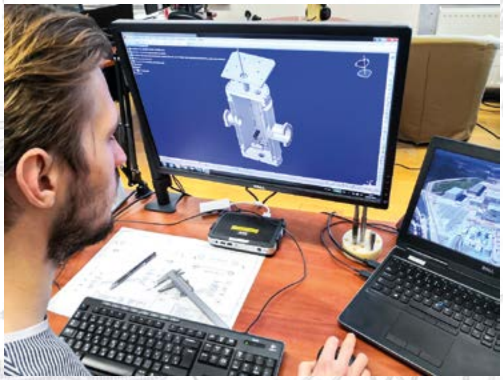
The activities of the department encompass basic research, technology development, hardware design and construction, therefore the staff is composed of a nearly equal number of engineers and physicists. Specialist services and manufacturing tasks are performed by a pool of trusted subcontractors. Collaboration with universities and training of students from B.Sc. to Post. Doc. level is also an important element of the activities.



Head of Department:
Dr. Gábor Veres

The Fusion Technology Department seeks solutions to technology related issues that emerge during controlled nuclear fusion research. Our most important activity areas are connected to offering engineering services for large research infrastructures, such as ITER, DEMO and IDONES. These include all kinds of services from systems engineering through detailed design to prototype manufacturing and testing, up-to the installation of the final product.





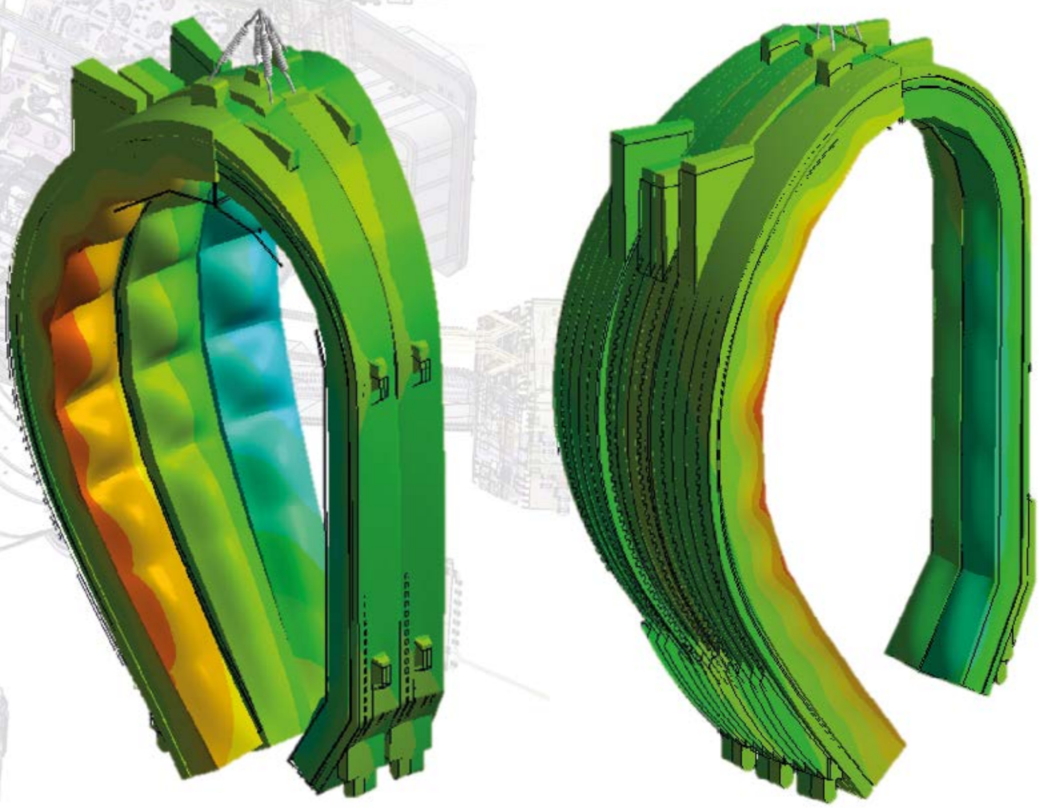
ITER:

The ITER (International Thermonuclear Experimental Reactor) project is run in a wide international collaboration in Cadarache, southern France, with the aim to demonstrate the technical and technological feasibility of fusion energy production. Fusion related activities worldwide are focused on the realisation of this goal and project.
Our collaboration with colleagues who work directly on ITER in France dates back to many years, our laboratory is the main contact in Hungary. As an example, during the past ten years members of our laboratory, have largely contributed to the development of the electric infrastructure that will be responsible for the transmission of diagnostics signals inside the ITER's vacuum vessel and from inside to the outside of it. These diagnostics signals include quantities of plasma physics importance, such as radiation, temperature, etc., or quantities related to magnetic fields or device security. This infrastructure consists of many tens of thousands of elements with many tens of kilometres of special mineral insulated cables and must reliably do its job during the entire 20 year's lifetime of the ITER machine. At present, our colleagues also deliver engineering support to the ITER Port Plugs & Diagnostics Integration Division in relation to the integration, analysis, design, real-size mock-up manufacturing and testing of diagnostics located in the lower vacuum vessel ports. The work also extends to the application of nuclear standards ASME and RCC-MRx for the validation of structural integrity of components.

ITER - EDM:

The Erosion Deposition Monitor (EDM) is one of the key ITER diagnostics, that guarantees the long lifetime of the divertor plates via measuring their erosion rate under high power plasma discharges. The design, testing and manufacturing of the complete diagnostics is the task of a consortium composed of Hungarian stakeholders only, including the engineers of CER's Fusion Technology Department. The central unit of this diagnostics located below the divertor dome will be manufactured by an advanced technique, by Hot Isostatic Pressing welding. Fundamental physical-technological aspects of the HIP welding process are also actively studied by our engineers.

Although our colleagues take mainly part in the engineering development of various ITER diagnostics subsystems, our engineers also contribute to the development of diagnostics equipment for other fusion research devices (e.g. MAST – UK and COMPASS – CZ) and also deliver auxiliary engineering services for other departments of the research centre.



Fuel and Reactor Materials Department

Head of Department:
Dr. Zoltán Hózer

The experts of the Fuel and Reactor Materials Department investigate the behavior of nuclear fuel and different reactor components using experimental facilities, material testing methods and numerical modelling. The activities of the department focus on the topics related to VVER-440 reactors used at Paks NPP, but several projects deal with new reactor types and fusion technology. The department regularly participates in international EU, OECD and IAEA projects.

The fuel related research covers normal operational conditions in the reactor, design basis and severe accidents, wet and dry storage of spent fuel assemblies.

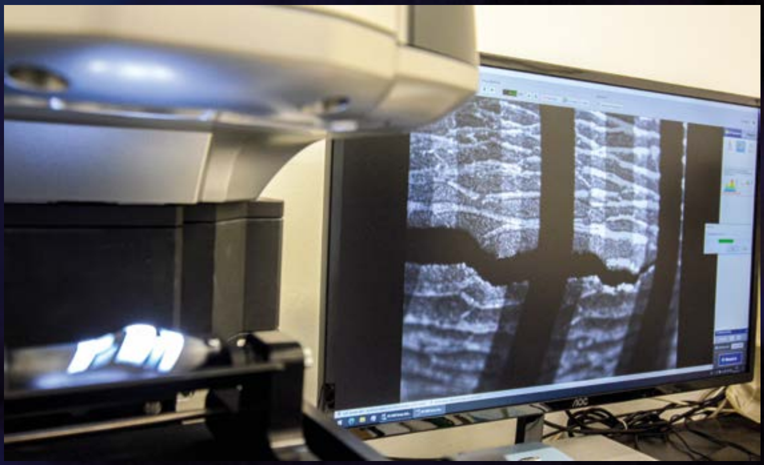
The experimental works focus on the investigation of zirconium alloy cladding applied in nuclear fuel elements. Separate effect tests on the oxidation, embrittlement, hydrogen uptake, plastic deformation and burst of Zr cladding material are investigated in small scale facilities. High temperature facilities have been built for the investigation of fuel behavior during incidents and accidents. Integral tests with electrically heated fuel assemblies can be performed in the CODEX facility. Computer codes are applied for the safety analyses of fuel behavior in nuclear power plants. The development and validation of codes is highly supported by the experimental programs.

The reactor materials investigations are carried out by two independent research groups:

Fuel and Reactor Materials Department

The Reactor Material Research Group investigates the irradiation effects of different materials using the BAGIRA irradiation channel in the Budapest Research Reactor. In order to characterize the aging of reactor vessel steel, mechanical tests and microstructure examinations are performed with specimens from the surveillance program at Paks NPP. Experimental testing and wide range of examinations are carried out with different perspective materials for fusion and fission technologies.

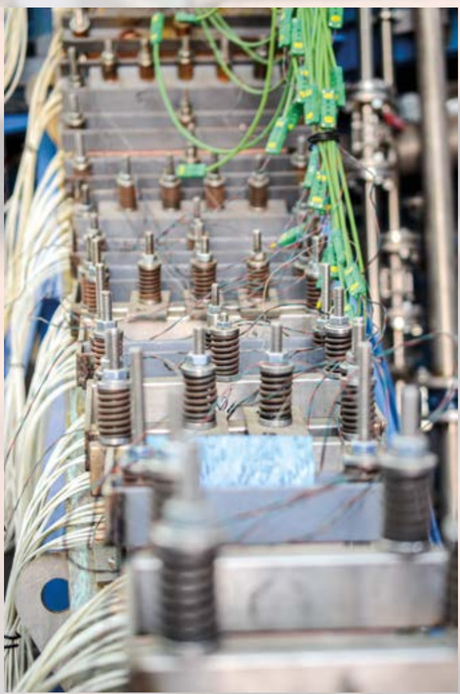
The Structural Integrity Research Group deals with the development of theoretical and numerical models for the safety analyses of reactor vessels and other large NPP equipment. The experts of the group developed sophisticated numerical models for the investigation of pressurized thermal shock phenomena in nuclear reactor vessels, which allows them to carry out thermomechanical and fracture mechanics calculations for the existing VVER-440 units and for the planned VVER-1200 reactors.



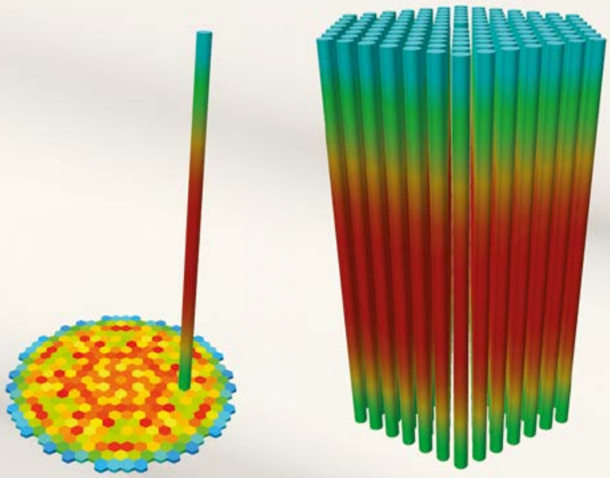
Head of Department:
Dr. István Panka

The Department is composed of the Reactor Analysis and Thermohydraulics Groups and focuses mainly on researches related to deterministic safety analyses of different generations of nuclear reactors.

Traditionally, the activity of the Reactor Analysis Group covers the development, validation and application of static and kinetic neutron physics calculation tools for Light Water Nuclear Reactors, moreover their coupling to thermohydraulic and thermal mechanics models. Special attention is paid to the reactors of VVER-440, VVER-1000, VVER-1200 power plants and to the VVRSM Research Reactor of EK which can be analyzed by own developed codes: the KARATE code system for the core design, the KIKO3D dynamic code for safety analyses. The quantification of computational accuracy (validation), the reduction of uncertainties, the application of developed methods for specific purposes (e.g. licensing) are also an important part of R&D. For validation, criticality experiments, benchmark exercises and measurements in nuclear power plants are used. The developed and validated codes enable to perform the following investigations: safety analyses of the RIA and ATWS events for licensing of new cores, fuel types and power upgrade, design of the reactor cores including periodic reloading, etc.



The Thermohydraulics Group has acquired important experience in the thermohydraulic analysis of VVER-type reactors, both in experimental and in analytical fields. The PMK-2 facility is an integral-type scaled model of the primary and partly the secondary circuit of Paks NPP. On the basis of the experiments conducted thermohydraulic system code validation was performed (RELAP5, ATHLET and CATHARE), ensuring proper applicability for safety studies of VVER power plants. Experimental evidence aided in developing accident management strategies for various accident scenarios like in case of secondary side bleed and feed procedure. Number of the NPP's safety enhancement projects have been supported by computer analysis made by RELAP5 and ATHLET codes. A research program had been set up at the Institute to give scientific support to address the vessel coolability at the very unlikely condition of total core melting. To clarify the uncertainties related to the physical processes occurring in such a severe accident an integral type experimental facility CERES (Cooling Effectiveness on Reactor External Surface) was built. Measurement series performed prove the applicability of the concept which led to a major safety increase in the power plant.



The research carried out in the Department has contributed significantly to the earlier power upgrade at Paks NPP and the introduction of new fuel types (most recently „slim fuel"). For Paks II, independent safety analyses were carried out. The continuous study of the normal operation and the accident conditions of the power plant ensured the high quality of the safety analysis reports prepared for the licensing the NPP.

One of the major innovations of coming decades in nuclear engineering will be the development of Gen IV NPPs. Recently, studies on sodium-cooled fast reactor types have continued: the KIKO3DMG code has been validated in an IAEA project through the China Experimental Fast Reactor (CEFR). In the field of gas cooled reactors, the design of the ALLEGRO demonstrator reactor has been under way for a long time. Research on the ALLEGRO reactor is ongoing in the framework of the EU H2020 SafeG project, and the Department plays a key role in core design and safety analysis.

Reactor Monitoring and Simulator Department

Head of Department:
Dr. Gábor Házi

The Reactor Monitoring and Simulation Department is focusing on the development of

- on-line core surveillance and analysis systems,
- noise diagnostics systems,
- nuclear power plant simulation systems,
- reactivity measurement systems,
- operator support and expert systems.

To be applied mainly at nuclear power plants of VVER-440 type. The staff of the department consists of experienced reactor physicists, electrical and mechanical engineers, system and application programmers.

Traditionally the Department is responsible for the development and maintenance of the VERONA core monitoring system, operated at all four units of the Paks NPP. The present version of VERONA is the result of a sequence of refurbishment projects aimed to create a system supporting reactor power increase, the application of new fuel containing burnable poison and the extension of the length of fuel cycles to 15 month. Another traditional R&D activity at our Department is the development of reactor noise diagnostic measurement methods, complete noise data acquisition systems and interpretation tools. Our Department has been performing regular noise measurements at Paks NPP since 15 years, providing valuable information on the long term trends of core behavior. The full-scope simulator NPP of Paks was developed by the Simulator Department in the eighties in co-operation with Nokia Afora (Finland). The full-scope simulator is an indispensable tool for training control room personnel . The

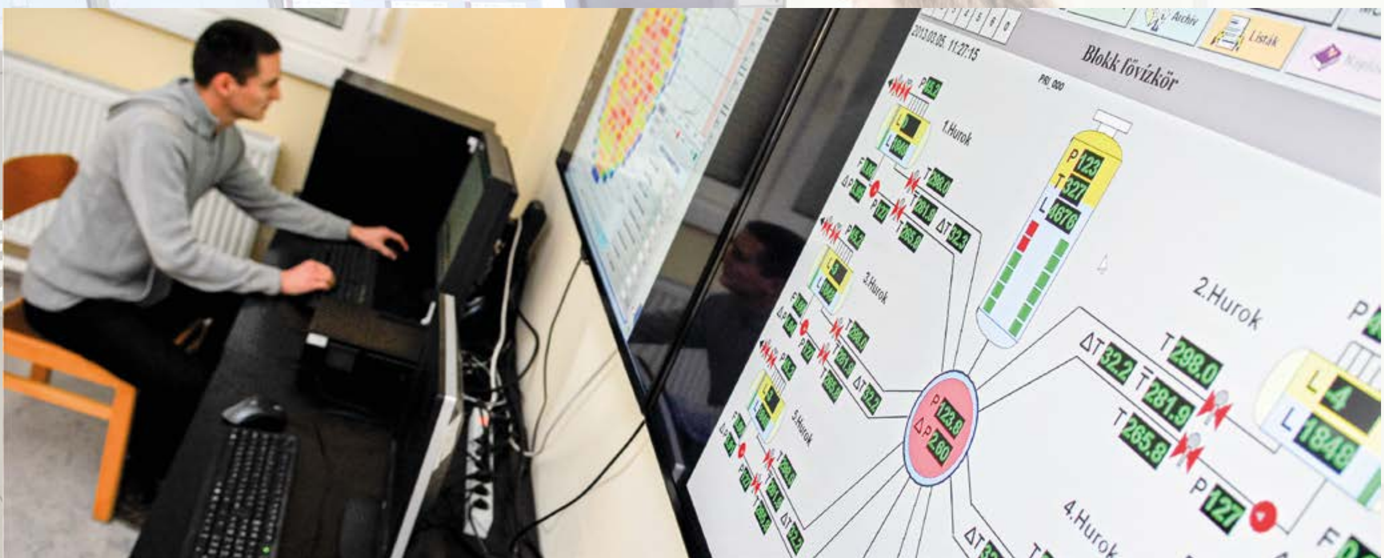
staff of the lab modernized the model system of the simulator at the beginning of this century, introducing the application of a new, 3D core neutronics and a new, two-phase thermal-hydraulics model .

The lab also contributed to the development of several technological information systems, including the plant computer system of Paks NPP, where the Critical Safety Monitoring System was designed, developed and commission by our staff a few years ago.

The implementation of a new refueling neutron monitoring and reactivity measurements system (its Hungarian acronym is ÁNEREM) using a new type of neutron detector was finished in 2020 in each unit of Paks NPP, significantly simplifying the startup measurements of the reactors.

The radiation and environmental monitoring system of Paks NPP applies five different types of measurement stations. The system consists of more than forty stations, which are placed around the plant in a circle having 1.5 km radius. One of the conclusions of the stress-test performed after the events of Fukushima was that the resistance of these stations to earthquakes and station blackout needs to be improved. The design and implementation of the new stations is an ongoing work, and it is being done by our staff.

The CERTA (Centre for Emergency Response, Training and Analysis) VITA system, developed by our laboratory, maintains an online data link between the four units of Paks NPP and the Hungarian Atomic Energy Authority (HAEA). It collects and displays more than 500 selected data from each unit and from the full-scope simulator of the NPP. In 2015 further development of this system was started and successfully finished with the aim to extend the capabilities of CERTA VITA with the online monitoring of safety related measurement data of the Budapest Research Reactor (BRR).



Nuclear Security Department

Head of Department:
Dr. Péter Völgyesi

The activities of the Nuclear Security Department (NSD) cover research and practical application in the field of nuclear security and nuclear safeguards, as well as professional support for domestic and international organizations and companies. The research, method development and technical service tasks are carried out in several closely cooperating groups: non-destructive (gamma spectrometry and neutron measurement), destructive (alpha and mass spectrometry), dosimetry, instrument development, detection and mobile expert support team, and a detector testing laboratory.

One of the main activities of the NSD is to participate in combating illicit trafficking of nuclear materials and nuclear terrorism (misuse of radioactive materials). The professional on-site analysis and laboratory measurement of unknown nuclear or other radioactive materials found or seized (ie nuclear forensic examination), is delegated to the Centre for Energy Research by a Governmental Decree (490/2015 (XII.30). The NSD maintains a mobile expert support team and a preparedness service to carry out the activities described by this Decree and, if necessary, to perform on-site investigations and to transport radioactive materials with unknown origin to the KFKI site. The other task of the mobile laboratory is to secure major public events with its hand-held and remote radiation detection capacity. In the field of nuclear forensics, EK was nominated to a Collaborating Center of the International Atomic Energy Agency in 2016.

A detection test laboratory, with which we have successfully participated in international projects and comparisons, is operated at our department to further support nuclear security. Due to the experience on detection capabilities and wide range of nuclear and other radioactive materials available at our site, the team of the NSD is working closely together with radiation detector manufacturers to develop more efficient and faster radiation detectors (e.g. portal monitors and border security systems).

In recent years, a special operating procedure has been developed for radiological crime scene management in close cooperation with the Rapid Response and Special Police Services, National Bureau of Investigation, Criminal Forensic Department to respond specific scenes where nuclear or other radioactive material is present. A training facility has been established to serve national and international purposes by providing an opportunity for first responders to test and practice operating procedures using various type of scenarios. Connecting to nuclear security the NSD is participating in several international projects.

NSD is carrying out scientific support activities related to the nuclear safeguards based on decades of relationships with the Paks Nuclear Power Plant, the Hungarian Atomic Energy Authority and the International Atomic Energy Agency.

The NSD also supports the Hungarian nuclear industry (mainly Paks Nuclear Power Plant) within the framework of long term cooperation with its research and development activities related to industrial applications (e.g. measuring the burn up of fuel assemblies, measuring the enrichment of fresh fuel assemblies, analysis of corrosion products). In addition, the department provides an expert background and performs professional tasks to support the various official activities of the Hungarian Atomic Energy Authority.

Radiation Protection Department

Head of Department:
Dr. Tamás Pázmándi

The Radiation Protection Department was established in January 2012 and researchers of the department deal with several aspects of radiation protection. The main research activities focus on identifying the uncertainties of the measured or calculated results and on the ways to reduce them.

The scope of the activities in the department is on:

- personal dosimetry, including measurement and modelling of internal and external exposure to ionizing radiation.
- environmental dosimetry with the aim to increase the accuracy of real-time, periodic and sampling measurements used in environmental radiological monitoring;
- model, algorithm and software development for calculations of atmospheric and hydrospheric activity dispersion in the environment and inside the buildings as well as estimating dose consequences for emergency preparedness and safety analysis of nuclear facilities.

Radiation Protection Department

In addition to perform safety analyses of operating and planned nuclear power plants, researchers of the department are involved in the preparation of several regulatory guidelines in the fields of monitoring of internal exposure of workers, optimization of environmental radiation monitoring and verifying compliance with atmospheric release criteria in safety analysis of nuclear facilities.

Models for atmospheric dispersion, dry and wet deposition, cloudshine and groundshine doses, dose consequences of inhalation and ingestion were developed in the recent years.

SINAC environmental simulator developed to follow the consequences of radioactive releases of a (hypothetical) nuclear accident is used as an interactive decision support system in the Hungarian Atomic Energy Authority Centre for Emergency Response, Training and Analysis.

In the recent years an improved method and software tool was developed for confirming compliance with release criteria for nuclear facilities. The method is used for safety analyses of operating and planned nuclear power plants in Hungary.

Space Research Department

Head of Department:
Dr. Attila Hirn

Centre for Energy Research (EK) is one of the research institutes having the biggest space heritage in Hungary. As a result, the number of space instruments or detectors made in EK or its predecessors and delivered to space on board geophysical rockets, satellites, interplanetary space probes, manned spacecraft and space stations is close to a hundred.

The predecessor of the Space Research Department, the Space Electronics Group (later Space Dosimetry Research Group), was founded in 1970. In the past half century, parameters of micrometeorites and characteristics of the Earth's ionosphere were measured; solar wind parameters as well as the plasma around comet Halley and planet Mars were studied with the help of instruments developed by the researchers and engineers of the laboratory. Significant contribution was made to two scientific payloads on board Rosetta lander Philae, with which measurements were conducted on the surface of comet 67P/Churyumov-Gerasimenko. The Pille on-board thermoluminescent dosimeter (TLD) system developed by the institute is unique in the world. Since 1980, different generations of the instrument have been used on several Russian and US spacecraft and space stations, as well as for environmental dosimetry on the Earth. The latest version of the Pille system has been continuously operated as part of the service dosimetry system in the Russian segment since 2003. Pille is indeed an important contribution of Hungary to the largest international space laboratory of the world. For the invitation of the European Space Agency (ESA), the Space Research Department is currently working on the feasibility study and the basic concept of the Internal Dosimetry Array (IDA) instrument suite, which will be the first European internal scientific payload on the Lunar Gateway, the space station to be built in the frame of the Artemis programme in lunar orbit. IDA will also include the TRITEL 3D silicon detector system, developed in EK.

Space Research Department

The main research areas:

- Space dosimetry (dosimetry mapping of the spatial distribution of space radiation, radiation dose monitoring, personal dosimetry, measurement of the dose distribution in antropomorphic phantoms, dosimetry support for biological experiments) with active (powered) and passive (non-powered) dosimeter systems; method, detector and instrument development.
- Space weather related method, detector and instrument development; simultaneous space radiation and geomagnetic field measurements.
- Radiation analysis including radiation environment description for different space missions/orbits, radiation transport calculations with Monte Carlo methods to provide estimation of total ionizing dose (TID) and linear energy transfer (LET) spectra.

Our projects are realized in international collaboration, mostly in the frame of European Space Agency programmes or in the frame of the Hungarian-Russian space research and space technology cooperation agreement.

In recent years, a space research development laboratory and space test centre, audited by the ESA, have been founded to provide test facilities also for domestic space industry, in accordance with ECSS space industry standards.

Forrás: NASA JSC

Webpage of the Space Research Department:
http://spacedosimetry.com

Webpage of EK's space industry spin-off company, REMRED Ltd.:
http://remred.space






Institute for Energy Security and Environmental Safety

Director:
Dr. Tamás Belgya

AThe research profile of the Institute shifted the emphasis of the research activities to perform:

improvement of nuclear analytical and imaging methods and their applications for energy and materials science, performing studies in the field of environmental physics related to energy generation and its impact on the public health and on environmental safety, study of environmentally benign and economic -"green"- catalytic and surface processes, storage of energy and in the field of renewable energies.

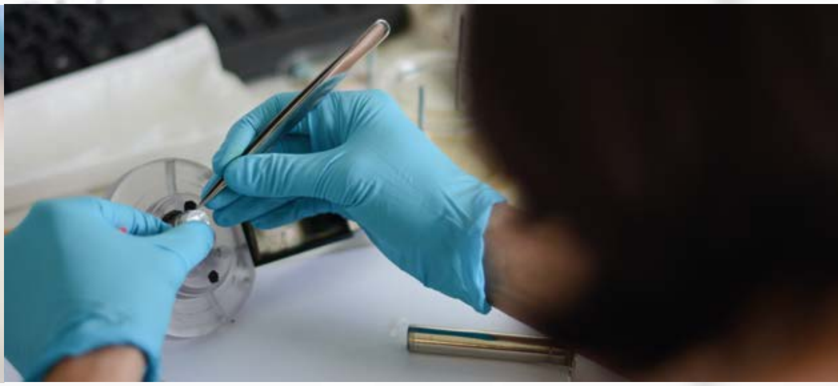
- green energy,
- energy mix optimization,
- radiation chemistry,
- radiation safety and security,
- nuclear reactions, analysis, application of radioisotopes,
- surface chemistry and catalysis.

Departments:
- Surface Chemistry and Catalysis Department
- Environmental Physics Department
- Neutronspectroscopy Department
- Nuclear Analysis and Radiography Department

Head of Department:
Dr. Tamás Ollár

Our laboratory deals with some important issues of efficient energy storage and use. We are investigating new catalytic systems for electro- and photoelectrocatalytic water splitting, and novel, environmentally benign catalytic conversions of greenhouse gases (such as CO_2 and CH_4) that result in the formation of CO and H_2 or pure H_2.

1. Electrolytic water splitting. One of the outstanding technologies of chemical energy storage relies on the use of pure hydrogen produced by electrolysis of water. The key issue is the development of more efficient components, the achievement of efficient and flexible energy storage and recovery. Our goals: modification of the surface of 2D materials in order to increase the electrocatalytic activity, developing grafting methods for molecule-nanomaterial electrocatalysts, atom-efficient use of metals in nanoma-

terials of mixed composition and their use as electrocatalysts, creation of bottom-up molecule-nanomaterial mixtures on carriers with tuned bandgap, characterization of water splitting cells based on new catalysts and increase the lifetime of laboratory-scale whole cells.

2. Catalytic conversions of greenhouse gases. The general aim here is to understand the relationship between catalyst structure and catalytic activity in order to give feedback to a new catalyst generation highly active and stable for sustainable utilization of methane. Methane and carbon dioxide in the low heating value natural gas or biogas can be converted by the so-called dry reforming reaction into syngas (DRM: CH_4+CO_2 -> $2CO+2H_2$) that can be further used in a subsequent catalytic step for the production of value-added products such as synthetic fuels. The other reaction being investigated is the methane pyrolysis carried out under inert atmosphere and so it does not produce CO_2 nor CO but pure, so-called turquoise H_2 and solid carbon. The composition and structure of the catalyst can influence the amount of pure H_2 product and also the morphology and purity of nanostructured carbon (ranging from nanotubes to carbon black).

Surface Chemistry and Catalysis Department

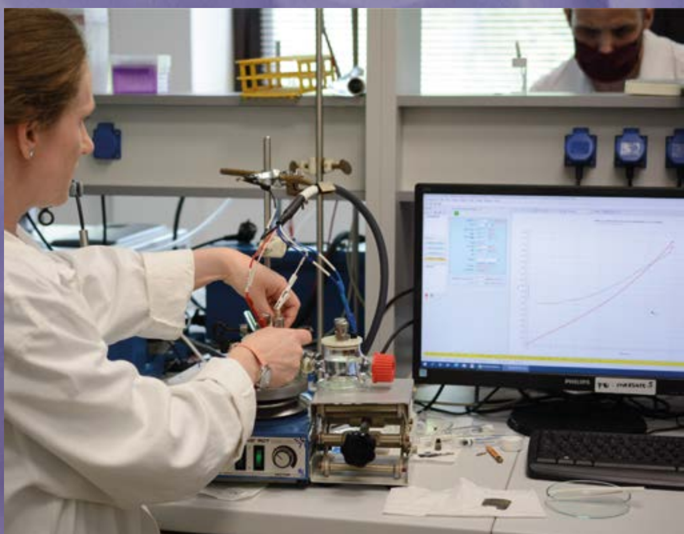
In addition to the main research topics, our laboratory also deals with the electrochemical investigation of corrosion processes and the quantitative determination of the components of fuels produced from renewable sources.

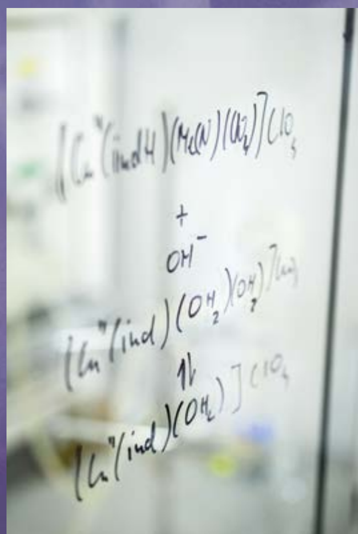
Competences:

- heterogeneous and homogeneous catalytic transformations
- catalyst, electro-catalyst design and characterization
- spectroscopic/structural/surface analysis
- modification of the surface of 2D materials
- production and application of nanoparticles (mono- and bimetallic)
- electrochemistry, electrocatalysis, corrosion
- liquid scintillation isotope analysis

Research fields:

- Development of electrodes for electrocatalytic water splitting, research of bottom-up catalytic systems for water splitting
- preparation of nanostructured, multicomponent metal and metal oxide catalysts and electro-catalysts investigation of their structure and catalytic properties
- catalytic activation and conversion of CH_4 and CO_2 molecules: investigation of structure-reactivity relationship on nickel-based catalysts
- electrochemical investigation of corrosion processes





Environmental Physics Department

Head of Department:
Dr. Árpád Farkas

The mission of Environmental Physics Laboratory is to carry out research on the environmental burden originating from different sources and on the human-environment interaction. The evaluation of the environmental impact of fossil, renewable and nuclear energy cycles and the quantification of health effects of environmental pollutants are also in the focus of our research.

Main research topics:

Research supporting final disposal of radioactive waste involving physico-chemical-geological investigations of natural barriers and optimization of multi-step engineered barriers by: (i) evaluation of host rocks selected for final disposal of high level and long-lived radioactive waste with respect to retardation of radionuclides, (ii) development of mixed actinide-lanthanide-containing borosilicate glass compositions for conditioning of radioactive wastes, (iii) determination of dissolution parameters for glass components. Corrosion study of metal containers applied as part of engineered barrier system for different surfaces (glass/steel/clay and glass/steel/concrete) and experimental conditions. Supporting

project: EU Horizon2020 EURAD-847593, https://www.ejp-eurad.eu/

Research on power and heat energy systems, building and city energy, energy meteorology and climate and energy statistics. Supporting project: VEKOP-2.3.2-16-2016-00011

Determination of solid atmospheric pollutants of energy generation and utilization origin. Development and application of sampling and measurement methods for morphological and chemical compositional characterization of submicron and ultrafine aerosol particles. Supporting projects: VEKOP-2.3.2-16-2016-00011, EMPIR 16ENV07 AEROMET, EMPIR 18ENV08 AEROMET II, http://www.aerometproject.com/.

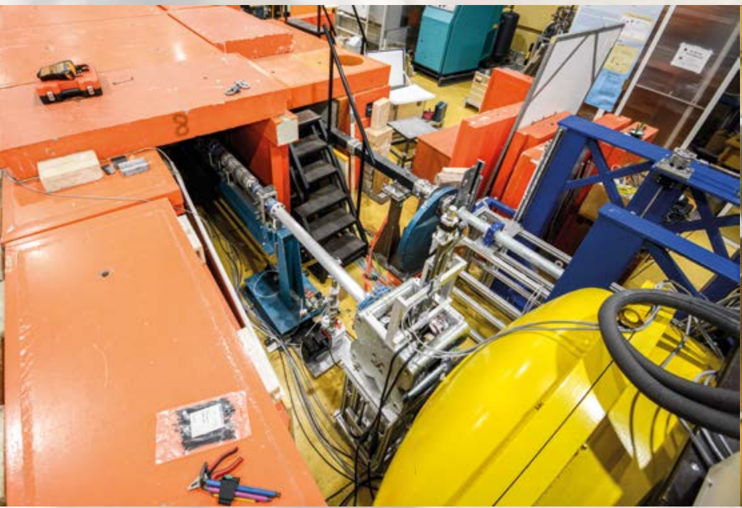
Our activities also cover research on the biological effects of ionizing radiation including but not limited to the modelling of deposition, clearance and decay of inhaled radon progeny within the human airways. Supporting project: RadoNorm, www.radonorm.eu. The developed methods are partly applicable also to inhaled non-radioactive particles such as aerosolized drugs, atmospheric aerosols, bioaerosols or fibres.

Research on neutron physics and radiation shielding of large European research facilities (e.g. ESS, ELI) Supporting project: European Spallation Source, https://europeanspallationsource.se/

Neutron Spectroscopy Department

Head of Department:
Dr. Zoltán Imre Dudás

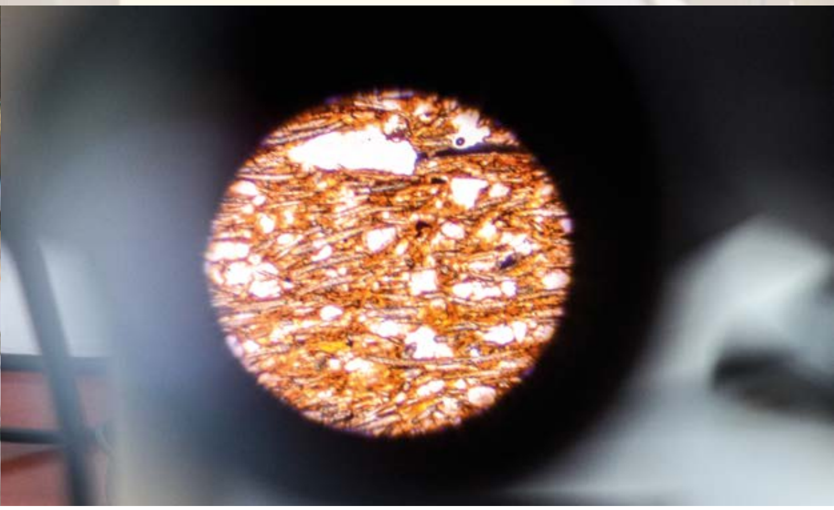
The researchers of the Department conduct basic and applied research of multidisciplinary subjects (such as studies related to photosynthesis, medical and pharmaceutical material research, archaeological science, energy storage research, neutron optics developments) mainly using neutron scattering. The Department operates nine large-scale neutron instruments within the user system coordinated by the Budapest Neutron Centre (BNC) to provide opportunities of neutron experiments for national and international research groups in an open access proposal scheme. The instruments operated by the Department are the two small angle neutron scattering spectrometers, the traditional-range SANS and the focusing FSANS, two reflectometers, GINA and REF, the thermal and cold neutron triple-axis spectrometers, TAST/HOLO and ATHOS as well as two diffractometer beam-lines, TOF-ND and MTEST. These facilities offer a plethora of experimental options and sample environments for very different types of specimens from liquids to solids, bulk to bio-membranes, powders through embedded nano-particles to foams not solely at ambient conditions, but at high to cryogenic temperatures, in vacuum and in gas atmospheres, with and without external magnetic field.

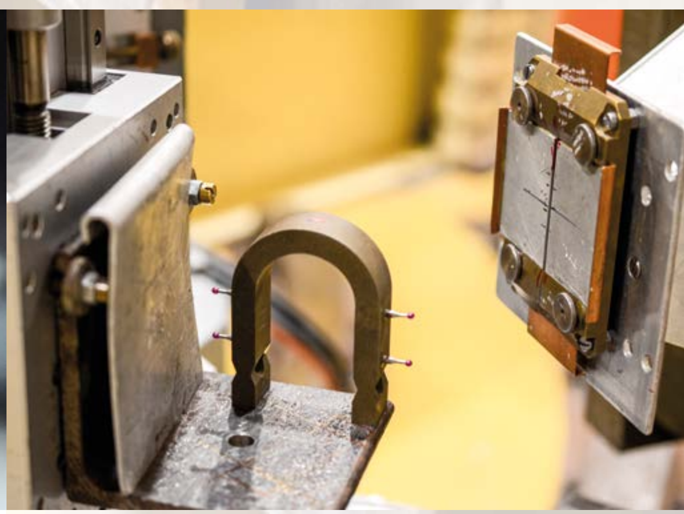


At the same time, a number of EU spported and direct contract projects of the Department are linked to neutron optics, neutron methodology and even industrial developments (CREMLIN+, EASISTRESS). The experience of the research staff in neutron instrumentation is favorably utilized in projects common with other neutron scattering centres (like ESS ERIC Lund, HZB Berlin, JINR Dubna) and industrial partners (e.g. Mirrotron Ltd., Budapest).

Several staff members deliver undergraduate and post graduate courses at different Hungarian Universities. Many of the staff tutor and lecture at specialized courses, like CETS, the bi-annual training course of the BNC for PhD and early career attendees.

More details can be found on BNC and the instrumentation at https://www.bnc.hu





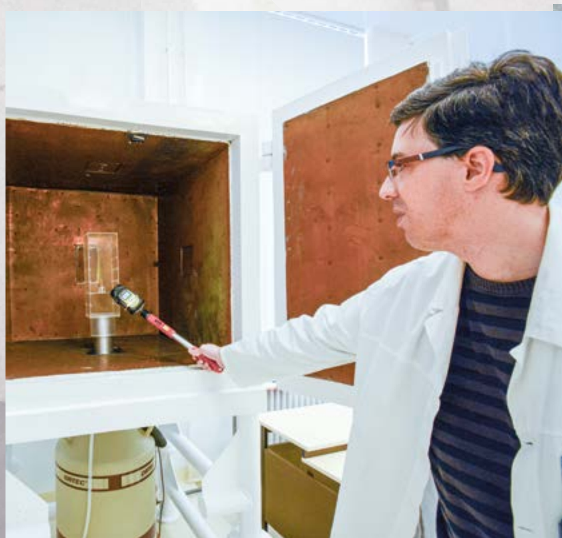
Nuclear Analysis and Radiography Department

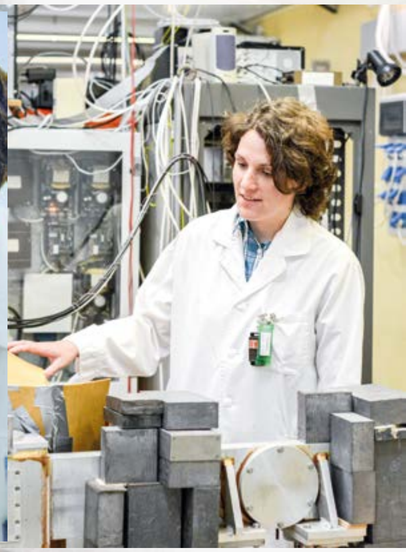
Head of Department:
Dr. László Szentmiklósi

The mission of the department is to utilize the neutrons produced at the Budapest Research Reactor, as well as complementary X-ray techniques, for nondestructive element analysis, imaging and macroscale structure analysis. These techniques rely on the complex interactions between the neutrons/gamma-rays/X-rays and the matter to characterize the sample's composition or structure.

Our lab is at the forefront of method development and applications of the following methods:

- prompt-gamma activation analysis and imaging
- neutron activation analysis
- handheld X-ray fluorescence analysis
- neutron radiography, -tomography with cold and thermal neutron beams
- dynamic neutron- and X-ray radiography and coupled nondestructive techniques
- in-situ element analysis and imaging in special sample environments
- determination of nuclear reaction cross-sections, nuclear structure data, and spectroscopic data to be used in NAA and PGAA
- radioactive tracing
- Mössbauer spectroscop





Nuclear Analysis and Radiography Department

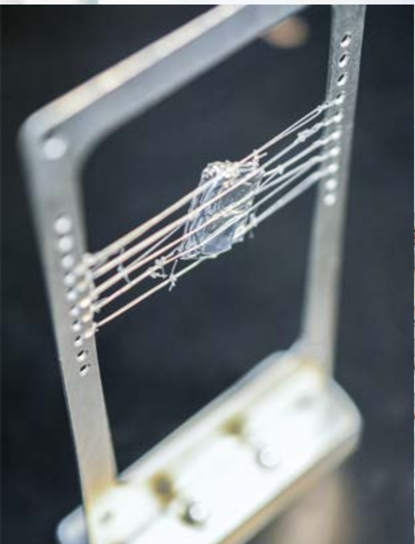
Seven large-scale facilities are operated by the Laboratory at the Budapest Neutron Centre:

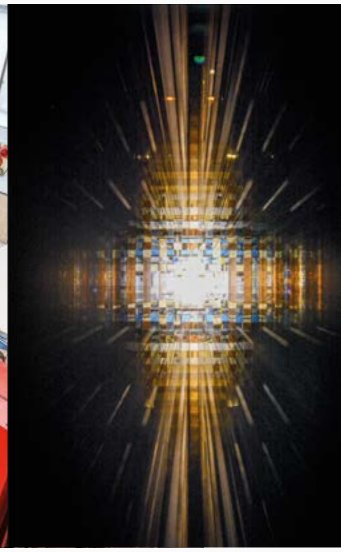
- Prompt Gamma Activation Analysis (PGAA) and Neutron Induced Prompt-gamma Spectrometry (NIPS) facility. The latter can be used with an imaging and 3D sample-positioning option (Neutron Optics and Radiography for Material Analysis, NORMA) as well
- Neutron Activation Analysis (NAA) laboratory
- Neutron- and X-Ray-Radiography (RAD) facility
- In-beam and conventional Mössbauer Spectroscopy (MS) facility
- Low-level gamma spectroscopy station (DÖME)

The main application fields are material science, geo- and cosmochemistry, cultural heritage science and nuclear physics. These facilities serve in-house research as well as external users. Four of the our facilities (PGAA, NIPS-NORMA, NAA and RAD) are open to the science community via transnational access programs (TNA) of the Budapest Neutron Centre (BNC), such as IPERION HS and ARIEL, as well as a partner of the distributed research infrastructure CERIC-ERIC. We are open to bilateral collaborations as well as industry-driven R&D activities.

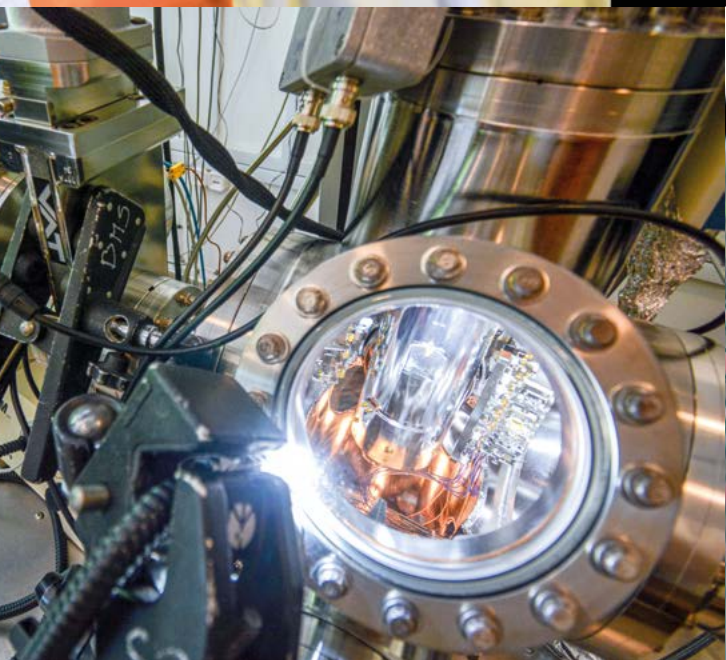
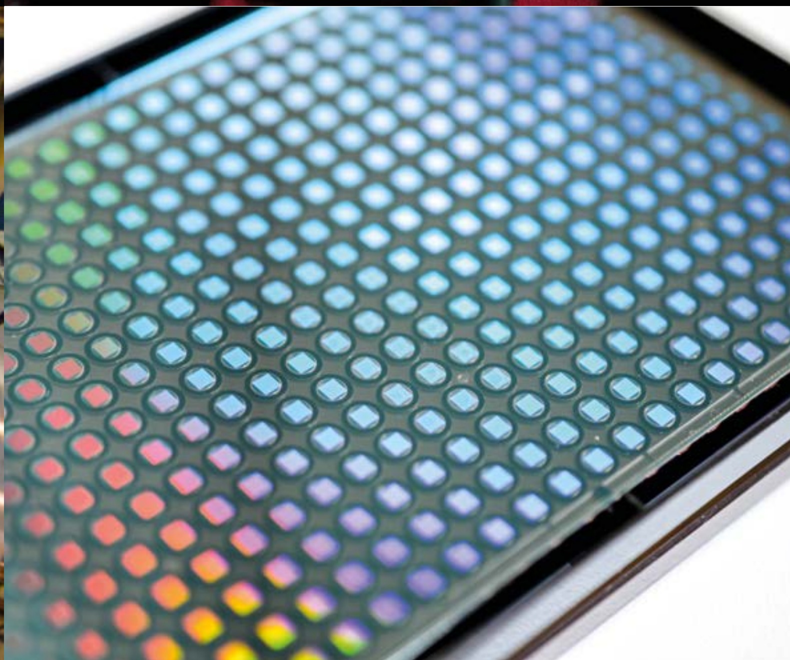
In addition to the experimental aspects, the lab has extensive expertise in gamma spectrum evaluation, nuclear data analysis, 2D and 3D image processing, 3D advanced visualization, as well as in Monte Carlo calculations with MCNP6 and geant4.

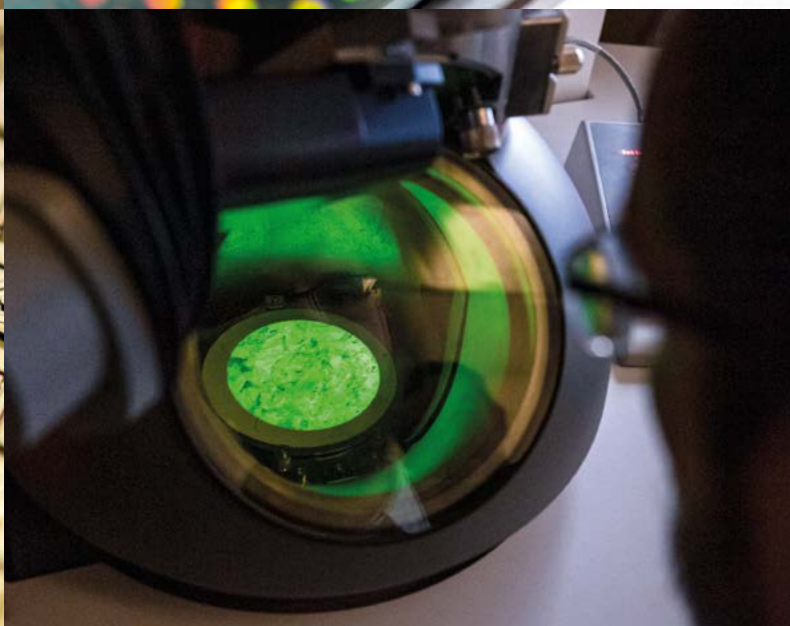
A BNC-ről és a berendezéseinkről további információt talál a www.bnc.hu honlapon.









Institute of Technical Physics and Materials Science

Director:

Dr. Béla Pécz

Interdisciplinary research on complex functional materials and nano-scale structures, exploration of physical, chemical, and biological principles, their exploitation in integrated basic phenomena and pathway of the formation of composite thin films.

Main topics of interest:

- engineering and characterization of nanocomposite thin films
- synthesis and engineering of various 2D nanostructures
- MEMS and MEMS related technologies
- development of microfluidic systems
- R&D on label-free optical biosensors
- development of non-destructive characterisation
- methods and the R&D on integrated photonic systems
- evolutionary game theory
- self-organization in complex systems

Departmens:

- Photonics Department
- Complex Systems Department
- Microsystems Department
- Nanobiosensorics Department
- Nanostructures Department
- Nanosensors Department
- Thin Film Physics Department

Photonics Department

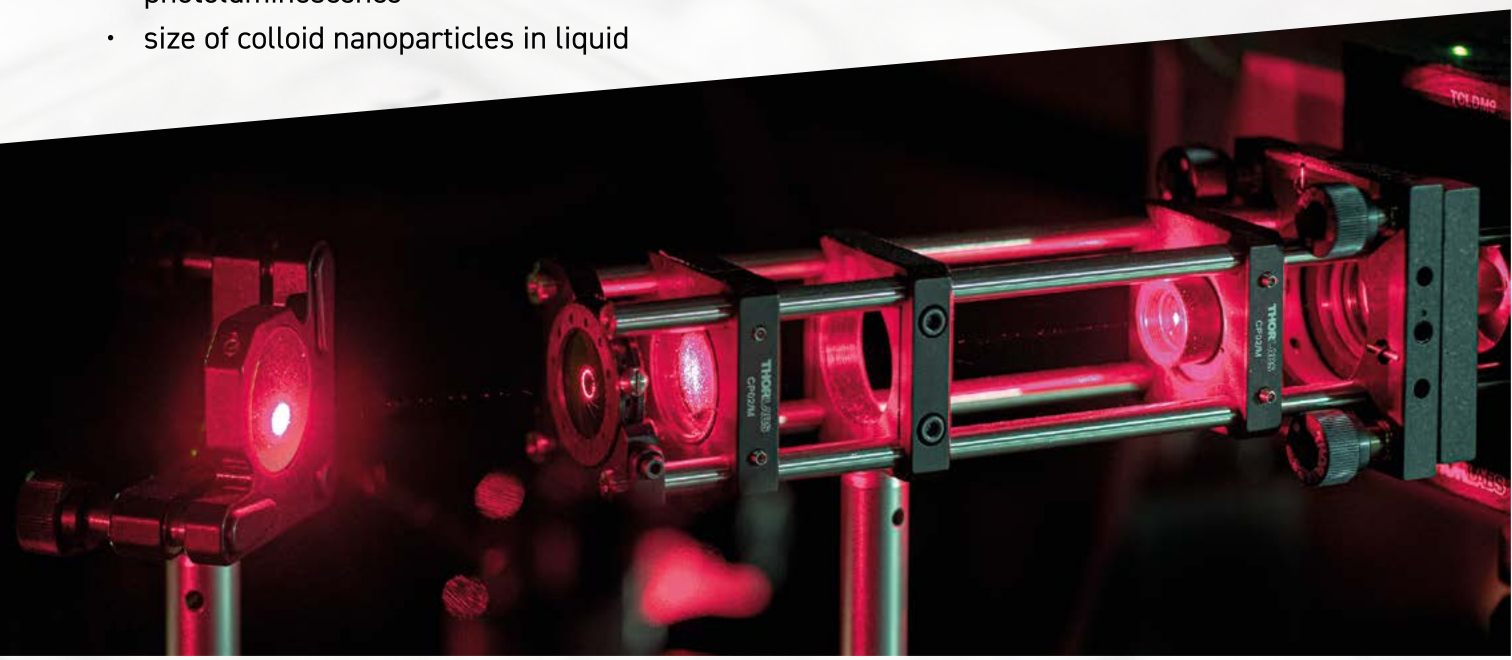
Head of Department:
Dr. Péter Petrik

The research targets of the Photonics Department are:

- the preparation as well as the non-destructive and real time characterization of thin films on large surfaces, in photonic and complex structures
- development of optical and magnetic measurement methods for the improvement of sensitivity and for the broadening of the range of studied materials
- preparation and spectroscopic characterization of self-organized surface nanostructures
- in-situ monitoring of solid-liquid interface processes for the understanding of the adsorption of complex biomolecules and for the optimization of thin film preparations for sensors

Examples of what we can measure:

- optical properties and thicknesses of films from 1 nanometer to 10 micrometer
- non-destructive magnetic characterization of materials
- transmission and reflection spectroscopy (also of individual nanoparticles)
- hydrophobicity and wetting characteristics
- flatness, curvature and topography of mirror-like surfaces
- photoluminescence
- size of colloid nanoparticles in liquid



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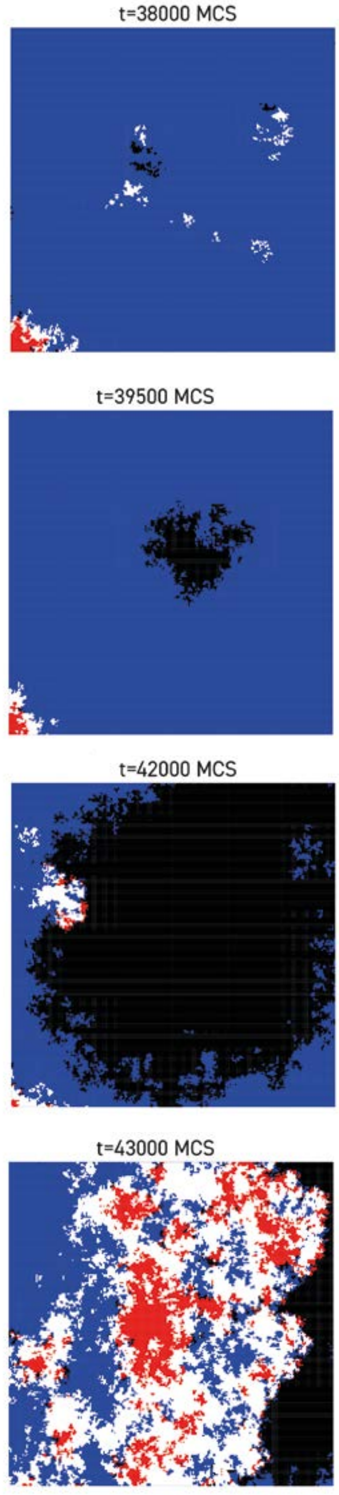
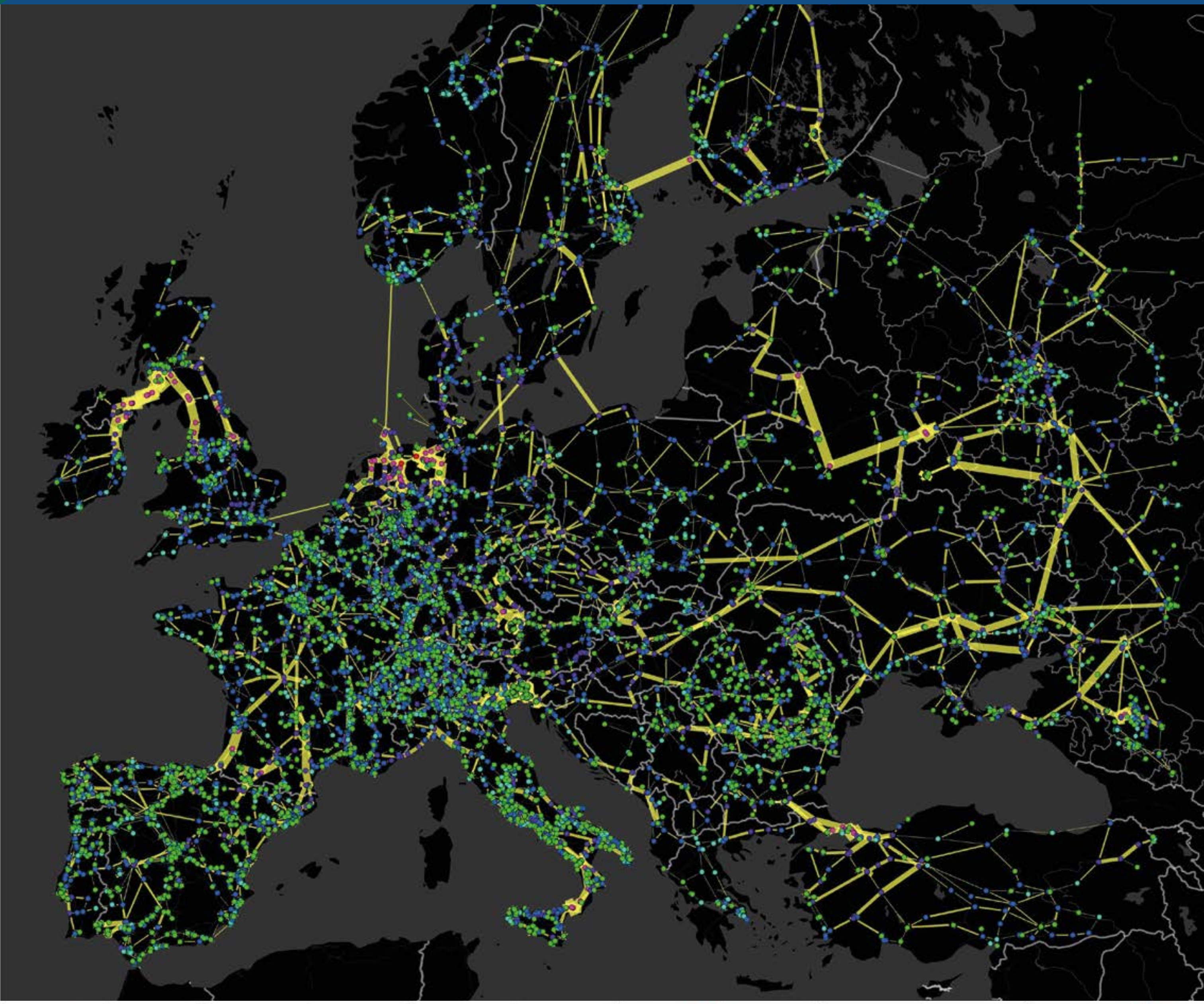
Complex Systems Department

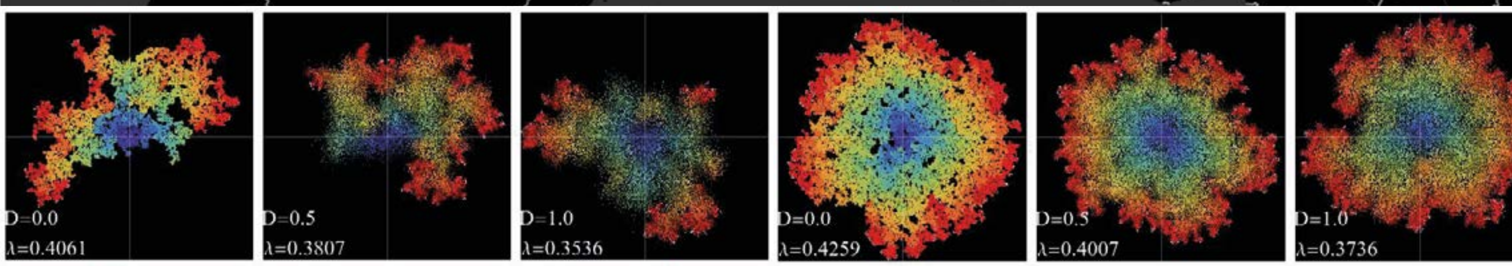
Head of Department:
Dr. Géza Ódor

Researchers in the Complex Systems Department use the methods of statistical physics to investigate evolutionary game theoretic models and dynamic phenomena on various graphs. These models offer a general mathematical background to multidisciplinary research areas (biology, economics, behaviour research, surface growth, reaction-diffusion,... etc.). They extended the analysis of relatedness of folk music and genetics of various ethnical groups in directions that allow the joint investigation of spatial and temporal processes.

- In evolutionary game theory they use mathematical models to pursue investigations to explore processes, strategies and relationship systems, developing between selfish individuals, which support cooperation advantageous for the community. Among the punitive strategies they have found variations that efficiently help the prevalence of a behaviour representing the common interest in spatial "Tragedy of the commons" games. In depth analysis is based on the ability to decompose interactions described in matrix form into the linear combination of four basic games. Systematic investigation of the coordination components cast light on the existence of social trap situations which are similar to phase-changes known in solid-state physics.
- They study the size and duration time distributions of avalanche-like failures in models developed for studying power grids and brain. Models, suitable to describe the spread of activity and synchronization are being used in synthetic and real modular networks to quantify the effects of the heterogeneity in networks of the critical dynamics of brain models.
- They continued to develop self-learning algorithms suitable to identify clusters observable in the space of folk music tunes and hereditary genetic codes characterizing ethnic groups, and to more accurately quantify the measure of relatedness. The continuous expansion of the folk music and genetic databases and their completion by archaeological data may even provide a background for the historical analysis of the migration of peoples.



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Microsystems Department

Head of Department:
Dr. Péter Fürjes

The main goal of the Microsystems Department of Centre for Energy Research is to develop integrated sensors and microsystems, MEMS and BioMEMS devices fabricated by micro- and nanomachining technology. The activity covers the research and characterisation materials systems and the development of novel sensing principles and technology solutions. The laboratory is focusing on the development of mechanical, physical, chemical (and biochemical) sensors, functional micro- and nanofluidic devices, implantable microsystems and infrared LED.

Development traditional MEMS sensors, such as gas, environmental and mechanical sensors with an emphasis on the technology of 3D microstructure implementation.

BioMEMS, medical applications

Development silicon based sensors, Si and flexible implantable microsystems and their electro-mechanical integration, specifically for medical applications.

Lab-on-a-Chip / Organ-on-a-Chip

Development micro- and nanofluidic systems, LoC devices for Point-of-Care diagnostic tools in the medical field. Research and characterisation OoC devices for analysis drug agents and cell physiology.

IRLED

Stabile small scale production and development infrared LEDs and their (spectroscopic) applications for environmental and food safety monitoring or bioanalytical tasks.

Microsystems Department

Infrastructure and technology

This unique infrastructure in Hungary supports the micro- and nanotechnology based system technology covering wide spectra of 3D micromechanical processes such as UV lithography with maximal resolution of 1µm, in-house lithographic mask generation, electron beam lithography and focused ion beam (FIB) milling with resolution of 20nm, physical and chemical layer deposition techniques or wet and dry etching solutions. The structural design and manufacturing are supported by multi-domain Finite-Element Modelling (FEM), and process simulation, and comprehensive characterisation and analysis methods: optical (fluorescent) microscopy, SEM, atomic force microscopy (AFM), profilometry, electrochemical impedance spectroscopy (EIS), UV-VIS-IR / FTIR / fluorescent spectroscopy, mechanical, electrical characterisations, climate chamber, etc.

Scientific, industrial and educational cooperations

The Laboratory works in close and comprehensive cooperation with international and national scientific research centres and industrial R&D partners. The technological and scientific results are directly transferred into the higher education, by means of several lectures, laboratory practices, TDK, diploma and PhD works.
Emphasized mission of the Microsystems Laboratory is to ensure access for students to the micromechanical technologies and the connected characterisation methods, and to broaden the related scientific knowlegde of coming engineers, physicists, chemists and biologysts.

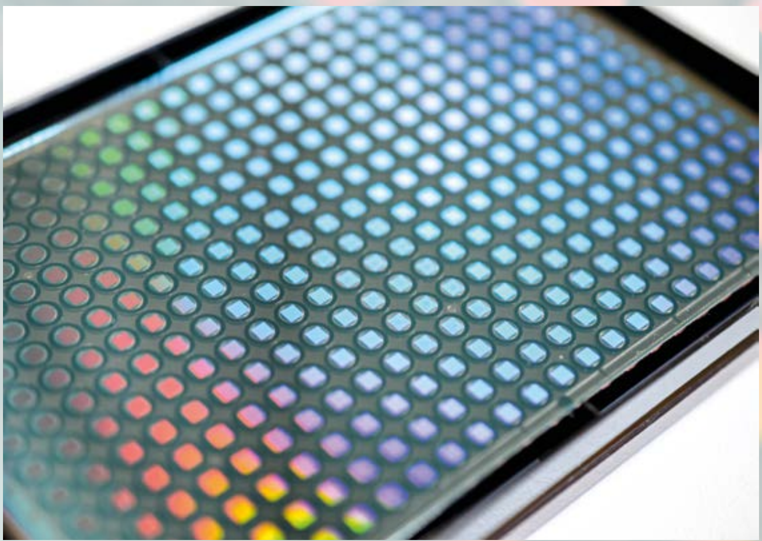
Webpages: www.mems.hu, www.biomems.hu

Nanobiosensorics Department

Head of Department:
Dr. Róbert Horváth

The Nanobiosensorics Department started its activity in July, 2012. The research profile is the development and application of label-free optical biosensors, the mathematical modeling of the relevant biological and biophysical processes.

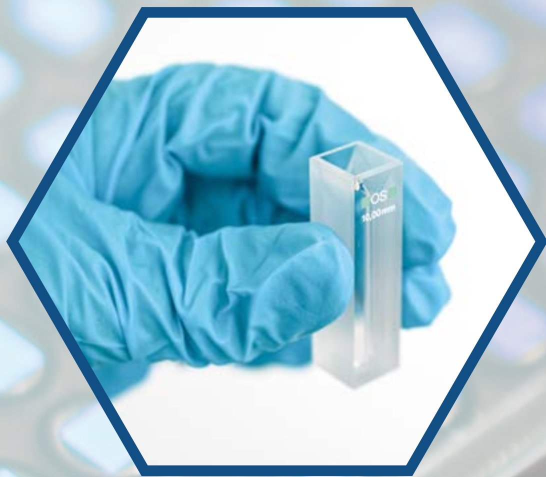
The group made important steps both in the development of the research infrastructure and both in creating personal and collaborative network. The group had a successful collaboration with the Swiss startup, Creoptix AG on high resolution label-free optical sensing. Our closest collaboration partners are scientists from various Hungarian universities. We have established a cell culture laboratory, making possible to launch a new and promising research line, the "label-free biosensorics of living cells". The group focuses on the following main research topics; ranging form the kinetics of cellular adhesion, migration and signalling on novel biomimetic interfaces to the mathematical modelling of the measured biological signals.



Label-free biosensors and techniques. Our research is centered around different biosensing technologies; development and application of optical biosensors and fluidic techniques, plate-based methods and visualization. By combining some of the most powerful optical and mechanical methods we are capable of manipulating and sensing single cells, as well as populations with an exceptional accuracy.

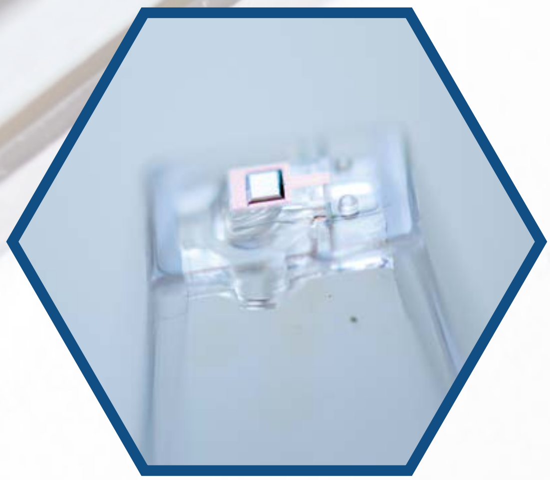
Nanobiosensorics Department

Biosensor coatings and characterization. Our laboratory has much experience in the production of polymers to influence cellular adhesion, for example dextran, PLL-g-PEG polymer and nanoparticle coatings on biosensor surfaces. We apply flagellin based biomimetic coatings as well to alter the adhesivity of the cells. Considering cancer cell adhesion and spreading the group first established a methodology to determine the integrin receptor-RGD ligand affinity constant in living cells without applying any labelling.



Single cell analysis and manipulation. Single cell analysis is a new trend that makes it possible to discover mechanisms not seen when studying a bulk population of cells. Our label-free techniques are capable of measuring single cell adhesion force and other properties, and deposit single cells as well.

Compounds and stimuli. Label-free biosensors are capable of monitoring cellular responses to different compounds and stimuli. We have experience in for example B cell stimulation, gold nanoparticles and natural compound (green tea polyphenol, epigallocatechin-gallate) treatment of mammalian cells monitored by label-free techniques. The role of cellular glycocalyx in adhesion is also investigated by high resolution label-free methods.



Analytical and numerical modelling of biosensor data. Interpretation and modelling of the measured kinetic data is essential to understand the biological phenomena. Our team employs home developed softwares to model biophysical processes (NBS tools).

Our results can find further applications in basic biological and biophysical research, biotechnology and medical diagnostics.

The website of the group: nanobisoensorics.com

Nanostructures Department

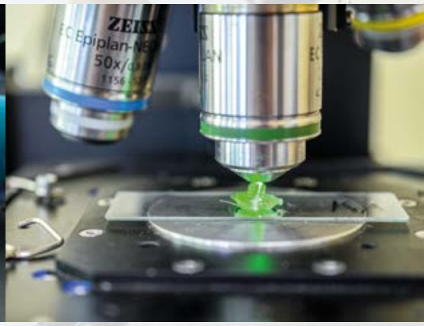
Head of Department:
Dr. Levente Tapasztó

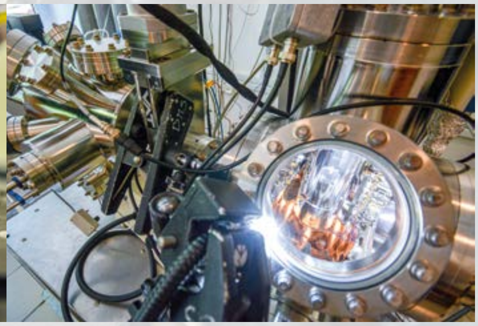
The main focus of the Nanostructures Department is the research of two-dimensional (2D) materials. Their research activity covers the synthesis of 2D materials, the atomic-scale characterization and nanometre precision modification of their structure for engineering the electronic, optical, magnetic and catalytic properties. Besides graphene, they also focus on the research of 2D transition metal chalcogenides, topological insulators, 2D materials/metal nanoparticle hybrids, as well as artificial crystals (2D heterostructures) assembled atomic layer by layer. They also actively investigate biological and bioinspired photonic nanostructures.

Main research areas:

Synthesis of 2D materials:

They have developed a novel exfoliation technique for isolating various 2D crystals with up to cm2 lateral dimensions. The gold assisted exfoliation technique developed in the Laboratory has been adopted and developed further at leading universities around the world, such as Stanford or Berkeley. Besides mechanical exfoliation, they also synthesize large area 2D crystals by Chemical Vapour Deposition (CVD) technique.

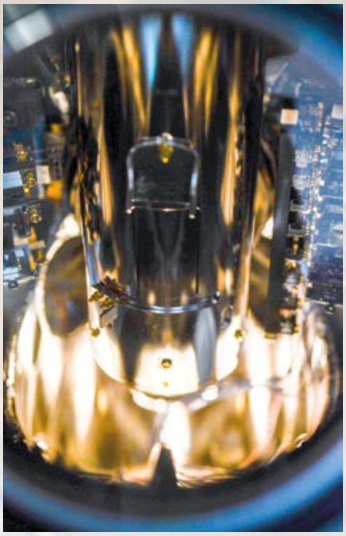





Imaging the atomic and electronic structure of novel materials: The Laboratory's main expertise is in the field of characterizing the atomic and electronic structure of materials at the atomic resolution level by Scanning Tunneling Microscopy (STM). They were the first to image, at the atomic scale, the spontaneous incorporation of O atoms from air into MoS2 single-layers. They also provided the first experimental evidence on the topological bandgap of Pt2HgSe3 crystals, and revealed the corresponding topologically protected electronic edge states.

Nanostructures Department

Nanometre precision engineering of 2D materials:



The Nanostructures Department has developed several nanoengineering techniques, including the highest precision nanofabrication technique for defining 2D nanostructures. The STM lithographic technique developed here is able to define graphene nanostructures with 0.5 nm precision, enabling the control of their electronic and magnetic properties. They have also developed the most precise (< 10 nm) Atomic Force Microscopy (AFM) nanofabrication method based on cleaving 2D crystals along their high-symmetry crystallographic directions. The major advantage of the AFM cleavage lithography is the fabrication of 2D nanostructures that can be directly integrated into nanoelectronic circuits.

Nanoelectronic devices and catalytic applications based on 2D materials: They have realized the most robust graphene-based quantum point contact electronic device, displaying quantized conductance plateaus at temperatures up to 40K. By engineering the structure of 2D crystals at atomic or nanometre level, they can significantly increase the catalytic activity, which is an essential step for developing cheap and efficient catalysts for hydrogen evolution.

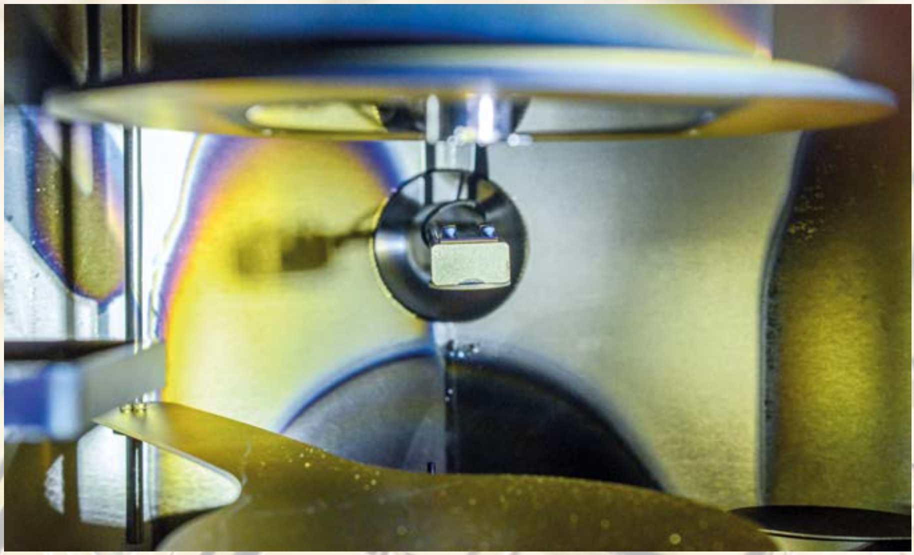
Bioinspired photonic nanoarchitectures: They investigate the complex structure and optical properties of biological nanoarchitectures, conferring the colour to the wings of various butterfly species. The application potential of such biological or bioinspired photonic nanostructures in optical sensing is also investigated.

Website of the department:

www.nanotechnology.hu

Nanosensors Department

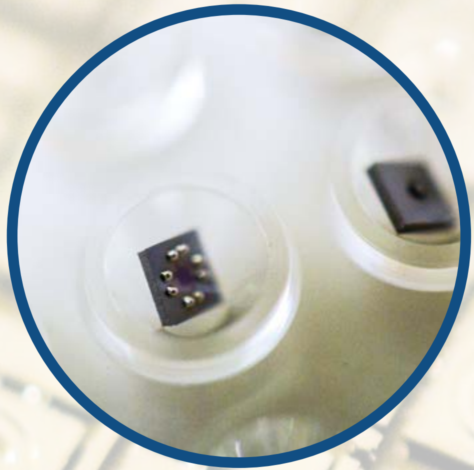
Head of Department:
Dr. János Volk



Nanosensors Department was established at the beginning of 2019 from the former Department of Microtechnology. The core infrastructure, having two semiconductor clean rooms, is shared and operated together with the Microsystems Department. Their mission is to utilize the emerging results of nanotechnology and materials science for novel physical sensors, particularly for micro- and nanometer sized electromechanical systems (MEMS/NEMS). The activity of the research group is related to and supported by five domestic projects and several scientific collaborations with national and international partners.

In the most significant project of the group, titled 'Advanced Functional Materials for Autonomous Sensor Networks', the work was divided into three levels: i) research of CMOS compatible functional thin films; ii) development of MEMS energy harvester and sensor devices; iii) development of wireless proof-of-concept (PoC) sensor nodes.

ScAlN is one of the investigated functional materials. Because of its high piezoelectric coefficient, it is a promising candidate for next generation piezo-MEMS devices. The aim of the group is to optimize the properties of the layers by changing their stoichiometry during the reactive co-sputtering. The deposited piezoelectric layers are characterized by several ion-beam, electron-beam, and scanning probe techniques (RBS, EDS, PFM). VO2 is another functional material, which is studied by the group. It attracts considerable interest because of its semiconductor-to-metal transition at relatively low temperature (67 °C), which is beneficial both for electronic and thermochromic applications. They have pointed out that a rational and upscalable synthesis can be done by post-annealing of matallic vanadium under ambient air atmosphere.



The main motivation of device related research is to study novel vibrational energy harvesters for autonomous sensor nodes and novel frequency sensitive vibration sensors for middle-ear human implants. Besides, the group performs research in the field of novel tactile sensors and artificial skins where AlGaN/GaN heterostructure based membranes can play a significant role.

The developed wireless sensor systems include an intelligent bicycle traffic monitoring sensor, an autonomous vibration analyzer, a 3D force sensor based integrated tire sensor, as well as a mobile gamma-radiation detector. For the vibration analyzer, they have demonstrated a new RF communication protocol for low power consumption sensors.

Nanotechnology related research was carried out mainly in collaboration with Physics Department of BME. On the one hand, the group continued the work on spintronic devices in the framework of National Quantumtechnology Program (HunQuTech), on the other hand, they have progress in the field of memristors.

Website of the department: www.nems.hu

Head of Department:
Dr. Katalin Balázsi

The department carries out research in the field of thin films and ceramics. Based on their multi decade experience they investigate the microstructure of polycrystalline layers, novel nanocomposite materials and semiconductor layers. The above subjects were expanded to the field of technical ceramics, bioceramics. The Department is strong at national and even international level at transmission electron microscopy (TEM), what they use in order to determine relationships between the microstructure and other physical properties. They also conduct development of special methods based on electron diffraction.

The most important results are the following:

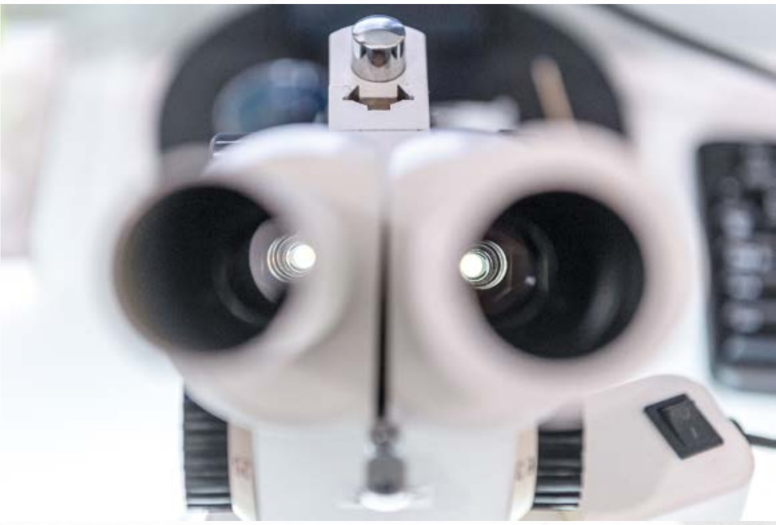
They firstly reported a brand new wide band gap semiconductor, 2D indium nitride .The project provides the possibility to develop 2D semiconductors by Metalorganic Vapour Deposition. Successful examples are 2D AlN and the subject of this news, indium nitride.

Webpage: www.thinfilms.hu

Facebook: https://www.facebook.com/VekonyretegFizika/

Available facilities: https://www.mfa.kfki.hu/research/thinfilmphysics/

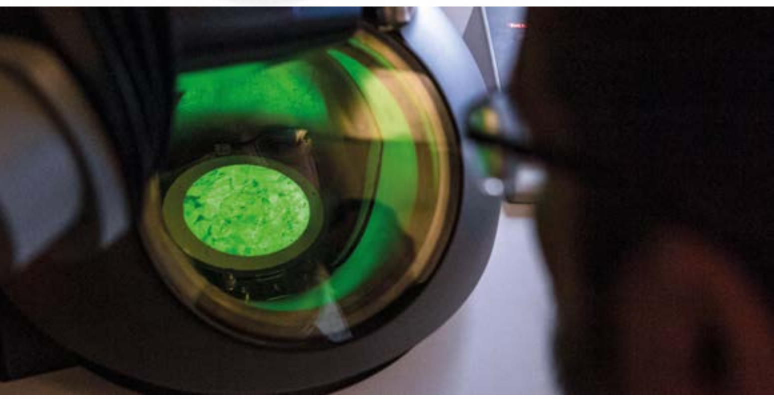
To be able to study of the concentration dependence of two-component thin-film systems more effective, the so-called “one-sample” micro-combinatorial method has been developed.

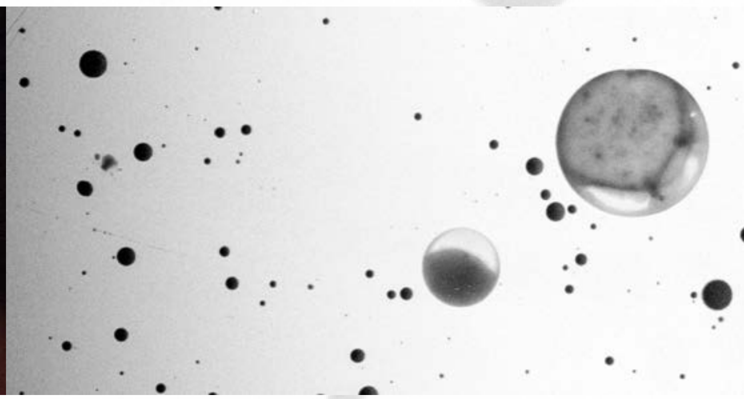


They made the preparation of TEM and HREM samples more effective by purchasing and applying a SEM Dual Beam FEI SCIOS2. Focused ion beam sample preparation is significantly faster than conventional methods.

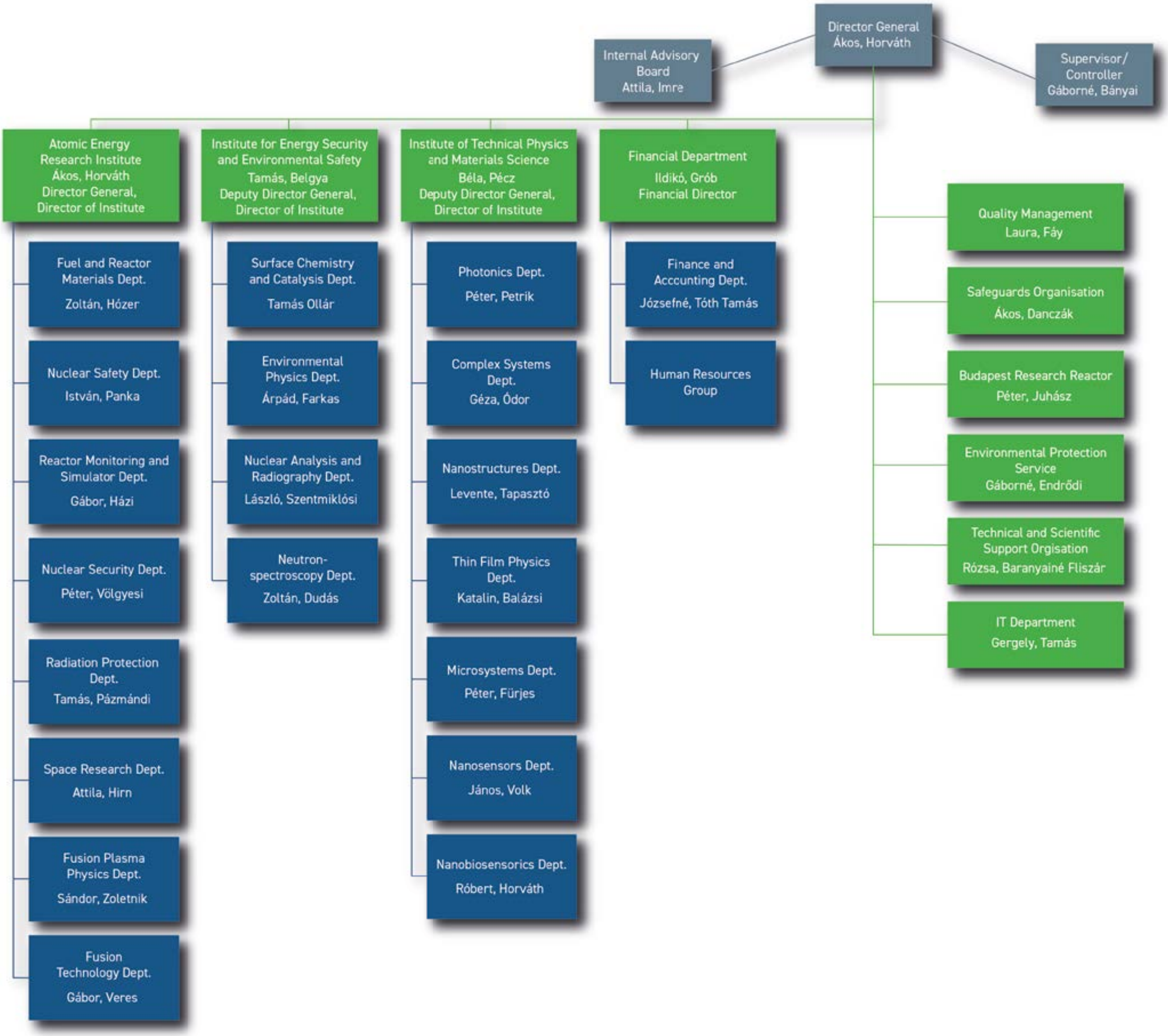
Multilayered silicon nitride / graphene stacks have been successfully produced using powder technology. The various Si3N4 – Si3N4/ 5 wt% graphene – Si3N4/30 wt% graphene bulk ceramics for multifunctional new breakthrough applications was sintered by hot isostatic pressing.

A nanostructured hydroxyapatite layer on Si3N4 substrate has been successfully prepared. The addition of carbon nanotube made the insulating Si3N4 conductive, thus an electrospraying method to form the bioceramic layer was applicable.





Main Partners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