FACULTY OF
NUCLEAR SCIENCES
AND PHYSICAL
ENGINEERING
CTU IN PRAGUE

ANNUAL REPORT

The Dean's Message

The Faculty of Nuclear Sciences and Physical Engineering at CTU in Prague was founded in 1955 as one of the essential parts of the Czechoslovakian nuclear programme. It became an excellent scientific institute that mainly focused on mathematics, physics, nuclear chemistry, materials, electronics, IT and nuclear reactors. It combines excellent science with educating future experts.

The faculty has unique facilities that attract scientists and students from all over the world. Not only a school fission reactor or a Golem tokamak. We also have state-of-the-art chemical laboratories, laser laboratories, fractography workplaces, a centre for detection systems, PlasmaLab@CTU, a quantum laboratory and many others, which we continue to improve and expand.

In addition to the technical equipment, proof of an excellent scientific background is also the fact that, although we are the smallest in terms of the number of bachelor's and master's students among the eight faculties of CTU, we are fourth in the number of doctoral students! We are also fourth in terms of the number of academic staff, and we have the same ranking if we count only the number of professors working at the faculty. Regarding the number of citations and publications, considered an essential indicator of scientific performance, we have long held the third rank within the university. We can also state that we are the third in the number of experts from the application field participating in teaching and practice in accredited study programs.

Studying here is demanding, and we do not hide that. However, the reward for our graduates is that they are in high demand. "Jaderňák" can be found not only in the management of large corporations but also, for example, in political positions. Many graduates remain at the faculty or move on to scientific positions at prestigious workplaces worldwide. I am glad that the "Jaderňák" family is still growing and that it is still a guarantee of the highest quality and expertise, as well as the ability to cooperate.

doc. Ing. Václav Čuba, Ph.D.
Dean of the Faculty of Nuclear Science
and Physical Engineering at CTU in Prague

About the Faculty

The Faculty of Nuclear Sciences and Physical Engineering of the Czech Technical University in Prague is one of the leading scientific and educational institutions in the Czech Republic. Its unique equipment and experts in a relatively wide range of fields – from mathematics to physics, chemistry, material sciences, electronics, quantum technologies and nuclear reactors – have an international reputation.

Experienced scientists participate in large-scale international projects directly on the faculty premises or during short-term and long-term trips abroad. Many of them work at the Swiss CERN, others at the American BNL, the South Korean KINGS, and at many other scientific workplaces and universities. Faculty employees also play essential leadership roles. Excellent references are returned to the faculty from foreign institutions by the faculty's students, who are directly involved in research work.

The faculty has its workplaces divided into four main locations. In addition to the main building in the centre of Prague (Břehová 7), other laboratories and teaching premises can be found at Karlovo náměstí (Trojanova 13), at the border between Troja and Libeň (V Holešovičkách 747/2) and also in Děčín (Pohraniční 1288/1). The faculty is gradually modernising the premises to provide the best possible background for scientists and students. Numerous successes in various scientific competitions – the Werner von Siemens Prize, the Henri Becquerel Prize, the Josef Hlávka Prize, the Milan Odehnal Prize and many others – testify to their qualities.

Technical equipment and specialised scientific facilities, some of which are unique, are constantly being transformed and supplemented. It is not only school reactors and other equipment linked to them. These are, for example, dosimetric laboratories equipped for measuring ionizing radiation from brought samples or recording in the free environment. Their detectors are used, for example, for unique analyses of historical artefacts. Similarly, chemical laboratories for working with radioactive material, fractographic workplaces, or even systems for high-performance calculations are also important. The VR-1 reactor is part of an international network of reactors that, in cooperation with the International Atomic Energy Agency (IAEA), have been equipped with the Internet Reactor Laboratory system for distance learning. Its advantages are used by people from practically all over the world.

The faculty also has extensive experience in cooperation with the industry. Examples include Aero, ČEZ, ČZ, GE Aviation, Honeywell, KHNP, Nuvia and Škoda JS. In addition to joint development, this includes, for example, the management of student work, internships or cooperation in employee recruitment. Faculty employees also participate in the expertise of unique works of art, such as the Reliquary of St. Maura.

The unique detectors developed as part of the joint project of FNSPE, the company esc Aerospace and the Institute of Nuclear Physics of the Academy of Sciences of the Czech Republic (ÚJF), currently orbiting the Earth since 2019, were supplemented two years later by another detector, this time launched by a Falcon rocket.

Academic Departments

Department of Dosimetry and Application of Ionizing Radiation (KDAIZ)
experimental nuclear physics and technology; personal dosimetry; problems of the environment; dosimetry of nuclear energy installations; radiation and applications of ionizing radiation and research of monuments and their dating.

Department of Physical Electronics (KFE)
physics and technology of lasers; applications of lasers in various fields from medicine through optics to nanotechnology or space technology, X-ray photonics and nanophotonics, computer physics for simulations of interactions of laser radiation with matter, quantum technologies, molecular photophysics and spectroscopy

Department of Physics (KF)
issues of mathematical physics, quantum information and communication, nuclear and particle physics, plasma physics and tokamak physics

Department of Social Sciences and Languages (KHVJ)
courses of modern languages; social sciences courses; preparatory courses of Czech for foreign students seeking admission to higher education, intensive preparatory courses for foreigners

Department of Solid State Engineering (KIPL)
classical and quantum mechanics physics of solids; theoretical and experimental physics of solids; atomic structure of solids and their most important physical properties according to the type of material, their properties and analytical procedures

Department of Nuclear Chemistry (KJCH)
general, physical, inorganic, organic, analytical chemistry and biochemistry; applied nuclear chemistry; chemistry of the environment and radioecology; nuclear chemistry in biology and medicine

Department of Nuclear Reactors (KJR)
nuclear technologies; nuclear power engineering and protection against ionizing radiation; reactor and neutron physics and thermohydraulics; safety of nuclear installations; nuclear fuel cycles and spent fuel

Department of Mathematics (KM)
applied mathematics: physical, biological, and social systems; applied algebra and calculus; modelling and numerical simulations; discrete mathematics

Department of Materials (KMAT)
solid state physics; applied mechanics; fracture and computational mechanics; properties of materials; physical metallurgy; theory of reliability

Department of Software Engineering (KSI)
fundamentals of programming and algorithmization SQL database; work with languages Java, Python, etc. applications of software engineering

Research Centres

School nuclear reactors VR-1 and VR-2

The faculty has two nuclear fission reactors. Since 1990, it has been operating a light-water training nuclear reactor of the pool type VR-1. Thanks to the Internet Reactor Laboratory system, the reactor is used for distance learning. Since 2022 the faculty has had a subcritical VR-2 reactor, which needs an external source of neutrons to maintain the fission chain reaction.

Both reactors serve as scientific facilities and as an aid to students of Czech and foreign technical schools. Nuclear power plant workers, professional workers for the nuclear field in developing countries, and even IZS units have trained here. International courses focused on reactor physics take place here.

Fusion Tokamak GOLEM

It is a unique teaching and research facility for executing controlled thermonuclear fusion, available to students and scientists around the world in itself, but also via the internet through remote-controlled experiments. It is used to demonstrate the facility to the public, to run workshops or laboratory sessions on physics, technology, and diagnostics of high-temperature tokamak-type plasma. As for its use for scientific purposes, it is exploited to study the behaviour of so-called runaway electrons and physics of marginal plasma via various electrostatic probes.

golem.fjfi.cvut.cz

Satellite Laser Ranging Station in Egypt

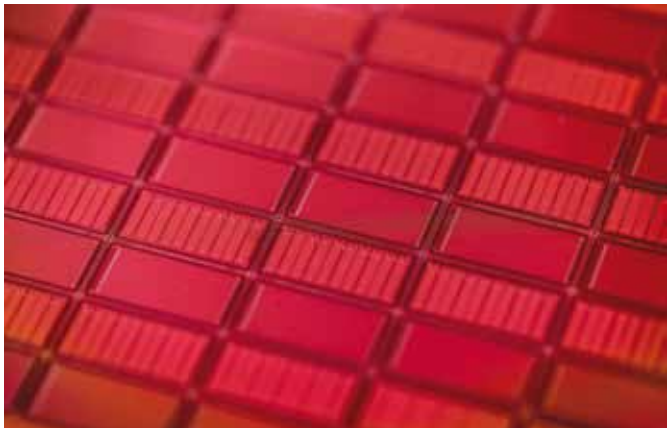
The laser ranging station in Helwan, Egypt, for measuring distances is a joint laboratory of the astronomy section of the Egyptian National Research Institute of Astronomy and Geophysics (NRIAG) and the Department of Physical Electronics of FNSPE. Its purpose is to perform most exact measurements between a reference point at the station and some satellites.

kfe.fjfi.cvut.cz/- blazej/cz/res/prj/helwan.html

Doppler Institute for Mathematical Physics and Applied Mathematics

The Doppler Institute (DI) was founded in 1993. It is staffed by academics from FNSPE (Department of Mathematics and Department of Physics), the Czech Academy of Sciences (Institute of Nuclear Physics), and the University of Hradec Králové. The Institute helps talented students and PhD students starting their scientific career and provides contacts with foreign experts.

doppler.ujf.cas.cz



Centre of Applied Physics and Advanced Detection Systems

CTU in Prague; UJP Prague; VF Černá Hora; ATG, and TESTIMA teamed up in a consortium to carry out research and develop detection systems of ionizing radiation for applications in diagnostics in medicine, radiotherapy, radiation dosimetry, defectoscopy, and other fields. The centre is located at the Department of Physics, a leading institution in the development of and research into new technologies for the detection of ionizing radiation.

It is concerned with:
- research and development of top detection technologies of ionizing radiation
- instrumentation of the most pre-eminent experiments in particle physics in the world
- research studies into possible practical application of fundamental research technologies
- involvement of students in top international research projects

capads.fjfi.cvut.cz

Multidisciplinary Research Centre of Advanced Materials AdMat

This centre teams up the Faculty of Mathematics and Physics of Charles University – Department of Physics of Metals; FNSP – Department of Solid State Engineering, Department of Mathematics, and Department of Materials; the Institute of Physics of the Czech Academy of Sciences (CAS) – Department of Functional Materials; the Institute of Plasma Physics – Department of Materials Engineering; the Institute of Nuclear Physics and the Institute of Thermomechanics –Laboratory of Ultrasonic Methods, both of the Czech Academy of Sciences.

admat.fjfi.cvut.cz

Nanobiophotonics for Medicine of the Future

Fundamental oriented research into biophotonics oriented towards biosensors based on photonic nanostructures covers both research into photonic phenomena of metallic nanostructures, and interconnection of these nanostructures with biomolecules and with the study of their mutual interactions.

www.ufe.cz/cs/nanobiofotonika-pro-medicinu-budoucnosti-projekt-excelence

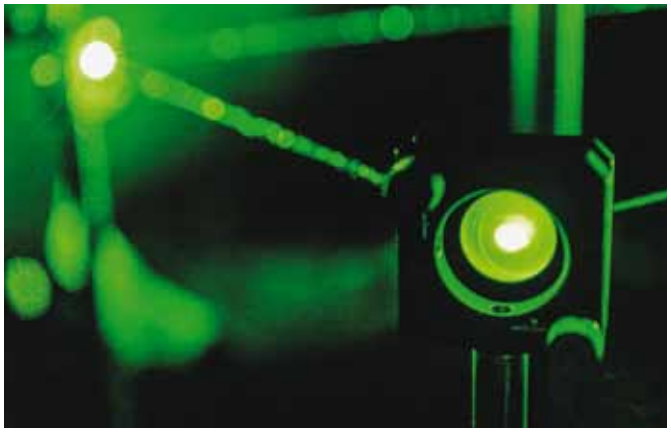
Laboratory of Fractography

This laboratory studies failure processes of a number of materials – not only metals and alloys – but also ceramic, plastic, rubber or glass (the study included also biological items like wood or teeth). It develops techniques for theoretical and experimental research, methods of quantitative fractography, and studies probability aspects of crack propagation.

fraktografie.fjfi.cvut.cz

PlasmaLab@CTU

The laboratory of hot plasma and fusion technology, abbreviated PlasmaLab@CTU, and the Golem tokamak forms an international centre for thermonuclear fusion research at the faculty. The laboratory has experimental equipment for thermonuclear fusion research. Scientists and students have at their disposal a system of vacuum chambers, the possibility of working with five different gases, a linear magnetic trap, a resonance cavity or microwave interferometry and several top-notch instruments for optical measurements. The laboratory also has a 3D microscope of the highest class of optical microscopy, which reaches the very limit of visible light. The microscope is here mainly for material research of one of the most serious topics of fusion: monitoring the consequences of the interaction of the plasma with the surface of the container.



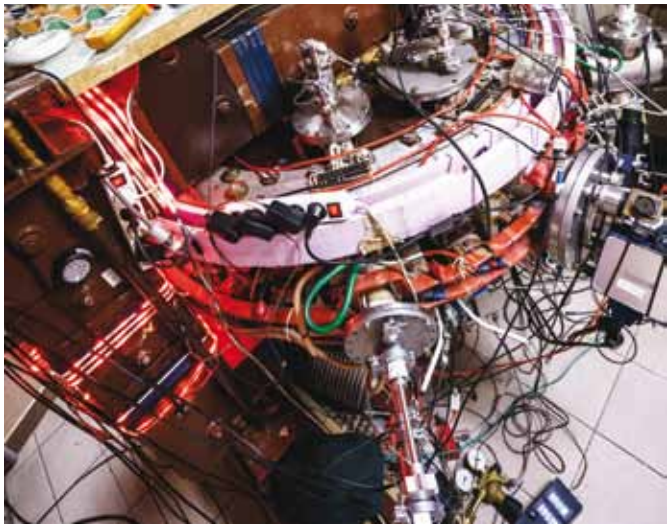
Studying at FNSPE

Our Faculty offers programmes closely linked with their practical application right from the Bachelor Course, i.e. programmes reaching medicine, economics, IT, safety of the population, and other fields. Graduates start their career as highly-valued experts, never lacking in job offers. Cooperation with over 140 universities and research establishments both at home and abroad and the small number of students make it possible to guarantee participation in addressing current scientific issues and their application and shorter or longer study stays or internships abroad.

The Faculty also offers and organizes informal cultural, social, and scientific events, such as the winter ball, the Nuclear Night, student conferences, the Art Festival, theatre performances, etc. The friendly environment helps students overcome the hardships of their demanding courses.

FNSPE in numbers:

- number of students: over 1,200
- number of graduates: over 200
- academic staff: over 160
- number of research centres: 9



The only Faculty in Europe equipped with two types of teaching reactors:

- fission reactor – VR-1 and VR-2
- fusion reactor – GOLEM tokamak

Modern applications of natural sciences in various fields:

- Applied Statistics
- Electronics
- Elementary Particles and Accelerators
- Informatics and Software
- Quantum Technologies
- Mathematical Modelling
- Mathematics
- Nuclear Physics
- Nuclear Chemistry
- Quantum Physics
- Lasers
- Nanotechnologies
- Optoelectronics
- Radiation Protection
- Radiopharmaceuticals
- Radiology
- Reactors and Power Generation
- Thermonuclear Fusion
- Theoretical Physics

Research Trends

Applications of Ion Beams

The group is concerned with the technique of ion beams, interactions of fast neutrons with solids, and applications of ion beams in modifications of thin surface layers of materials (IBMM), and their analyses (IBA). The Laboratory of Ion Beams of the Department of Physical Electronics (KFE) now operates equipment using light H+ and He ion beams at an energy of 1.5 – 2.3 MeV from the Van de Graaf accelerator (Institute of Theoretical and Technical Physics, CTU – ÚTEF, CTU). It also studies the degradation process in insulators due to irradiation with fast light ions. The Laboratory has at its disposal a facility with ions of various elements with accelerating voltage of up to 120 KV.

Application of Isotopes in Biology and Medicine

The radiopharmaceuticals team does research into the use of radionuclides for studying metabolism of various xenobiotics in the organism or the use of radioimmunoanalytical methods in determining biologically significant substances by in vitro tests. They are used in clinical practice to determine e.g. some biochemical parameters from blood samples.

Applied Photonics

The group investigates the development and characterization of structures based on metallic nanostructures and polymer layers used for constructing chemical and physical waveguide sensors and active waveguide parts. In order to prepare functional structures, use is made of methods of rotation deposition of thin films from solution, the LBK, deposition of vapour layers in vacuum, pulse plasma deposition, solution drawing, and chemical doping. To test the microstructure of the materials developed, the following methods are available: optical spectroscopy, optical (light) microscopy, attenuated total reflection spectroscopy, optical reflectometry, and Raman microspectroscopy. And also, the team has at its disposal a testing place equipped for preparation of precision gaseous mixtures.

Applied Mathematics and Stochastics (GAMS)

The GAMS group is concerned with the study of physical, biological, and social systems by methods of mathematical statistics, mathematical analysis, and probability theory. The chief focus is on statistical analysis of data, formulation of theoretical transportation models, searching for appropriate analytical solutions, math4-ematical methods in defectoscopy, probabilistic estimates based on small social samples, studying so called f-divergences, mathematical models for pedestrian movement, panic models, etc.

Applied Radiation Chemistry

The radiation group focuses on radiation and photochemical applications in the field of nanomaterials and bioradiation chemistry. The former field concentrates on research, development, and radiation chemical or photochemical preparation of nanomaterials (even on a quarter scale), in particular those based on oxides or metals intended for various applications, such as preparation of luminophores or nanomaterials for biomedical applications. In the latter field, I.e. bioradiation chemistry, research focuses on the study of modification mechanisms of radiation sensitivity of living cells via chemical modifiers.

Fractographic Analysis (Fractography)

Research into fracture properties of construction materials carried out by this group is closely related to the latest findings from the physics of metallurgy. Of course, development of new methods of quantitative fractography analysis is an integral part of this research. Moreover, it also explains the causes of various failures and accidents. The information obtained can be used to eliminate the causes of accidents and to study the disturbance laws of failure of complex mechanical systems and to estimate the service life of structures.

Physics and Technology of Thermonuclear Fusion

The team participates in research on the Faculty's GOLEM tokamak, COMPASS tokamak and the pan-European JET tokamak. In addition to conducting classes, the group studies application of high-temperature superconductors in tokamak operation, investigates the retention time of radiofrequency plasma excited by an electromagnetic wave in magnetic field, and maps poloidal asymmetry of plasma flow measured by the Mach probe field.

Elementary Particle Physics

The group investigates the production mechanisms of elementary particles and their properties. The main sources of information are a series of experiments performed by the group on particle accelerators, i.e. mainly the ATLAS, ALICE, and STAR experiments, and other experiments, whose results are compared with own phenomenological models. Moreover, attention is also paid to developing modern detection technologies on silicon designed for research and industrial use.

Physics of Heavy Ion Collisions

The research group uses nucleus-nucleus collisions to create the state of matter present during the Big Bang, where the formation of matter known as quark-gluon plasma is predicted. The study focuses on the behaviour of nuclear matter during and immediately after the collision of two nuclei and the presence of a wide range of effects and phenomena requiring correct theoretical treatment. The group members are involved in the STAR experiments at the Brookhaven Laboratory, USA, the ALICE experiment on the LHC accelerator at CERN (Geneva), and the CBM FAIR Darmstadt experiment. Their aim is to understand particle production and interactions with dense and hot nuclear matter.

Physical Metallurgy

The group deals mainly with phase transformations in metals and alloys, degradation processes associated with them, the effect of shock transformations on mechanical properties of materials, as well as with their use in heat treatment. An integral part of the research is the development of progressive materials (e.g. intermetallic alloys, high-entropy alloys, thin films, plasma spraying). This research accentuates the use of advanced research methods such as electron microscopy, energy dispersion analysis, and nanoindentation.

Informatics Physics

The group members develop methods for the numerical solution of partial differential equations and their applications in fluid and particle simulations of laser radiation interactions with targets. They are mainly concerned with ablations on the target surface, shock wave origin and propagation, transport of energy and radiation, and other issues related to inertial thermonuclear fusion. The main aim is laser acceleration of particles and new sources of energetic particles. The group also operates a femtosecond laser laboratory, cooperates on preparation of special targets with microscopic surface structure, and studies the effects of this structure in laser-target interaction.

Nuclear Fuel Cycle

The nuclear experts at the Faculty devote their time to optimization of the middle part of the fuel cycle, which has considerable impact on the operation economy of nuclear power plants. In addition to assessing the uranium-plutonium fuel cycle, the experts are considering the possibility of introducing the thorium-uranium cycle or MOX fuel. Another issue of their research interest is the fuel cycle as such, including fuel storage and spent fuel repository, in the event that the fuel is not going to be reprocessed.

Quantum Dynamics, Optics, and Informatics (Q 3)

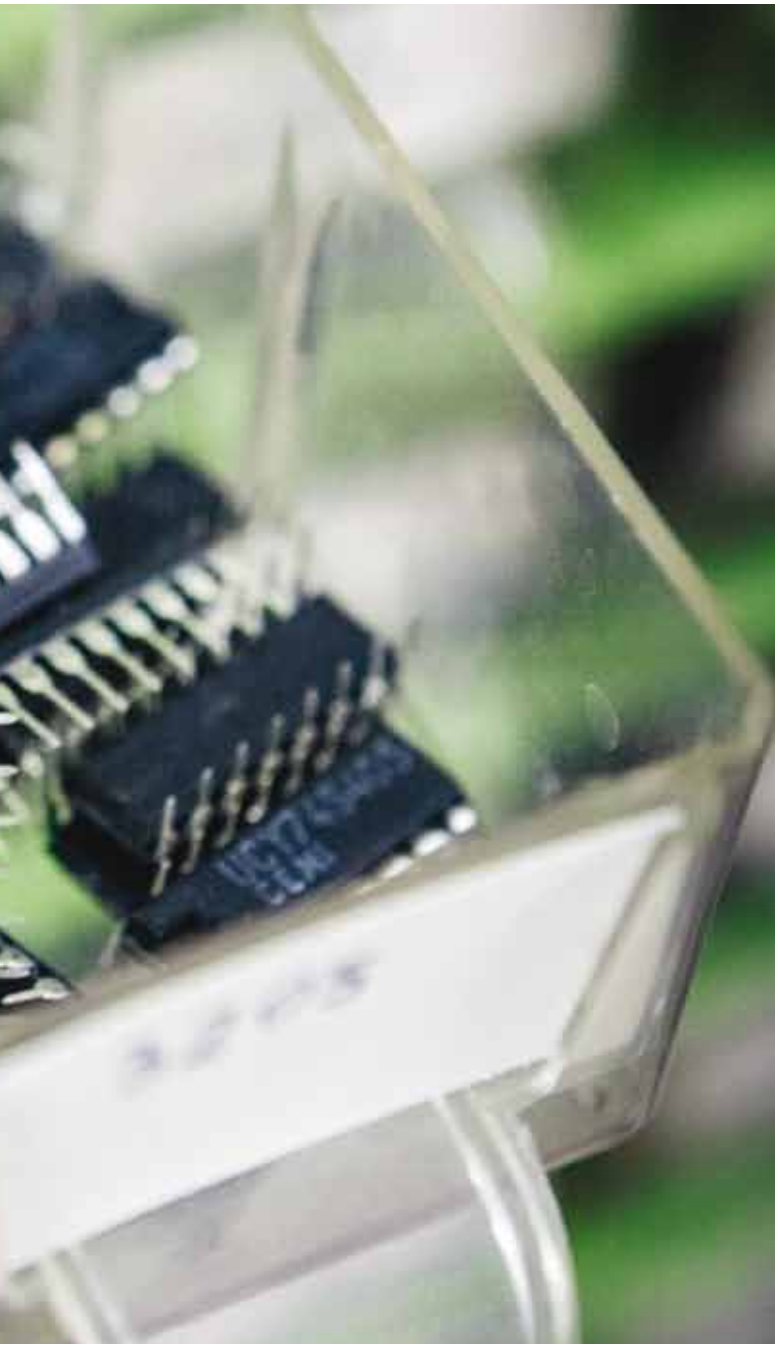
Research of this group focuses on quantum dynamics, quantum information, and quantum optics. It studies the properties of quantum walks and their applications in simulating coherent excitation transfer. The group's interests also include open dynamics, i.e. evolution of physical systems due to interactions with the surroundings, and their effect on quantum systems. Further, the group studies the effect of measurements on quantum systems. As regards quantum information, it is concerned with search algorithms and transmission of the state between network nodes. Another issue of interest to the group is the so called boson sampling.

Mathematical Modelling (MMG)

The Mathematical Modelling Group is engaged in mathematical modelling and numerical simulations of complex phenomena in high-tech design, protection of the environment, and computer sciences. The group participates in research and development and education of young experts in mathematical engineering and successfully cooperates with prestigious universities and institutes abroad and industrial companies all over the world.

Methods of Algebra and Functional Analysis in Applications (MAFIA)

The scientific group does research into mathematical physics, mathematical biology, non-equilibrium thermodynamics, and other sub-fields, where the rigorous mathematical approach faces topical problems of natural and engineering sciences. The group prefers analytical and algebraic approaches to numerical simulations. Thus, for instance, it pays attention to toy models of relativistic and non-realistic quantum physics, reaction kinetics, pattering in biological systems, spectral geometry, spectral theory of special matrix classes and non-self-associated operators or representation theories of groups and algebras.



Research Methods of Historical Monuments

The group is developing an X-ray fluorescence analysis method for investigating samples of artefacts and historical monuments. The analyses can be performed by points, by determining the distribution of the measured elements on a surface (2D analysis), or, in particular cases, it is possible to perform a 3D analysis. However, the analysis of pigments in murals and paintings, the study of polychromies on old sculptures and of inks and paints used in old manuscripts, and determination of the composition of ceramic and metallic objects are also important issues of the group. Thanks to the data obtained, it is possible to determine or refine data on the age of the analysed object and provide art historians and restorers with data on the composition of the artefacts or monuments analysed.

Migration of Radionuclides in the Environment

The topic under investigation is an experimental study into the interaction of selected radionuclides with barrier materials used in waste repositories and with rock materials. The topic also addresses diffusion of critical radionuclides with barrier materials, including modelling of the processes under study. The team also creates and applies codes for a comprehensive assessment of underground repositories of irradiated, i.e. spent, nuclear fuel and highly radioactive wastes (Performance Assessment).

Molecular Photophysics and Spectrometry

Molecular photophysics and spectrometry study photoinduced processes in organic molecules, including photoluminescence or photoinduced transfer of electrons or electron excitation energy, and their interactions using a strongly localized electromagnetic field near plasmonic microstructures. These processes are the basis of organic optoelectronics, photovoltaics, and artificial photosynthesis, and, to elucidate them, synthesis of specially designed multi-chromophore compounds, stationary and time-resolved spectroscopy, and quantum-chemical calculations are used.

Nuclear Medicine and Radiopharmacy

The group engages in research and development of new radiopharmaceuticals for functional diagnostics and targeted radionuclide therapy. Its work accentuates the preparation of diagnostics based on positron emitter 68Ga for positron emission tomography and nanocarriers for targeted alpha-particle therapy. The aim of the research is timely and more accurate diagnostics and targeted personalized therapy relating in particular to oncological diseases.

Optical Physics

The team members are engaged in theoretical and experimental research into photonics and plasmonics, in particular photonic and plasmonic nanostructures, their design, analysis and implementation techniques, as well as selected applications. They investigate mainly advanced functionalities in sub-wave structures and substrates, and quantum properties. Moreover, they create and develop various models and algorithms for numerical analysis, design, and optimization of the structures studied.

Optical Spectrometry

The research group focuses on optical diagnostics of bulk and thin-film dielectric and semiconductor materials. Its aim is to clarify the electron structure, formation, and properties of the point defects and properties of impurities in the materials under study. The findings are used to optimize crystal growth, to prepare various ceramics and thin films, and to check the content of some impurities in the fabricated materials. These find practical application in optoelectronics, production of lasers, luminescent detectors, and scintillators for ionizing radiation.

Solid-state Lasers

The group does research into solid-state lasers based on crystalline, ceramic, glass, and fibre materials. The focus is on the research and development of special laser systems generating radiation in the visible, near- and mid-infrared regions and generation of short and ultra-short pulses. Activities of the group also include applications in medicine, sensor technology, and transmission of high-power laser radiation by special optical fibres.

Computer Mechanics

The mathematical modelling group uses the principles of continuum mechanics and the numerical method of finite elements to simulate failures of materials and structures. Reverse analysis procedures are also developed to determine the mechanical properties of small volumes of material and thin films. The research results are applicable in the aircraft and power engineering sector to determine the service life of structures under stress and the nuclear energy sector to estimate the degree of radiation damage to reactor materials.

Computer Simulations of Solids

The group focuses on multiscale modelling of solids. Its research covers both ab-initio quantum mechanical calculations of electron structures (based on DTF) and simulations based on molecular mechanics (Forcefield Theory), and selected issues of continuum thermodynamics. Its most important projects include chemical stability calculations of molecules suitable for reprocessing spent nuclear fuel, solutions of polymer elasticity and diffusion of gaseous molecules in polymers depending on the mode of crosslinking between polymer chains, or simulations of modulated martensitic structures in advanced multiferroic materials.

Advanced Detection Systems of Ionizing Radiation

The Centre of Applied Physics and Advanced Detection Systems of FNSPE engages in research and development of semiconductor sensors of ionizing radiation. The group's work includes the entire detection chain, starting from the design of microchip readers, through data acquisition and transport systems, the subsequent signal processing to the final digital or visual information. The members of the group participate in instrumentation of the world's leading particle physics experiments performed by such major institutions as CERN, the Brookhaven National Laboratory, JINR Dubna, and others. They also facilitate technology transfer from fundamental research to practical applications, and are involved in near-space exploration experiments.

Advanced Space Technologies

The FNSPE experts are involved in the development and testing of methods for processing signals originating from measurements carried out in space and separating the useful signal from noise. The main objective is to develop unique detectors of single photons, fast electro-optical switches, and precision time-keeping devices. All of these enable extremely accurate time measurements with an accuracy up to the fraction of picoseconds. The instruments and methods are in use and operate successfully both in Earth-based measuring stations spanning five continents and on board five cosmic missions.

Advanced Methods of Synthesis and Study of Nanocrystals

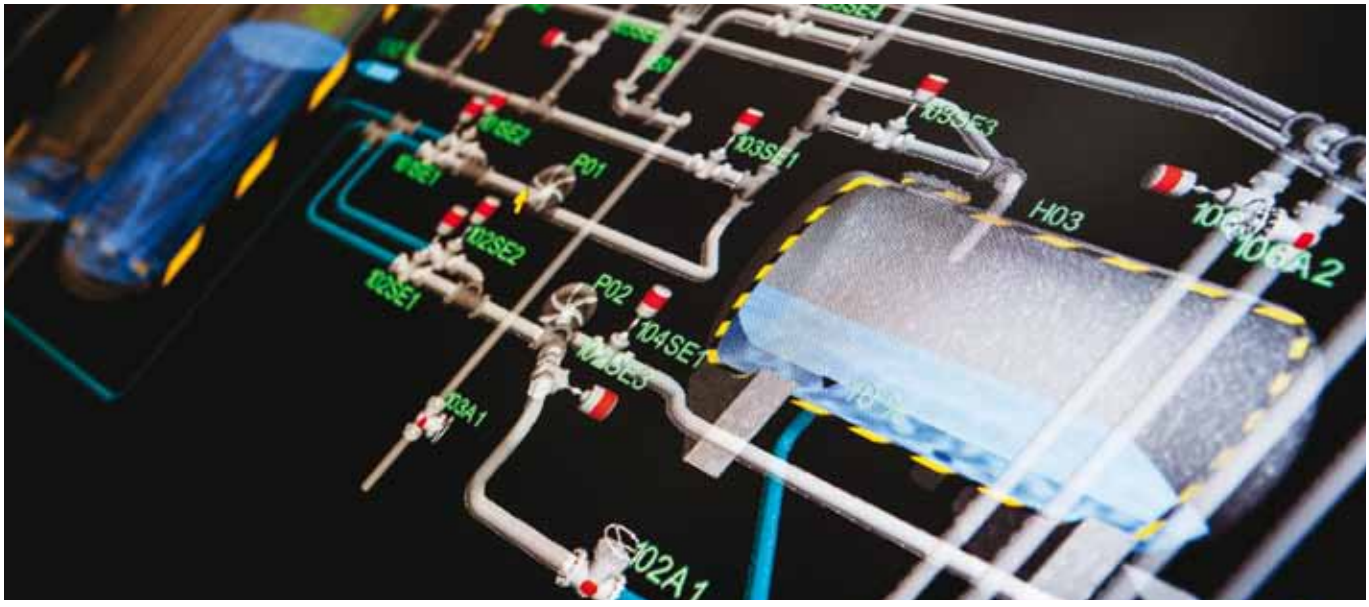
The research is focused on the preparation of complex crystalline structures at a nanoscale. The nanocrystals find use as materials for the production of ultra-fast detectors for imaging tumours in medical diagnostics or in optical ceramics. They are also used for producing advanced pharmaceuticals for treating cancer by X-ray photodynamic therapy. To prepare these materials, chemical, photochemical, and radiation methods are used.

Radiation Protection

Experts in this group are concerned with in-vivo measurement methods used to determine the internal radiation exposure of persons. In order to refine and optimize the measuring geometry or to improve the devices as such, knowledge of computational methods is put into practice. Furthermore, they examine the mathematical models used for calculating internal radiation. The research objective is to streamline the treatment and minimize the doses to which patients are subjected during the treatment using open radionuclide sources in nuclear medicine.

Radioactivity and the Environment

The group engages in monitoring the environment and radionuclide deposition by using laboratory gamma-spectrometry analysis of bioindicator samples and in situ gamma spectrometry focused both on natural radionuclides (NORM) and contamination by man-made radionuclides. The group is also involved in the development of monitoring methods by means of aerial gamma spectrometry and in the study of natural radon radiation, in particular in conjunction with dose estimates for underground workers and with modelling the effect of seismic events on a long time series of radon concentrations.



Radiopharmaceutical Chemistry

The group concentrates primarily on the development of new materials, whether on an organic or inorganic basis, for the needs of radiopharmaceutical practice. These materials are used for transport or separation of radionuclides to meet the requirements of nuclear medicine and preparation of radionuclide carriers or targeting vectors. Radionuclide production and separation consists in preparation, simplification, and streamlining of medical radionuclides. The development of materials focuses also on the preparation of carriers of the radionuclides studied.

Radiotherapy, Nuclear Medicine, and X-ray Diagnostics

The research is oriented towards the strategy and optimization processes of medical procedures, especially towards the experimental verification of the scheduled therapeutic doses. With a view to this, special 3D gel dosimeters are developed and further optimized. Another field of interest is in vivo dosimetry, i.e. measuring the radiation doses directly during the irradiation process. The research focuses also on individual doses of patients in nuclear medicine or clinical dosimetry of the proton beam. In proton radiotherapy, the focus is on determining the radioactivity of the detectors and phantoms after irradiation during a clinical procedure.

Reactor Physics

The group members use computation codes to analyse the criticality of the reactor systems, study neutron fluxes and gamma radiation at various locations, determine fission product and actinoid concentrations, and analyse the quality of shielding. Experiments in reactor physics are carried out on the VR-1 reactor operated by the Faculty; they focus on measurement of neutron flux density and diffusion parameters, determination of the effect of various samples on reactivity or approach to criticality.

X-ray and Neutron Diffraction

The group studies X-ray diffraction of the residual state of stress in polycrystalline metallic and ceramic materials, qualitative and quantitative phase composition, and preferred orientation (texture) of polycrystalline materials. As the only group of its kind in the Czech Republic, the group also investigates new materials, such as synthetic zeolites, perovskites, high-temperature superconductors, and fast ion neutron conductors.

X-ray Photonics

X-ray photonics studies the generation and interaction of electromagnetic radiation within the photoenergy range of 25eV to 420keV. It is primarily concerned with applications of EUV and XUV radiation, XUV microscopy of the so-called water window, X-ray radiography, and tomography. The group also studies various X-ray-optical systems and imaging methods of absorption, phase and scattered radiation in the EUV/SXR, and XR regions for the microscopy and high-energy plasma diagnostics.

Control Systems of Nuclear Reactors

Experts in this group are now engaged in developing hardware and software for programmable systems and microprocessors, the underlying control systems of all current nuclear installations. The independent power protection system of the VR-1 reactor was developed as part of the control systems for research installations. Another long-term project is the implementation of electronic signal processing of detectors using the Campbell method.

Separation and Radioanalytical Methods

The group develops methods for the separation and determination of radionuclides from environmental samples, the fuel cycle – both fission and activation - products and transuranians, natural decay series, and short-lived radionuclides. It is also focused on in-the-field development of advanced nuclear fuel cycles and preparation of radionuclide samples with a long half-life of radioactive transformation for measurements by means of accelerator mass spectrometry (AMS).

Study and Modelling of Radionuclide Speciation

The main concern of this group is speciation study of selected lanthanoids and actinoids by the method of time-resolved laser-induced fluorescence spectroscopy (TRLFS) and the subsequent mathematical procedures for data evaluation and obtaining the parameters sought. A part of the research is devoted to the study of selected forms of uranyl in various systems. Speciation studies of europium and americium with other complexation agents are part of the development aiming to obtain new methods for advanced fuel cycles.

Symmetry and Geometry

The group deals with the use of symmetry in analytical and numerical solutions of differential equations or in the constructions of models in string theory. The group members also investigate the related fields of differential geometry and algebra, i.e. the structure and applications of Lie groups and their algebras. They classify various special classes of Lie algebras, investigate them and make use of them in applications. The group also studies the properties of symmetric functions with several variables and corresponding orthogonal polynomials.

Theoretical Informatics (TIGR)

The group deals with current topics of discrete mathematics with applications in information technology and physics, such as non-standard representations of real and complex numbers, combinatorial properties of infinite word languages, or non-periodical tiling of space. Algorithms for efficient computations in non-standard systems are also the focus of their interest, as well as the study of infinite word languages which lead to solutions to combinatorial, algebraic, and numerical-theoretical issues.

Thermohydraulics of Nuclear Reactors and Heat Removal from Spent Nuclear Fuel

In the reactor, all processes, from heat transfer from nuclear fuel to its release in the form of mechanical energy in the turbine, are part of structural calculations and operation of nuclear power plants. Due to the development of residual heat output in spent nuclear fuel, it is necessary to guarantee its removal even for a long time after the fuel has been withdrawn from the core. Using advanced calculation codes, the group of experts calculate temperature profiles, coolant flow rates, heat transfer coefficients or heat conduction in the reactor core and even during fuel storage or deep storage in repositories.

Computational Methods and Monte Carlo Modelling

The group develops computational methods and program simulations for radiation transport through matter, especially the issue of spectra processing, analysis, and evaluation, spectra convolution and mathematical and statistical processing. Use is made of both the universal MCNP, Fluka, Geant, and Penelope programs, specialized programs like SCALE, SRIM/TRIM, visualization programs, and instruments for work with anthropomorphic phantoms for medical calculations, etc.

Labelled Compounds

The study of labelled compounds deals with the preparation and use of compounds isotopically labelled with a stable or radioactive isotope. The isotopes used within the group are, e.g. 2H,3H,13C, 14C, or 1N. These compounds are needed primarily for the study of metabolism of relevant substances in organisms, of new drugs or radiopharmaceuticals, or to meet the requirements in radioimmunological methods.

The Faculty is Open

The Faculty presents itself at various events which are open to the general public, and some of the other events taking place at the Faculty itself are also open to the public.

Festival of Science

Since 2021, the Dejvice Campus hosts the traditional festival where the CTU faculties and other universities present themselves to the public.

The Night of Scientists

In October, during the Night of Scientists, the Faculty opens its doors to those who want to see the GOLEM tokamak, and attend popular science lectures. The Department of Dosimetry and Application of Ionizing Radiation came up with an escape game that will take place at the Department in the Dejvice campus.

University of the Third Age (U3V)

At FNSPE, U3V combines lectures in the history of physics and popular science lectures with visits to scientific places of work and laboratories and an offer for attendants to take part in experiments of their choice. In addition to the course programme, the course participants can also attend other FNSPE activities, like physics seminars, practicals of the Department of Physics, and others.

Young Minds

The Prague section of the European Physics Society (EPS), Young Minds associates students of FNSPE, the Faculty of Mathematics and Physics of Charles University, and other schools. Their objective is to popularize science among the young and arouse interest in science. Young Minds organize activities where students can present their research in an informal setting, but also events where students can meet experienced scientist quite informally.

Faculty Colloquia

This is a regular series of lectures attended by Czech and foreign experts informing attendants about the latest research findings. The Colloquium is designed for the general public, Faculty academics and students, and guests and visitors outside the Faculty. The Faculty intends to inform potential applicants about the study and the careers open to graduates at such traditional events as e.g. Education Fairs or Open House, and others.

Become a Medical Physicist for a Day

This event introduces the work of a radiological physicist or technician working in a hospital and about other possible jobs and careers for students of the Department of Dosimetry and Application of Ionizing Radiation. They will attend lectures and try to operate an X-ray and a radionuclide, prepare a radiotherapy plan for oncological patients, and visit the Motol and Thomayer Hospitals.

Become a Lady Scientist for a Day

This event is designed especially for female students on the occasion of the International Women's and Girls' Day in Science. It is organized in cooperation with the Brookhaven National Laboratory (BNL-CZ) and CERN-CZ. Along with particle physics, the attendants will also get acquainted with other fields of study offered by FNSPE.

Become a Reactor Physicist fora Day

This event is designed for secondary school students aged 16 and up. They will be able to experience and carry out – in one day - some basic experiments on the VR-1 school training nuclear reactor and learn more about the operation of the fission reactor and its use - in power engineering and other uses besides.

Become a Particle Physicist for a Day

This event is part of an International Master Class project that usually takes place in March. Secondary school students have a chance to work with data from the CERN laboratory and compare them online with students of other foreign universities and directly with CERN scientists.

A Day at FNSPE

At FNSPE, there are many interesting experimental laboratories which can be visited by students from secondary schools. On agreement with the tutor, a bespoke programme may be prepared for every group of visitors.

Mathematics for Life

The content of the course is examples of applications of mathematics in industrial and academic practice. Lectures are given by leading experts in individual fields. The course is accredited by the Further Education of Pedagogical Workers (DVPP). The event is organised by FJFI in cooperation with the Faculty of Education of Charles University.

Chemistry at CTU

A seminar for high school chemistry teachers and their students prepared in cooperation with the FJFI and the Faculty of Civil Engineering, the Faculty of Electrical Engineering, the Klokner Institute and the Letec Educational Institute. The full-day seminar with lectures and practical exercises is accredited as part of the Further Education of Pedagogical Workers (DVPP).

Science Week at FNSPE

Science Week at FNSPE is a traditional semi-social event taking place towards the end of the academic year, during which the Faculty´ s staff and students prepare about 50 miniprojects, visits to the departments and laboratories, and popular scientific lectures for about 180 attendants. The programme starts on Sunday with an icebreaker session followed by the Fort Břehyard game, during which students face various tasks in mathematics, chemistry, physics and look for logical solutions to problems. From Monday onwards, the attendants work on miniprojects required by laboratories, involving instruments, or measurements outside of the Faculty. To have a clearer idea of what scientific work is really like, the participants have to summarise their research results in a paper and present them at the closing session.

Secondary School Competitions

FNSPE supports or takes part in organising many all-year secondary-school competitions and projects, usually in nominating representatives for posts of mentors, reviewers, or direct organisers for Olympiads in chemistry, mathematics, or physics, secondary school professional activity (SOČ), AMAVET, or the Tournament of Young Physicists.

Popular Scientific Lectures at Secondary Schools

Secondary schools have been greatly interested in lectures in the field of natural sciences, and so our staff and students prepare popular scientific lectures, the topics of which are available on their websites, for their visits to grammar schools and secondary schools all over Czechia and even Slovakia. We have also prepared a roadshow presenting various experiments.

Visits to the VR-1 School Training Reactor and GOLEM Tokamak

Throughout the year, the VR-1 school training reactor and the GOLEM tokamak welcome groups of secondary school students for school trips. Moreover, these facilities are visited by foreign students or guests attending training courses, workshops, or conferences.

CTU Technical Club

The Czech Technical University in Děčín operates a Technical Club, which offers programming, robotics, 3D printing and logic classes for children of all ages. You can find information about the Technical Club and details about the individual clubs on the club's website: www.tk.cvutdecin.cz.

Tuesdays with Science

In order to present science with a friendly face to the interested public, the FNSPE branch at Děčín organizes Tuesdays with Science.

Sparrow flies to schools.

An online educational program for high school and second-grade elementary school students aims to support the teaching of nuclear physics topics. The approximately 40-minute program is accompanied by pedagogues from the faculty directly from the premises where the school's nuclear reactor VR-1 Vrabec (Sparrow) is located.

Our Cooperation

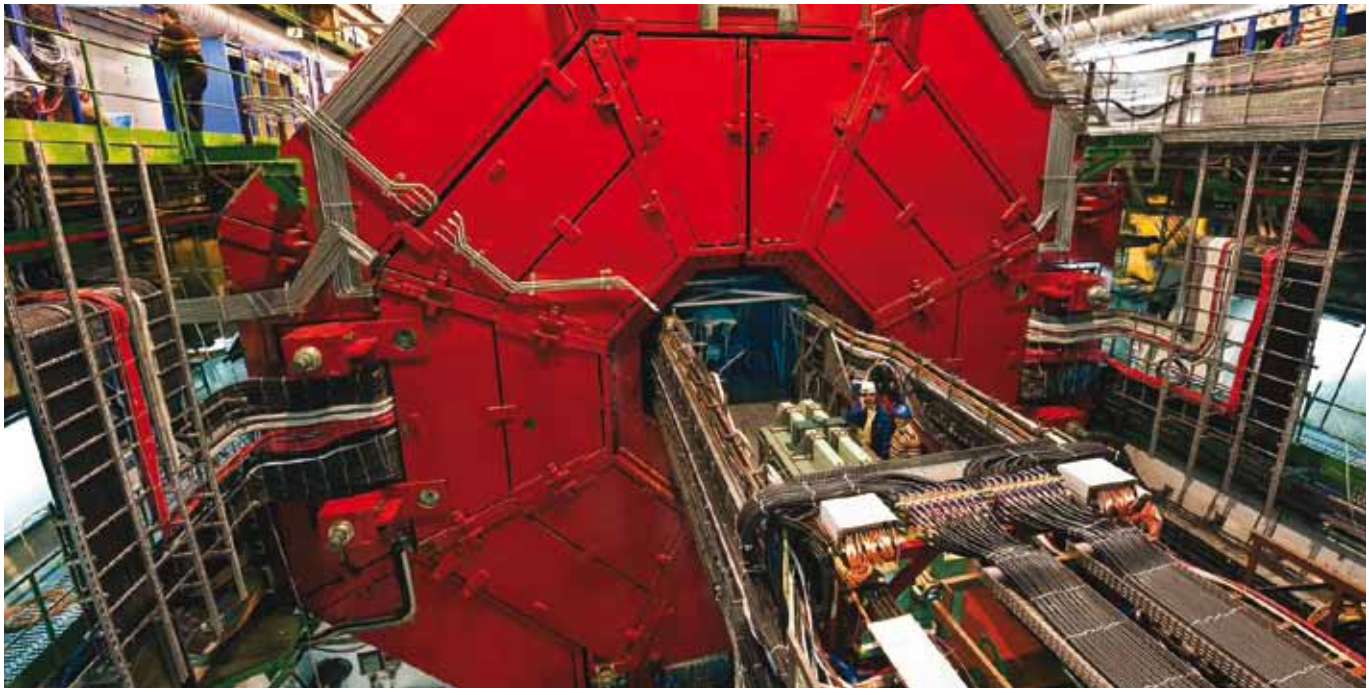
FNSPE participates in many international scientific projects joined by both scientists and students. It cooperates with universities abroad on granting qualification known as double degree, which means that the student is awarded a degree by both the home university and the partner university. Some fields of degree courses must inevitably rely on close cooperation with other faculties, as is the case, for example, with the 3rd Faculty of Medicine UK in educating future radiological physicists.

FNSPE and some members of staff are members of professional associations or societies. They cooperate with over one hundred organizations and companies and thus help the commercial sector develop new installations, carry out tests and analyses, or even offer study stays or topics for degree or doctoral theses.

Every year, FNSPE holds or helps to organize many conferences, seminars, or workshops taking place at the Faculty or elsewhere.

Examples of cooperating institutions:

- Brookhaven National Laboratory (BNL)
- CERN
- European Nuclear Engineering Network Association (ENEN)
- European Physical Society
- European Radiation Dosimetry Group
- International Atomic Energy Agency (IAEA)
- International Radiation Physics Society
- International Experimental Nuclear Reactor (ITER)
- Research Reactor Operating Group
- European Radon Association

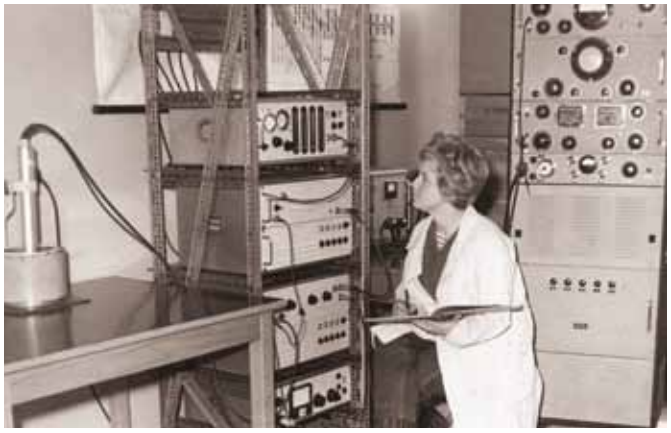


History of the Faculty

The Faculty of Technical and Nuclear Physics was founded as a part of Charles University in 1955 to support the Czechoslovak nuclear programme. In the beginning, there were only three departments headed by famous Czech scientists enjoying international fame: the Department of Nuclear Physics was headed by Václav Petržílka, the Department of Chemistry by František Běhounek, and the Department of Nuclear Engineering by Bohumil Kvasil. Indeed, there were a number of other famous personalities present at the foundation of the Faculty, namely Vladimír Majer, Václav Votruba, and Čestmír Šimáně. In 1959, before the first graduates received their Master's Degrees, the Faculty officially withdrew from Charles University to join the Czech Technical University.

The Faculty was established as a centre of science, research, and teaching and has always been focused on demanding fields of science and has initiated and fostered many more. It has also contributed to the development of new technologies, such as ruby and medical lasers, vacuum technologies, fractography analyses, and quantum optics. The Faculty is also responsible for the design and development of satellite laser ranging stations measuring the distances of satellites from the Earth. They have been located in Egypt, Bolivia, Ecuador, Cuba, Russia, Bulgaria, Hungary, Poland, India, and Vietnam.

1955 the Faculty of Technical and Nuclear Physics is established as a part of Charles University
1956 the Faculty is established in its headquarters in Břehová Street in the centre of Prague
1959 the Faculty becomes part of the Czech Technical University
1960 first 63 graduates receive their degrees
1968 the Faculty changes its name to the Faculty of Nuclear Sciences and Physical Engineering of the CTU in Prague
1970 a new campus is opened in Holešovičky (Troja)
1990 the VR-1 school training reactor is commissioned
1992 the Faculty obtains the Trojanova Street building
1995 the Faculty opens its branch in Děčín
1995 the Student Union of FNSPE is founded
2007 the Faculty receives the training thermonuclear fusion reactor, the GOLEM tokamak
2018 preparation works start on constructing the second school training reactor, the VR-2 fission reactor
2019 launch of a five-year project of the Center for Advanced Applied Natural Sciences (CAAS), co-financed by the European Union
2022 opening of the PlasmaLab@CTU laboratory for the study of hot plasma
2022 launch of the VR-2 subcritical fission reactor



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