2023
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NCBJ HIGHLIGHTS

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Polish Scientific Institution

GENERAL INFORMATION

NCBJ since 2011 (IBJ since 1955)

GENERAL INFORMATION

The National Centre for Nuclear Research is a Polish research institute that is a state legal entity. It is supervised by the Minister of Industry and subsidised by the Ministry of Science and Higher Education.

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A WORD FROM THE DIRECTOR

The National Centre for Nuclear Research is nearing its 70th anniversary, since it was established (initially within the structure of the Polish Academy of Sciences) in June 1955 by a decision of the Polish government as the Institute for Nuclear Research (IBJ). Despite many challenges faced during 2023 and 2024, the Institute continues to develop.

In 2023-2024 NCBJ began many new projects and continued numerous ongoing ones, including large infrastructure projects. CERAD – the Centre for Design and Synthesis of Molecularly Targeted Radiopharmaceuticals – was equipped with a state-of-the-art cyclotron that will enable the production of new radioisotopes for medicine. POLFEL – the Polish Free Electron Laser, which will be the largest research infrastructure built in Poland since construction of the MARIA reactor – received new funding from the National Reconstruction Plan (KPO), together with the NOMATEN CoRE and Maria Neutron Laboratory projects.

In October 2023 the MARIA research reactor resumed operation after a break for modernisation work. This was the largest modernisation project since the reactor began functioning in 1974, an extremely difficult undertaking that required considerable commitment. Such a thorough modernisation is unique on a global scale. I believe that the modernisation programme will allow the MARIA reactor to operate safely and benefit hundreds of thousands of patients for many years to come. In 2024 we also celebrated a very important anniversary – 50 years of the MARIA reactor. Despite operating for half a century, MARIA remains one of the youngest and most modern research reactors in Europe. The reactor's contributions to nuclear medicine and materials research make it an indispensable part of NCBJ's infrastructure.

Another important project – the High Temperature Gas Cooled Reactor Project (HTGR) realised by NCBJ together with the Japan Atomic Energy Agency (JAEA) and funded by the Ministry of Science and Higher Education, has been completed. The main goal of the project: documentation of the basic design of a 30 MW IV generation research high-temperature gas cooled reactor, is now complete. Still more technical documentation is needed to begin construction of the reactor and I hope that the next two years will allow our experts to complete all the missing parts.

I would like to congratulate all the employees of the Institute who assist in advancing scientific knowledge, serving our society and contributing to the Polish economy. It is their achievements, activities and projects that contribute to the success of NCBJ. I believe that we will maintain the highest levels of research, both in basic and applied science, and continuously increase our competences in one of the most demanding of scientific fields, nuclear technology.

Krzysztof Kurek

Director of NCBJ

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Jan Błocki

On February 14, 2023 the late Prof. Jan Błocki passed away at the age of 83.

Professor Jan Błocki was the author of one of the best-known publications in nuclear physics. His paper with Władysław Świątecki presenting the concept of the "proximity force" in nuclear physics received around two thousand citations. Despite this, he remained a modest and straightforward colleague. He worked with many scientists at Świerk, as well as in Berkeley, Paris and Kyiv, on the physics of heavy collisions, the fission process, the mechanism of collective excitation and on the question of chaos in nuclear physics. Prof. Błocki will be remembered as a good colleague, an astute observer and a man capable of formulating refreshingly original and uncompromising opinions.

Mieczysław Zielczyński

On June 22, 2023 the late Prof. Mieczysław Zielczyński passed away at the age of 93.

Professor Zielczyński was a long-time employee of the Institute. He worked in the field of radiation protection, its effects on human body, dosimetry and radiation surveying. He studied the phenomenon of recombination of ions formed under the influence of ionizing radiation in pressurized gas, which was used to determine the quality factor of mixed radiation in the radiation fields of nuclear devices. As a result, he developed ionizing chambers operating in the recombination regime, which brought him worldwide success. Prof. Zielczyński was remembered as an extremely warm, ever-smiling and kind-hearted man, and a great teacher of two generations of scientists.

Andrzej Deloff

On June 24, 2023 the late Prof. Andrzej Deloff passed away at the age of 92.

Professor Andrzej Deloff started his research when scientific interest was focused on dispersion relations and the interactions of pi mesons and nucleons. An internship at CERN provided him with contacts in this field, but he soon turned to study strange particles: K mesons and Λ hyperons. The discovery of hyper-nuclei and contact with Warsaw experimenters inspired him to work and helped him achieve the best results. He was, and remained to the end, a proponent of phenomenological research concluded by experimental verification.

Ryszard Sosnowski

On December 6, 2023 the late Prof. Ryszard Sosnowski passed away at the age of 91.

Professor Sosnowski was a co-founder of the experimental research environment in the field of high-energy physics in Warsaw, an internationally recognized authority in the field of nuclear physics and elementary particle physics, educator for generations of physicists and a creative participant in major international experiments in particle physics. For many years, he was a member the Scientific Council of the Institute, the Polish Academy of Sciences and represented Poland on the CERN Council. For his merits, he was awarded the Marian Smoluchowski Medal, the Officer's Cross and the Commander's Cross of the Order of Polonia Restituta.

NCBJ remains at the forefront of the Nature Index ranking among Polish institutions

The latest edition of the Nature Index, spanning the period September 1, 2023 – August 31, 2024, classified NCBJ in 4th place in Poland in the Physical Sciences category. The ranking includes the most influential scientific journals and assigns points based on contributions to research articles. For many years NCBJ has been placed among the best research institutions in Poland.

Stanford's Top 2%

Stanford University publishes a yearly ranking of the top 2% of scientists in the world, prepared together with the Elsevier publishing house and SciTech Strategies. The latest edition contains over 217,000 names, with over 1,200 from Polish scientific institutions. The ranking is based on complex methodology and takes into consideration indicators such as Hirsch index and scientific activity in different fields within a research team.

The current edition of the Top 2% Scientists ranking includes researchers from NCBJ: Grzegorz Wilk, Mariusz Dąbrowski, Stanisław Mrówczyński, Jerzy Kowalski-Glikman, Andrzej Królak, Leszek Roszkowski and Gillaume Beuf, as well as the late professors Andrzej Deloff and Marek Moszyński.

NCBJ still at the top of... Polish universities

In the 2024 edition of the Global 2000 list, ranking the world's top universities, NCBJ ranks in the top 4.2% and still ranks seventh among universities in Poland. The list, prepared by the Center for World University Rankings, includes the best universities in the world. In the rankings, both the learning environment at an institution and the quality of the research conducted are equally important. Almost 21,000 universities appeared in this year's ranking. Despite the fact that only doctoral studies are conducted at NCBJ, once again the Institute was ranked in the top 4.2% of universities in the world, at the same time taking 7th place in Poland. This is mainly thanks to our scientists, whose research makes it possible for NCBJ to occupy such a high position.

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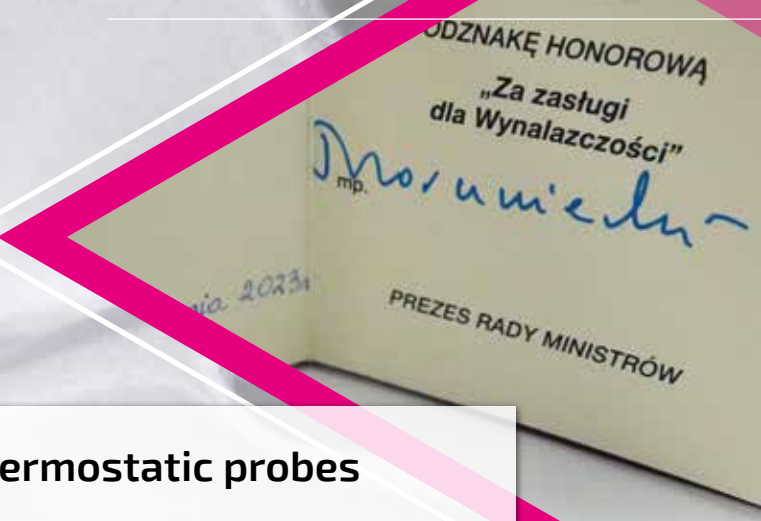

Developers of experimental thermostatic probes awarded badges of honour

Research into materials to be used in future high-temperature reactors or fusion facilities can be carried out at nuclear research reactors. The high neutron fluxes present in these reactors make it possible to reproduce the conditions that will be present in future installations. It is therefore possible to study the effects of radiation fields, high temperatures and pressures on the strength and structure of materials envisaged for use in the construction of new reactors. However, these experiments require special thermostatic probes, in which strictly defined conditions exist during irradiation: temperatures as high as 1000°C, high pressure, or a helium atmosphere. Scientists at NCBJ's MARIA reactor have designed and constructed several probes of this type, for which they were awarded the badge of honour "For Services to Innovation". Badges of honour were awarded to Maciej Lipka, Piotr Mazerewicz, Marek Migdal, Anna Talarowska, Grzegorz Wojtania and Antoni Zawadka during a ceremony at a meeting of the NCBJ Scientific Council.

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Polish Nuclear Society prize for doctoral thesis on a two-fluid reactor

Every year the Polish Nuclear Society announces a competition for the best theses in atomic science. Among the winners announced in 2023 was Jakub Sierchuła, from NCBJ's Division of Nuclear Energy and Environmental Studies, who took second place in the PhD thesis category. The thesis concerned research into Dual Fluid Reactors (DFRs). This is a concept for a high-temperature fast-neutron reactor in which both the fuel (in the form of molten salts or metal) and the coolant (lead/lead-bismuth) are in liquid form. This solution makes it possible to achieve a very high power density, make efficient use of the fuel, as well as improve safety. In a DFR reactor the working medium can reach temperatures as high as 1000°C, which would enable it to be used for industrial processes such as hydrogen production.

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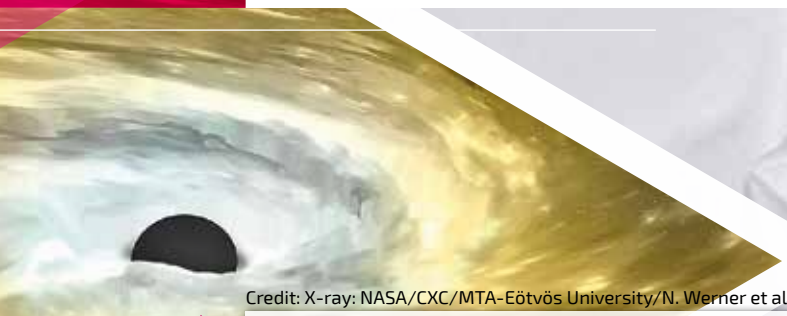

Credit: X-ray: NASA/CXC/MTA-Eötvös University/N. Werner et al., Ilustration: NASA/CXC/M. Weiss

The project of a PhD student from the NCBJ Astrophysics Division has qualified for the "Pearls of Science" programme

The "Pearls of Science" programme organised by the Ministry of Education and Science aims to create conditions for the development of exceptionally talented graduates. Among the projects qualified for the first edition of the 2023 competition is the research of Krzysztof Lisiecki, a doctoral student in NCBJ's Astrophysics Division, under the title "In search of witnesses of the early universe - a study of the properties of red nuggets." The project aims to study the properties of extremely massive small galaxies, called red nuggets. These galaxies are incapable of forming new stars and are therefore an extremely important part of the study of galaxy formation and evolution, as they are suspected of being the seeds of the most massive galaxies in the local Universe. The study of these galactic nuclei allows us to reconstruct the conditions in the early Universe. The project has the potential to make a significant contribution to the theory of galaxy evolution and, in particular, to the formation processes of these unique objects.

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2023 Paul Phelps Continuing Education Grant for NCBJ scientist

Tomasz Rajkowski, of NCBJ's Electronics and Detection Systems Division, has been awarded the Paul Phelps Continuing Education Grant, given annually to several young scientists by the Radiation Effects Committee of the IEEE Nuclear and Plasma Sciences Society. The award is intended to motivate further education and research, and includes, among other things, participation in training at a conference in Kansas City. Tomasz Rajkowski conducts research into the effects of radiation on electronic components and devices, with a particular focus on cosmic radiation. He also uses linear electron accelerators to test for single event effects, i.e. phenomena caused by a single particle, which are responsible, among other things, for bit falsifications in digital circuits and sometimes the destruction of entire components and systems. At the same time Tomasz Rajkowski is developing cooperation between NCBJ and the space industry by providing consultation on the radiation resistance of electronics in the EagleEye satellite project.

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Article about FLASH appreciated by SEP

The promising results of the first studies and trials of FLASH ultra-high-dose-rate radiotherapy mean that interest in this technique is growing steadily. Research in this field is being recognised, as evidenced by the award won by the article of Aleksandra Lenartowicz, Janusz Pracz and Vasyl Markopolski "FLASH therapy: a new miracle in radiotherapy of malignant tumours?". The publication won second place in the Prof. Mieczysław Pożaryski Competition "For the best articles published in journals - organs of the SEP". In the article, the authors described in detail the novel FLASH radiotherapy technique, in which the effect of sparing healthy tissues with a high level of destruction of tumour cells is observed. To date, a number of radiobiological and preclinical studies have been carried out using radiation at high dose powers (>40 Gy/s), which offer hope for widespread clinical application of the FLASH technique. At NCBJ this topic is being developed by the Department of Nuclear Equipment, in collaboration with the Greater Poland Cancer Centre.

▸ *Full Article* ◂

Michael Romano received prestigious award from Astronomy & Astrophysics

Michael Romano from NCBJ's Astrophysics Division has been awarded the prestigious Early Career Research Reward by the journal Astronomy & Astrophysics. The award is given annually to young scientists who have distinguished themselves with outstanding achievements in the field of astrophysics. Michael Romano received the award for his pioneering research into the dynamics and evolution of galaxies. Using observational data from the ALMA telescope he analysed the merging processes of galaxies in the early Universe. The information provided by the ionised carbon emission line observed by ALMA was used for the first time and showed that about 40% of galaxies observed in the early Universe were in the process of interacting and colliding with other galaxies. He is also principal investigator of an ESO observational programme using the capabilities of the KMOS spectrograph in Chile. The programme will enable further studies of galaxy formation by analysing the dust and metal content of primordial sources.

▸ *Full Article* ◂

Article by Professor Andrzej Strupczewski is one of the best works published in SEP scientific and technical journals

A jury of the Prof. Mieczysław Pożaryski Competition selected the best works published in the scientific and technical journals of the Association of Polish Electrical Engineers (SEP) in 2023. The award ceremony was held during a meeting of the SEP Presidents' Council. Among the 39 articles submitted to the Competition was the publication "Renewable energy sources or nuclear power - what does Poland need?" by Andrzej Strupczewski, NCBJ Spokesperson for Nuclear Power. Prof. Strupczewski's article was distinguished among the submitted works and won 3rd prize. As the congratulatory letter reads: "The paper not only enriched the content of the journal Wiadomości Elektrotechniczne, but also contributed to the knowledge and inspiration of our readers."

▸ *Full Article* ◂

Professor Gudowski has received the Eagle award of the weekly "Wprost"

At a conference in Warsaw entitled "Wprost o nauce. From basic research to development work. The Polish system of higher education and science in times of contemporary challenges. Prospects opportunities challenges", Wacław Gudowski from NCBJ received the "Wprost" Eagle Award in the "Business and Science" category. The award was given for outstanding scientific achievements and teaching activities in the field of nuclear energy, as well as for involvement in the development of scientific cooperation between Poland and Sweden. Wacław Gudowski is a professor of Reactor Physics and Neutron Physics at the Royal Institute of Technology in Stockholm, a member of the Royal Swedish Academy of Engineering Sciences and a professor at NCBJ. He is the author of more than 90 scientific publications in the fields of nuclear engineering and solid state physics, and is one of the European pioneers of research into transmutation of waste and nuclear materials.

▸ *Full Article* ◂

The Populariser of Science Main Award goes to the Education and Training Division

The Grand Prize in the 19th Edition of the Populariser of Science competition was awarded to the NCBJ Education and Training Division Team. The award was granted "For many years of contributions to the popularisation of knowledge on ionising radiation, radioactivity, nuclear energy and natural radioactivity. These activities have additional significance in the context of the implementation of Poland's energy transformation programme." The Populariser of Science competition has been organised for almost 20 years by the Polish Press Agency, and the Institute and its employees have been nominated and awarded prizes many times in past editions. NCBJ's Education and Training Division is dedicated to promoting broadly understood knowledge of ionising radiation, radioactivity, especially natural radioactivity, nuclear energy and the physics of the micro world, particularly nuclear physics. The department is developing a programme of free lending of simple radiation detectors to schools, conducts workshops, classes and training sessions, and is co-organiser of the national student competition "Physics Paths."

▸ *Full Article* ◂

CIŚ achieves Tier 1 status for the LHCb experiment at CERN

The Świerk Computing Centre at NCBJ has been granted official Tier 1 status in the Worldwide LHC Computing Grid. It is the first computing centre in Poland to be granted Tier 1 status for the experiment at the LHC at CERN. There are currently fourteen such centres operating worldwide. They provide data processing, storage resources and 24/7 network operation services. The Tier 1 centres are responsible for storing some of the raw and reconstructed data, reprocessing it, and further distributing the data to local Tier 2 centres. Receiving Tier 1 status is a huge success for NCBJ and Polish science, and a tribute to the work of the many scientists and engineers who have run the Tier 2 node and coordinated the supercomputers over the years.

▸ *Full Article* ◂

Professor Leszek Roszkowski elected to EASA

Leszek Roszkowski, an employee of NCBJ's Theoretical Physics Division and head of the international research agency AstroCent, operating at the Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences, has become a member of the European Academy of Sciences and Arts (EASA). EASA is one of the most prestigious scientific and artistic organisations in Europe. Established in 1990, EASA aims to promote the advancement of scientific and artistic activity in the spirit of freedom and the search for truth.

▸ *Full Article* ◂

NCBJ scientists elected as members of the Astronomy Committee of the Polish Academy of Sciences

Appointments to the Astronomy Committee of the Polish Academy of Sciences for the term 2024 - 2027 have been announced. The Committee, which has been active for over 70 years, is tasked with taking measures to develop astronomy and utilise its achievements. It also serves as the National Committee for the International Astronomical Union and elects Poland's representative to the international consortium publishing the journal Astronomy & Astrophysics. Three scientists from NCBJ's Astrophysics Division are among the 36 members of the Commission for the 2024 - 2027 term: Marek Biesiada, Katarzyna Małek and Agnieszka Pollo. In addition, Katarzyna Małek became one of three members of the Committee's Presidium. Marek Biesiada is also a member of the Physics Committee of the Polish Academy of Sciences.

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Awards of the NCBJ Scientific Council

In March, during a ceremonial meeting of the Scientific Council, NCBJ scientists and engineers are rewarded for their achievements in the previous year in three categories: scientific research, organisational-technical and educational. In recognition of achievements in 2023 the awards went to:

In the scientific and research category:

- **Edyta Wyszkowska, Cyprian Mieszczyński, Łukasz Kurpaska, Iwona Jóźwik and Witold Chromiński**, for a series of papers presenting experimental confirmation of the possibility of increasing the radiation resistance of structural materials by appropriate selection of their composition, with particular emphasis on Ni-Fe alloys,
- **Magdalena Gawęda**, for the development of amorphous protective coatings based on SiOC, increasing the radiation resistance and high temperature stability of structural elements of nuclear reactors,
- **Sebastian Trojanowski**, for proposing new methods to study the nature of dark matter and its possible interactions with neutrinos using observations of the microwave background radiation.

In the organisational and technical category:

- **Henryk Giemza**, for the individual commissioning and management of the Tier 1 grid node for the LHCb experiment.

In the educational category:

- **The team of the Education and Training Division** for popularising knowledge of ionising radiation, radioactivity, nuclear energy and natural radioactivity, with particular attention to the contribution of Justyna Jaczewska-Özcan for promoting the use of educational detectors in schools.

▸ *Full Article* ◂

Awards of the Director of the Department of Fundamental Research

In June, during a Special Seminar of NCBJ's Department of Fundamental Research, the Director's Awards are presented for achievements in the previous year. This time, the Jury honoured research into faintly luminous galaxies and attempts to explain phenomena occurring during relativistic ion collisions. Popular science articles and essays were also recognised. For achievements in 2023 the awards went to:

For scientific achievements:

- **Junais** from the Astrophysics Division for his study of the properties of the faintest luminous galaxies ever observed using machine learning,
- **Michał Spaliński** of the Theoretical Physics Division for his study of relativistic hydrodynamics used to describe relativistic ion collisions.

For popularisation activities:

- **Darko Donevsky** of the Astrophysics Division for his popularisation activities, e.g. in the popular science journal "Elements."

▸ *Full Article* ◂

Galactic outflows drive the evolution of dwarf galaxies

Feedback created in star formation and active galactic nuclei has a huge impact on the evolution of so-called dwarf galaxies. These mechanisms produce large-scale "winds" that entrain large amounts of gas and dust, carrying them into intergalactic space, depriving the galaxy of the material needed to form new stars. Feedback has been thought to mitigate inconsistencies between theoretical predictions and observations, so a thorough understanding of the mechanisms is essential. A team of scientists led by Michael Romano of NCBJ's Astrophysics Division studied the effect of galactic outflows on the rate of star formation and the depletion of gas and dust resources in dwarf galaxies. Using light emitted by carbon ions, the researchers found that feedback is responsible for up to 40% of the gas outflow into intergalactic space and is ubiquitous in low-mass galaxies. This phenomenon may provide a bridge to understanding processes in galaxies formed in the early Universe, whose physical properties are similar to the analysed dwarf galaxies.

▸ *Full Article* ◂

Gas on the run – ALMA spots the shadow of a molecular outflow from a quasar when the Universe was less than one billion years old

A quasar is a compact object whose luminosity is driven by a supermassive black hole at the centre of a galaxy. Because of their distance and brightness, they provide an opportunity to look at conditions in the early Universe when it was less than a billion years old. A team of researchers from the Universities of Hokkaido, Tsukuba and Waseda in Japan, with contributions from NCBJ scientists, has discovered the first evidence of slowing star formation caused by the influence of gas in a quasar's host galaxy in the early Universe. The researchers used the ALMA radio interferometer, the only telescope in the world with the sensitivity and frequency range able to detect outflows of molecular gas. Darko Donevsky of NCBJ's Astrophysics Division was also involved in the work and participated in analysing data from the ALMA interferometer. The results provide the first strong evidence for the existence of massive gas outflows from quasar host galaxies and their impact on the evolution of galaxies during the early cosmic period.

▸ *Full Article* ◂

Credit: NASA, ESA, CSA, STScI

Unveiling hidden stars: ALMA shines a light on dust attenuation

Interstellar dust is a key component of galaxies: it promotes star formation and drives chemical and physical processes. At the same time, it hides most of the newborn stars in such a way that their direct observation is impossible. An international team of researchers led by Mahmoud Hamed from NCBJ's Astrophysics Division conducted a new study of the properties of dusty star-forming galaxies more than 10 billion light years away. The researchers found that the properties of ultra-massive galaxies strongly depend on the dust suppression models used. The team succeeded in discovering a link between the way the light of young stars is dimmed by dust and the shape of the galaxy itself. These new findings provide insights into the nature of dusty star-forming galaxies and may inspire new researchers to look deeper into the dust attenuation relation.

▸ *Full Article* ◂

Midlife Crisis of the Universe: Galaxies' interactions did not affect interstellar dust

Dust is a very important element in galaxies. It absorbs and scatters light, but it also emits absorbed infrared radiation. The energy balance of these phenomena is a subject of study for astrophysicists, and a group of scientists from NCBJ, led by Mahmoud Hamed and Katarzyna Małek, analysed more than 1,000 galaxies from this point of view. The researchers found that the energy balance of radiation absorption and emission is related to the metallicity of galaxies, i.e. the ratio of the abundance of oxygen to the more common hydrogen. The greater the dust attenuation, the higher the infrared emission and the higher the metallicity. In addition, the team noted that dust attenuation is stronger in more compact objects, confirming previous observations. Importantly, the study found no correlation between the effectiveness of dust attenuation and the environment in which galaxies are located, and which affects their key properties such as star formation and mass. This is a surprising result and scientists will conduct further investigations into the relationship between the environment of galaxies and dust attenuation.

▸ *Full Article* ◂

In the Universe appearance matters: Dusty shapes of colourful galaxies

Star formation is a process that takes place in a very dusty environment. This dust makes observation difficult because it absorbs the light of the newborn stars. The light is then re-radiated in the infrared and carries with it the properties of young, massive stars. Observing a galaxy in light of different wavelengths - from ultraviolet, to optical light and infrared - allows us to analyse and understand its fundamental nature and assess the amount of interstellar dust. Unfortunately, galaxies with full wavelength coverage are rarely available. An international team of scientists led by Katarzyna Małek, Junais and Agnieszka Pollo from NCBJ analysed archival studies to propose a method to obtain information about the dust without observing infrared light. The researchers found that the dust attenuation of a young population of stars, obtained from optical data alone, can reproduce the main physical parameters of galaxies. This relationship works very well for less massive galaxies, but for more massive ones the derived star formation rate is overestimated.

▸ *Full Article* ◂

Can dust evaporate in harsh interstellar environments?

Dust particles existing in space are not only responsible for the formation of new molecules and the cooling of gas, but also for the distribution of energy in galaxies, as well as for estimating their physical properties. The amount of dust changes through various processes such as astration, shock waves from supernovae and galactic outflows. Another such phenomenon is so-called photoevaporation, caused by the absorption of ultraviolet radiation. This process may therefore contribute to the destruction of interstellar dust, as studied by a group of astrophysicists led by Ambra Nanni from NCBJ. The scientists analysed models of the evolution of gas and dust in galaxies with different processes, different time scales and for different environmental influences. The researchers found that photoevaporation is more important in the vicinity of massive star-forming clusters, but that the phenomenon itself is responsible for destroying a very small fraction of the dust in galaxies, much less than the possible accuracy of determining the gas and dust to star mass ratio.

▸ *Full Article* ◂

Credit: NASA, ESA and the Hubble Heritage Team (STScI/AURA)

Smashing galaxies into dust

Galaxies very rarely live in isolation, they tend to find each other and form pairs. As a result of such a meeting, the stars, dust and gas within them are forced to move, resulting in a rapid increase in the rate of new star formation. So far, we do not know exactly how galaxy collisions affect the formation of dust, or how the newly formed dust suppresses light. A team of NCBJ astrophysicists led by William Pearson under the SONATA grant is investigating these phenomena, as well as ways more reliably to identify colliding galaxies based on their shape. The scientists will compare traditional morphological classification methods with modern methods using AI. By simulating images of galaxies just before and just after a collision, the researchers will train artificial intelligence to recognise such objects. At the same time, work will be carried out on using modern tools to study the dust content of galaxies. Among other things, the analyses are expected to help understand the impact of galaxy interactions on the amount of heavier elements - including those necessary for the formation of life.

▸ *Full Article* ◂

Listening to the silence: Investigating the interstellar medium in evolved galaxies across cosmic ages

Galaxies combine the vast majority of physical processes known to modern science. They are also one of the most interesting topics in modern astronomy because of their relationship to the evolution of the entire Universe. Observations confirmed by theoretical models show that dust and interstellar matter have a key influence on the evolution of galaxies. However, this dust makes observations difficult due to its absorbing some of the radiation and emitting it in the infrared. A completely new opportunity to study interstellar matter has been opened up by the James Webb Space Telescope (JWST), which can shed light on galaxies that emit infrared radiation. As part of a PRELUDIUM grant involving NCBJ's Krzysztof Lisiecki, the new data from the JWST will be used to analyse the global dependence of the evolution of galaxies and their interstellar matter, particularly dust. This may help to find the origins of galaxies as they exist today.

▸ *Full Article* ◂

New observations of the outer Milky Way help understand the star formation process

Star formation depends on many factors, so it is still an incompletely understood process. Studies of our own galaxy may be helpful, as different areas of the galaxy are characterised by different environmental conditions. Such observations could provide a breakthrough for understanding star formation, thanks to the high resolution of the observations, impossible for distant galaxies. In a recent study a team of astrophysicists, including NCBJ's Miguel Figueira used data from the OGHReS survey to analyse the influence of the environment on star formation in the outer and inner regions of the Milky Way. The new results allowed a more precise determination of the distances of star-forming clusters, as well as conclusions about the behaviour of the areas where new stars are formed. For example, the scientists discovered that more low-mass stars are formed in more distant areas than closer to the galactic centre. This research is the first time that OGHReS data have been used on such a large scale. The team will continue their work to investigate further the physics and chemistry of star-forming regions, large-scale structures and spiral arms of the Milky Way.

▸ *Full Article* ◂

Credit: NASA

Barely visible galaxies are the key to understanding the Universe

All existing surveys of astronomical objects have limitations due to the accuracy of the instruments and, in the case of ground-based observations, the influence of the atmosphere. Our knowledge is therefore mainly based on observations of bright objects. However, it has been known for decades that there are galaxies with low surface brightness that very easily escape observation. Studying them requires the observation of huge areas of the sky with large telescopes, which the currently under construction Vera Rubin Observatory and the Legacy Survey of Space and Time (LSST) survey will help with. In a project „Barely visible: low surface brightness galaxies in the LSST era", financed under the MAESTRO grant and led by Agnieszka Pollo from NCBJ researchers will try to develop new and improved methods for finding and classifying low surface brightness galaxies, which can be applied to the data obtained in the LSST survey. This may help to answer questions about the role of low surface brightness galaxies in the evolution of the Universe and their relevance to the laws of physics.

▸ *Full Article* ◂

Neutrinos could be the key to understanding dark matter

Of the elementary particles known to us, putative dark matter particles most closely resemble neutrinos in terms of the strength of their interactions. The phenomenon of neutrino oscillations has convinced researchers that they could be a window into the discovery of so-called "new physics", also in terms of interaction with dark matter. However, it is almost impossible to verify such a hypothesis, due to the very rare occurrence of neutrino interactions. The early Universe may be a great source of information, in the form of the Cosmic Microwave Background (CMB) radiation, emitted when the first atoms were formed. Small irregularities in its distribution inform researchers about the distribution of matter in the very early Universe. Current methods and tools allow us to study much smaller areas of the sky in detail, but recent work has discovered inconsistencies between CMB observations for larger and smaller angular sizes. The authors, including Sebastian Trojanowski from NCBJ, suggest that these can be explained by introducing a non-zero strength for dark matter-neutrino interactions. The next generation of telescopes will shed more light on these considerations.

▸ *Full Article* ◂

What the spectral lines tell us about a rotating neutron star

Neutron stars are among the most extreme objects in the Universe. The density of matter in their interiors is twice that of an atomic nucleus, and exotic states such as condensates of pions, kaons and even free quarks can form in them. The only way to study matter under such conditions is through astronomical observations and theoretical models. Polish astronomers, including Agnieszka Majczyna from NCBJ, have created a model of the radiation spectrum of a hot, rapidly rotating neutron star. Analyses of the model have shown that the spectral lines vary depending on the plane of observation. By fitting the model to the spectra of observed real neutron stars, it is possible to determine not only the mass and radius of the star, but also the angular velocity of rotation and the angle of inclination with respect to the observer. These properties are extremely important for understanding the nature of neutron stars, in particular the question of their interior structure.

▸ *Full Article* ◂

Kick-off of the Astrophysics Centre for Multimessenger studies in Europe, ACME, an EU-funded project built by and for the astroparticle and astronomy communities

The inaugural meeting of the Astrophysics Centre for Multimessenger studies in Europe, ACME, was held in Paris in September 2024. The Centre brings together the astronomy and astrophysics communities in a joint effort to create a system of long-term collaboration between research centres, regardless of location, in order to equalise opportunities for access to infrastructure in Europe and beyond. The consortium will become a pioneer in expanding and improving access to relevant research infrastructure services and data. NCBJ is one of ACME's most active partners. Łukasz Wyrzykowski from the Astrophysics Division co-leads the work package responsible for providing and unifying access to archives on the different media of the Universe and the different wavelengths associated with them. In particular, he directs the BHTOM Global Optical Observatory, which provides access to a huge number of photometric archives.

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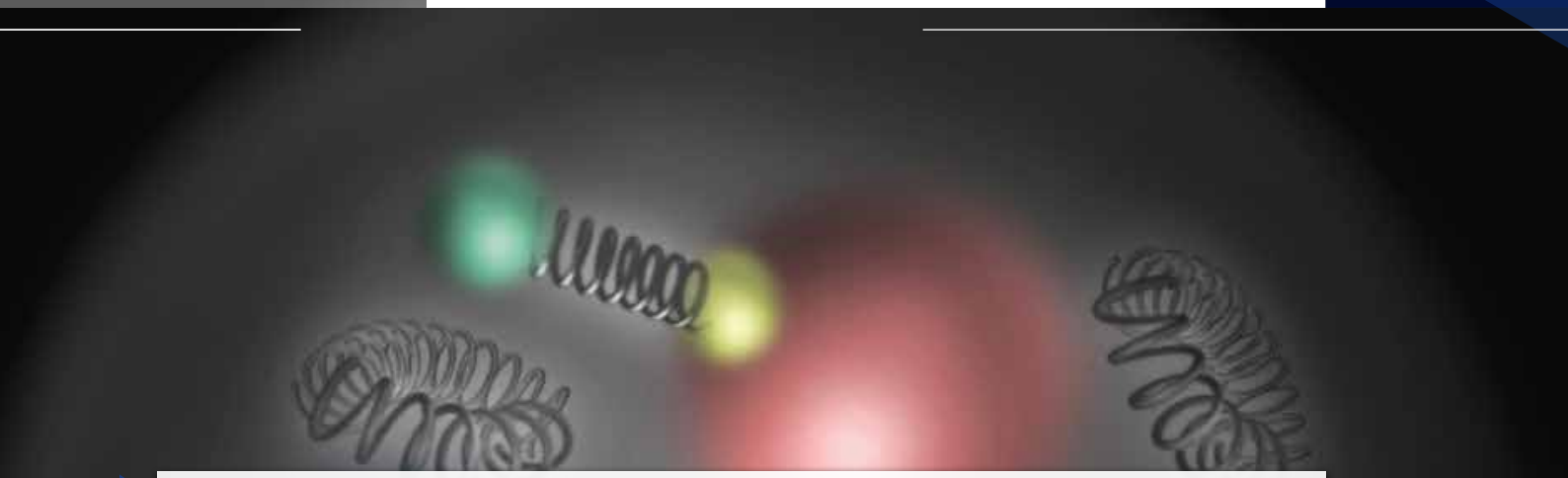
Credit: NASA/JPL-Caltech



The search for color-glass condensates

Color-glass condensate is an ultra-dense and exotic state of matter that is being researched by scientists all over the world for over 20 years. This topic also fascinates NCBJ scientists, including Guillaume Clement Beuf from the Theoretical Physics Division. At NCBJ, Guillaume Beuf is researching quantum chromodynamics, a field that deals with nuclear strong interactions, also known as color interactions. Understanding these is essential for analysing data from particle collisions in modern accelerators. In the case of proton-nucleus collisions at very high energies, according to the hypothesis formulated by the researchers, the nucleus is "seen" by the incoming projectile in the form of a very dense state of matter: a color-glass condensate. Continued research by scientists, including Guillaume Beuf, will contribute to the verification of this hypothesis and a better description of particle collisions at high energies.

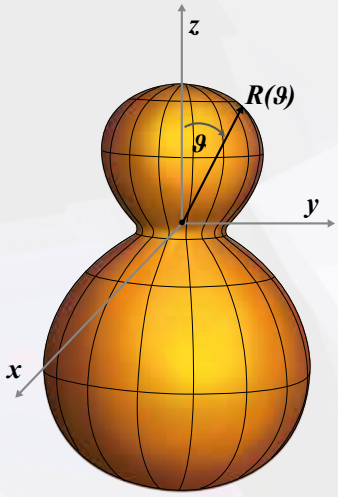
▸ *Full Article* ◂

Can gluons multiply indefinitely?

One of the most important questions in physics is the fundamental structure of matter in nature. Numerous efforts dedicated to understanding the fundamental constituents of matter and the interactions between them have led to a theory called quantum chromodynamics (QCD). This theory describes the interactions between elementary particles interacting strongly - quarks and gluons, which combine to form hadrons. One of the key features of QCD theory is that the number of gluons increases with increasing energy. An important question is whether this growth can continue indefinitely. The work of theorists in recent decades has led to the concept of gluon saturation: at sufficiently high energies, gluons begin to recombine, leading to a slower increase in their density. The development of theoretical models, which a team led by Tolga Altinoluk is working on at NCBJ under the SONATA BIS grant, will make it possible to make full use of data from experiments, such as at the Large Hadron Collider or the future Electron-Ion Collider, and provide theoretical support for future phenomenological work.

▸ *Full Article* ◂

A new description of superheavy element synthesis



β_{10} = +0.917
β_{20} = +1.757
β_{30} = +0.001
β_{40} = -0.292
β_{50} = -0.001
β_{60} = +0.078
β_{70} = +0.001
β_{80} = -0.018

The heaviest known elements can only be produced under laboratory conditions in a fusion process where light elements accelerated in a cyclotron are collided with a target made of lead, bismuth or actinides. The resulting object has excess energy and is unstable, so it disintegrates into smaller fragments or emits neutrons and gamma radiation. Of the whole process, the stage involving the fusion of the two atomic nuclei is the most difficult to study and describe, and there is still no consensus among scientists as to its mechanism. Therefore, Aleksander Augustyn and Tomasz Cap from NCBJ and scientists from the University of Warsaw's Faculty of Physics have developed a theoretical model that explains the probability of fusion and makes predictions for fusion reactions that have not yet been tested. The model is so promising that the researchers also plan to use it to analyse the fission process and shape evolution in more detail. In addition, once the model is enriched with the possibility of neutron and light charged particle emission, it will allow simultaneous modelling of fusion and cooling stage.

▸ *Full Article* ◂

In search of quantum gravity

One of the main challenges of modern theoretical physics is the coupling of the classical theory of the gravitational interaction with the principles of quantum mechanics. Researchers are looking for a quantum theory of gravity that allows gravity to be coupled consistently to the matter fields of the Standard Model. There are several approaches that attempt to solve the problem of quantum gravity. One of these is the loop quantum gravity programme, which follows the concept of quantisation of the general theory of relativity. This theory suggests that both space and time are quantised, so that there are smallest, indivisible parts of spacetime. In the ongoing SONATA project led by Mehdi Assanioussi from NCBJ, studies of certain coherent states in the context of loop quantum gravity will be carried out in order to construct a renormalisation procedure for loop quantum gravity theory coupled to matter fields. In addition, the physical symmetries of spacetime and matter fields will be investigated in order eventually to develop effective models and derive phenomenological consequences of quantum gravity theory.

▸ *Full Article* ◂

Credit: CERN

NCBJ researchers have obtained new constraints on CPT symmetry breaking in the charm quark sector

The Standard Model describes the fundamental interactions between elementary particles and is one of the best experimentally tested theories of particle physics. However, it is not complete, for example it does not describe the gravitational interaction. One way to look for deviations from the Standard Model is to test its fundamental properties, such as the CPT discrete symmetry. However, the predicted effects of breaking this symmetry proposed in hypothetical models are very small, making them difficult to verify experimentally. This topic was addressed by a team of researchers such as Wojciech Krzemień from NCBJ, who tested the effects of CPT symmetry breaking by measuring the oscillations of neutral flavor mesons. This was possible thanks to data from the LHCb experiment at CERN. The researchers calculated new constraints on CPT symmetry breaking, 100 times more accurate than previously. This means that if there are differences between the masses or decay times of charm mesons and their antiparticles, they are less than 10^{-16} GeV. The team's research continues, with analysis now being carried out using the formalism of the so-called Extended Standard Model.

▸ *Full Article* ◂

NCBJ scientists investigate quantum entanglement in ultrarelativistic scattering

Entanglement is the phenomenon by which the quantum states of two or more particles cannot be described independently of one another, even when the particles are separated by large distances. Such a feature is the most fundamental property distinguishing quantum from classical systems. There is growing pressure among theorists towards the possibility of discovering a deeper connection between quantum entanglement and ultrarelativistic scattering, which allows the study of particle interactions. In a recent paper, Kamila Kowalska and Enrico Sessolo from NCBJ's Theoretical Physics Division analysed the entanglement properties in the scattering of two particles carrying an internal quantum number ("flavor"). The researchers found that some amount of entanglement is always "injected" into a system of two initially non-entangled particles. In addition, the scattering process can convert entanglement between flavors into entanglement between particle momenta. This analysis is one of the first steps towards understanding the links between quantum entanglement and experiments that study elementary particles at the highest achievable energies.

▸ *Full Article* ◂

Radioisotope Centre POLATOM

As the world-renowned producer and distributor of isotope preparations used in medicine, science, industry and environmental protection, Radioisotope Centre POLATOM is an important supplier of high quality radiopharmaceuticals and diagnostic kits for customers all over the world. With over 60 years of experience, POLATOM manufactures radiopharmaceuticals and other radioactive preparations reaching over 2000 customers in more than 80 countries, as well as conducts research and development work in radiochemistry, biochemistry and immunology.

Radioisotope Centres POLATOM portfolio includes:

- a wide range of scintigraphic ^{99m}Tc labelling kits for organ examination and cancer diagnosis,
- preparations of Iodine-131 for the diagnosis and treatment of thyroid diseases,
- ^{99}Mo/^{99m}Tc radionuclide generators
- precursors for the preparations of therapeutic radiopharmaceuticals
- a wide range of preparations for clinical studies and medical research and development,
- sealed radiation sources,
- radioactive standard solutions and sources,
- radiochemical reagents,
- a wide range of special radioactive preparations tailored to users' needs,
- accessories and services for nuclear medicine units:
  - calibration and servicing of dose calibrators,
  - installation and maintenance of isotope equipment,
  - trans-shipment and transport of radioactive materials.

The National Centre for Nuclear Research POLATOM Radioisotope Centre holds the PN-EN ISO 9001:2015-10 Quality System Certificate and the implemented WSK (Internal Control System) for the trade in dual-use goods, as well as certificates confirming compliance with the requirements of Good Manufacturing Practice (GMP) and Good Distribution Practice (GDP). Its Radioactivity Standards Laboratory maintains a management system compliant with the international standard PN-EN ISO/IEC 17025:2018-02. The confirmation of RSL's technical competence as a calibration laboratory is the accreditation certificate granted by the Polish Centre for Accreditation. POLATOM also received Known Consignor status granted by President of the Civil Aviation Office.

▸ *Website* ◂

The CERAD cyclotron has arrived at Świerk

The CERAD cyclotron, designed and built by the Belgian company IBA, has been installed at NCBJ. The device is one of the most advanced medical cyclotrons in the world and one of the few that can accelerate three different charged particles - protons and alpha particles to energies of 30 MeV and deuterons to energies of 15 MeV. The entire CERAD laboratory complex will offer scientists state-of-the-art research and production facilities to search for new radiopharmaceuticals for diagnosis and therapy, based on biologically active ligands that act at the cellular and molecular level. The wide range of radioactive isotopes produced with the cyclotron and the MARIA research reactor will enable the design of tracers that will facilitate earlier and more precise detection of diseases and, consequently, earlier implementation of appropriate pharmaceutical procedures. The new cyclotron will make possible research into new radiopharmaceuticals that will be specifically designed to meet the needs of individual patients.

▸ *Full Article* ◂

The laboratory at NCBJ which is a real “standard”

Part of the Radioisotope Centre POLATOM, operating at NCBJ, is the Radioactivity Standard Laboratory (LWR), the depository of the State Standard Unit for Measurement of Radioactivity of Radionuclides. The staff specialise, among other things, in the control of activity and radioactive contamination levels of radiochemical preparations and radiopharmaceuticals, as well as in the calibration of activity meters. As part of their scientific and research work, LWR specialists carry out activity and half-life measurements of isotopes. In recent studies the isotopes Lu-177 and Ac-225, which have been used in nuclear medicine for many years, were analysed. Measurements of activity made with several absolute measurement methods gave consistent results with an accuracy of up to 0.013%. Such high precision allows the production of reference sources for calibration of activity meters. The Laboratory also conducts radionuclide purity measurements, up to 1,000 times more precise than the required limits. This type of research is very important in many different fields, from nuclear medicine, industry and environmental protection, to meteorite-related research.

▸ *Full Article* ◂

Modern nano-radiopharmaceuticals for diagnostics and therapy

The development of modern medicine necessitates the search for new diagnostic imaging methods and therapeutic strategies for the treatment of various diseases. Increasing hopes are being placed on nanotechnology, which makes it possible to create structures capable of overcoming biological barriers. However, the use of new nanostructures involves the risk of unwanted side effects, so it is important to design and clinically validate nanoparticles that will be safe. Within the framework of a SONATINA project carried out at NCBJ by Karolina Zajdel, multifunctional and efficient nanomaterials are sought, which will involve relatively low production costs and have high biocompatibility and minimal cytotoxicity in biological systems. These characteristics can be met by a new generation of nanomaterials doped with lanthanide ions, which have unique optical properties. They enable the conversion of lower energy radiation into higher energy radiation. The choice of dopant ions can give the nanomaterials different properties, allowing them to be used in several different imaging techniques. This could lead to novel materials for medicine, used for both diagnostics and cancer therapy.

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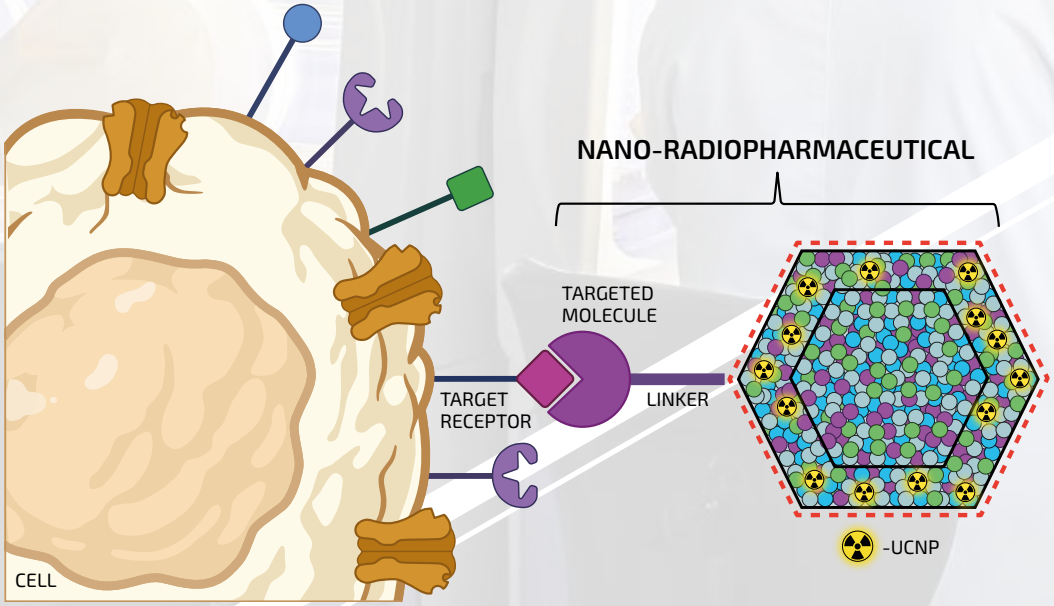

The work of OR POLATOM scientists in a special issue of the journal Molecules

The field of radiopharmaceuticals is seeing continuous development, influenced by its interdisciplinarity. A particular increase in interest can be observed in the area of radiopharmaceuticals based on metal radioisotopes. This involves the improvement of current and the emergence of new, efficient methods for their production. This subject is addressed in a special issue of the journal Molecules, where a paper authored by Renata Mikołajczak and Izabela Cieszykowska from OR POLATOM presents the production possibilities of the copper-67 isotope. The authors describe currently used methods of producing the radioisotope, as well as its detailed characteristics and possibilities for use in medicine. They emphasise the increasing availability of a way to produce copper-67, which will also be possible at NCBJ thanks to the new cyclotron, part of the CERAD project. Combined with the properties of the radioisotope, this could make it an important component of diagnostics and therapy.

▸ *Full Article* ◂

NOMRad 2024 – Review of the latest developments in radiopharmaceutical research

The NOMRad 2024 international radiopharmaceutical conference, organised by NCBJ's NOMATEN Centre of Excellence, took place in Warsaw. The event was centred around four themes: production and separation of radionuclides, radiopharmaceuticals, isotopic labelling and biomolecules, and clinical trials. Conference participants had the opportunity to present and discuss the latest research discoveries in the field of radionuclide production, the development of new diagnostic and therapeutic radiopharmaceuticals and their preclinical and clinical evaluation. Young scientists in particular had the chance to network with other researchers representing different disciplines.

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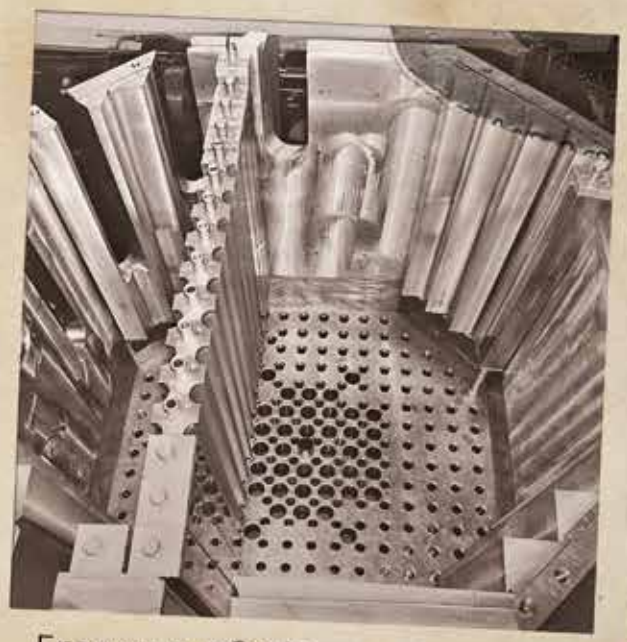
Model of the MARIA reactor

Foundation Act

Installation of formwork - concreting the safety enclosure



Fragment of the reactor core with aligned core matrix and reflector blocks

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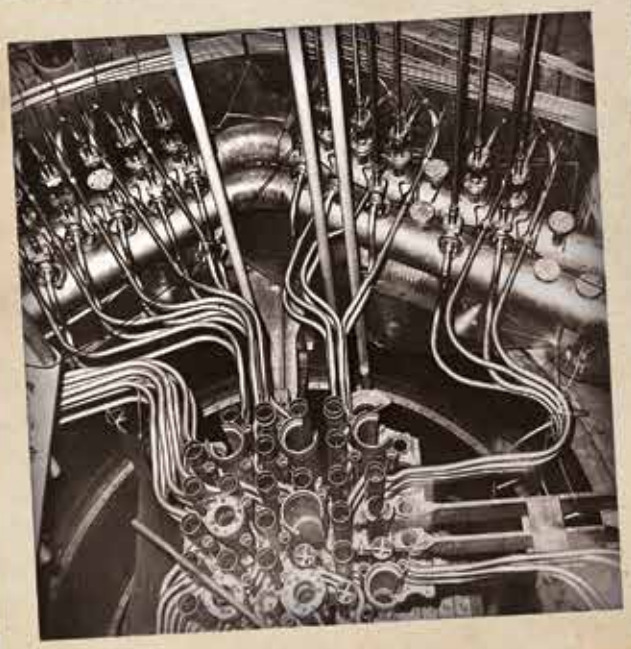
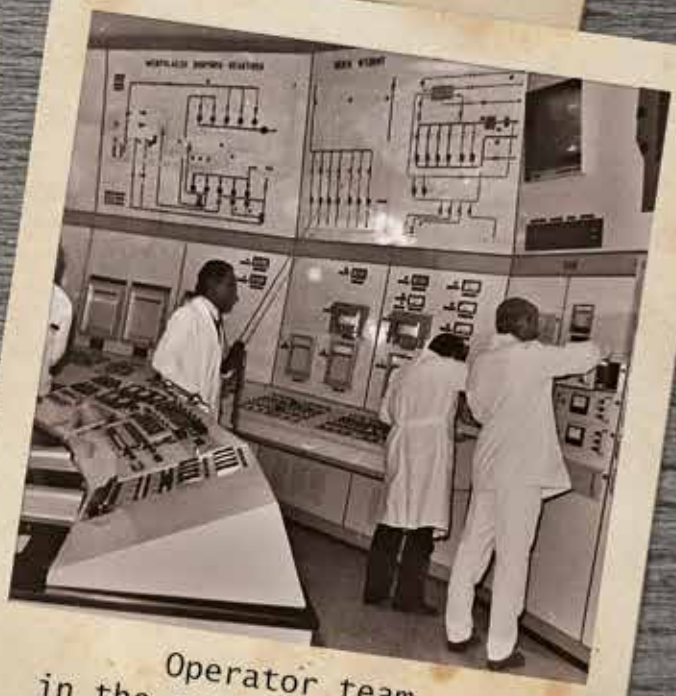


Interior of the reactor pool

Functional check of the control rod actuators

MARIA reactor in summer 1974



Operator team in the control room during the reactor start-up

MARIA - 50 years of service to science, the economy and medicine

50 lat Reaktor MARIA 1974 - 2024

The MARIA reactor is the only operational nuclear reactor and one of the largest research facilities in Poland. It is located on the premises of the National Centre for Nuclear Research. MARIA does not produce electricity, but neutrons, which create radioisotopes for cancer diagnosis and radiotherapy. The MARIA reactor produces innovative materials for industry, facilitates basic and applied research in physics, and enables the training of personnel in nuclear and radiological protection.

On the night of 17-18 December 1974 the MARIA reactor reached criticality, i.e. the appropriate conditions for a self-sustaining chain reaction, for the first time. This date is considered to be the moment when the reactor began operation. The reactor is named MARIA, in honour of double Nobel laureate Maria Skłodowska-Curie.

Physical research is carried out at MARIA using intense neutron beams, including radiochemical research and materials research, incorporating that necessary to master fusion energy production technology. The MARIA reactor is a major global producer of iodine-131, used in the diagnosis and treatment of thyroid diseases, as well as molybdenum-99, used in cancer diagnosis and therapy. One week of reactor operation assists 100,000 patients worldwide.

MARIA, as the only active nuclear reactor in Poland, enables the training of personnel specialised in nuclear power and radiological protection. The so-called physical hall is currently being refurbished, and will provide access to a laboratory facility for materials research that is unique in central Europe. The infrastructure, using intense neutron beams, centred under the banner of the Maria Neutron Laboratory, is included in the Polish Research Infrastructure Map.

An international symposium entitled “50 years of the MARIA reactor” was held at the NCBJ headquarters on 25 October. This symposium presented the achievements of several generations of experts from different scientific fields who are tackling the most important challenges in nuclear research. The symposium was attended by representatives of government authorities and key nuclear and reactor research centres from around the world. The panel discussion addressed topics concerning the operation of research reactors and their safety.

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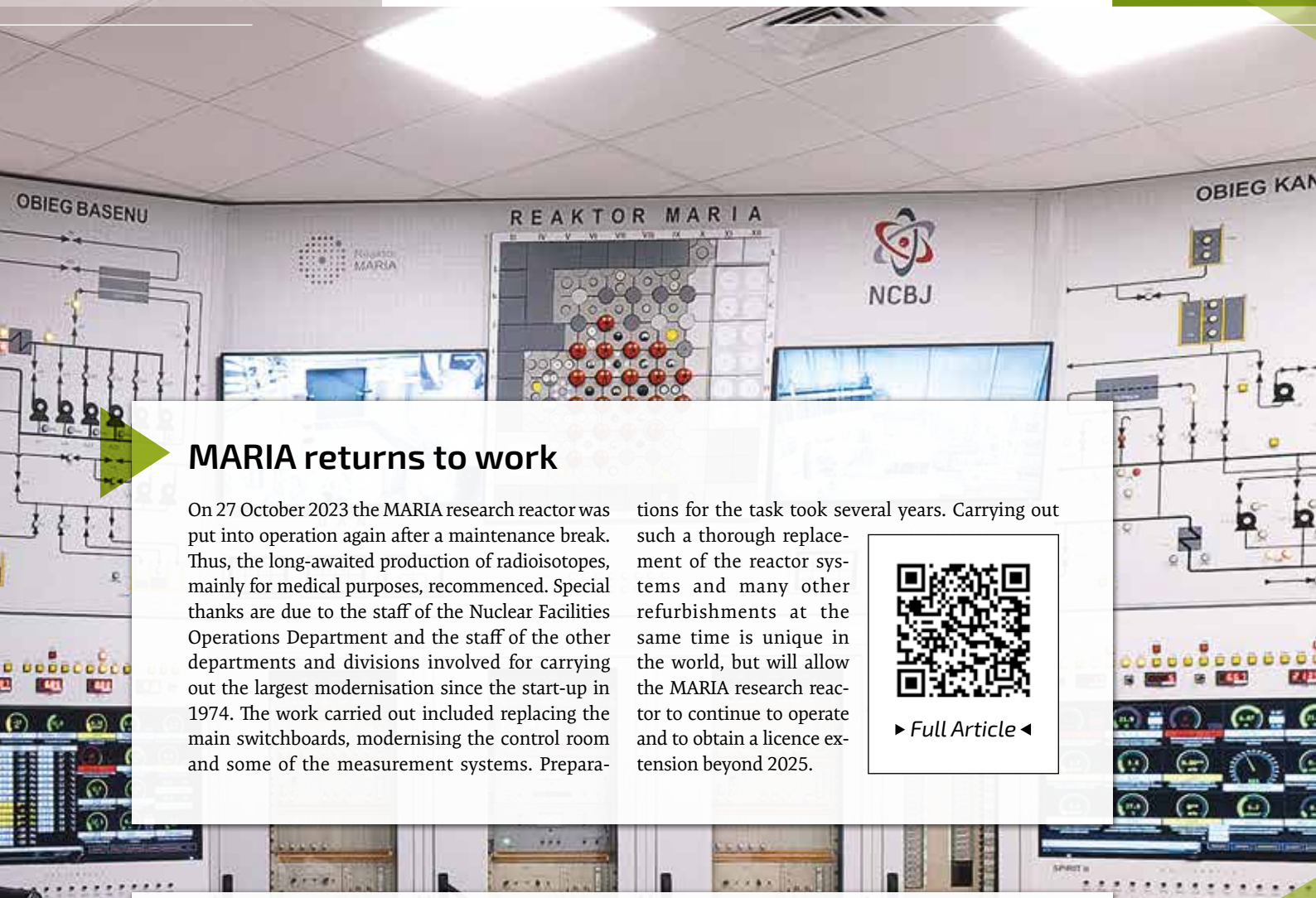

MARIA returns to work

On 27 October 2023 the MARIA research reactor was put into operation again after a maintenance break. Thus, the long-awaited production of radioisotopes, mainly for medical purposes, recommenced. Special thanks are due to the staff of the Nuclear Facilities Operations Department and the staff of the other departments and divisions involved for carrying out the largest modernisation since the start-up in 1974. The work carried out included replacing the main switchboards, modernising the control room and some of the measurement systems. Preparations for the task took several years. Carrying out such a thorough replacement of the reactor systems and many other refurbishments at the same time is unique in the world, but will allow the MARIA research reactor to continue to operate and to obtain a licence extension beyond 2025.

▸ *Full Article* ◂

Boron Neutron Capture Therapy provides hope for brain cancer patients

Despite the incredible advances in oncology in recent years, brain tumours remain one of the most dangerous forms of cancer. Boron-neutron capture therapy (BNCT), being developed at NCBJ, offers hope to patients, increasing the chances of recovery. In June 2024, experts from all over the world gathered to discuss and exchange experience in this field at the 20th International Congress on Neutron Therapy. Radiotherapy, of which BNCT is one variation, is one of the most widely used treatments for cancer, especially in patients whose surgically hard-to-reach organs have been attacked. Boron-neutron capture therapy itself is one of the oldest, but still under development. The boron-10 isotope used in it is not radioactive, so when it is introduced into the body it poses no threat and, with the help of a suitable pharmaceutical, accumulates in the cancer cells. Only when the patient is placed in a neutron beam are the boron nuclei broken down into lithium and an alpha particle, which deposits all its energy in nearby tumour cells, destroying them. Research into BNCT therapy is still ongoing, including at NCBJ.

▸ *Full Article* ◂

Neutrons from the MARIA reactor will be used for materials research and cancer treatment therapy studies at a new station

Horizontal channels in the MARIA reactor are used to direct the neutron beam out of the core for use in research. As part of a new project, a new test station will be constructed at horizontal channel H2. The specific location will allow a very high ionising radiation field to be achieved, comparable to the conditions in the reactor core itself. The design of the test station will allow the parameters of the neutron beam to be modified according to research needs, and samples of different sizes, even entire devices, to be irradiated. This will make it possible to observe changes in device performance in a radiation field. The experience gained by the team working on the station at the H2 channel is unique in Europe. R&D work using the new capabilities will also allow research related to boron-neutron capture therapy, which could result in a breakthrough in the treatment of head, neck or brain tumours.

▸ *Full Article* ◂

As part of NCBJ's collaboration with JAEA, the JMTR high-temperature material probe has arrived at the MARIA reactor

Cooperation between NCBJ and the Japan Atomic Energy Agency has been ongoing for more than 10 years. In addition to major undertakings, such as activities in the area of high-temperature reactors, projects have been developed over the past few years which allow the MARIA reactor to be used more fully. Together with Japanese partners an initiative has been taken to place JMTR-type material probes developed at the JAEA Centre in Ōarai in the MARIA reactor. These are devices for testing a number of components further to improve the safety, reliability and performance of light-water reactors. The experiment is to investigate the behaviour of FP (Fission Products) pressure sensors in the reactor radiation field over a long period of reactor operation. A visit to NCBJ by specialists from the JAEA Centre took place in 2023, during which the probe was installed in the reactor. This is a further step in the use of the MARIA reactor in the field of materials research and, at the same time, the implementation of new reactor technologies in research programmes.

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The most accurate picture of the turbulent flows in the heart of a nuclear reactor

Nuclear reactions heat the fuel rods in reactor cores. The collection of the heat thus generated is critical to the safe operation of the reactors themselves and the efficiency of the power-generating turbines. The complex physical phenomena occurring during coolant flows between fuel rods have been the subject of work by a team of scientists that includes Tomasz Kwiatkowski from NCBJ. Carrying out precise computer simulations that reproduced the turbulent coolant and heat flows between the closely packed fuel rods required three and a half years of work by ten thousand computing cores. The simulations performed used the direct numerical solution of the Navier-Stokes equations, which describe fluid movements in physics. This method is extremely precise, but also very time-consuming, even on huge computing clusters. The result of these difficult calculations is a publicly available reference database that can be used by other scientists to validate calculations carried out using simplified methods. This makes it possible to map the flows and heat transfer in the fuel casings even more accurately, thereby further enhancing the safety of new and existing reactors.

▸ *Full Article* ◂

Knowledge of cooling: crucial for nuclear reactor design

The proper operation of a nuclear reactor largely depends on its cooling processes. However, accurate modelling of turbulent coolant flow and heat transfer processes in fuel cases is a major computational challenge. Therefore, engineers often use simplified substitute methods, which must be validated and improved to increase their level of accuracy. Research in this area is also being conducted at NCBJ, where scientists have developed a comprehensive methodology within computational fluid mechanics to model accurately the phenomena of turbulent flow and heat transfer in a closely packed fuel case. Precise calculations performed primarily on the computational cluster of the Świerk Computing Centre made it possible to obtain criteria for so-called “best practices” when using simplified models. The work carried out at NCBJ by Tomasz Kwiatkowski has been recognized by the international community, as evidenced by the “Early Career Researcher Award” he received at the SCOPE international conference in Saudi Arabia.

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Nuclear Fuel Cladding Research – Collaboration with South Korea

Materials used in nuclear reactors are constantly exposed to high-intensity neutron and gamma radiation. To ensure the safety of reactors it is important to predict in advance when the impact of radiation cannot be ignored and a component must be replaced with a new one. As part of a new joint Polish-Korean project coordinated by Jacek Jagielski, NCBJ scientists will test by nanoindentation for structural, mechanical and thermal performance, a new type of fuel casing resistant to uncontrolled increases in operating temperature and pressure. The new fuel casings, so-called Accident Tolerant Fuel, coated with protective layers based on chromium and chromium-aluminum alloy, are expected to resist LOCA (loss of coolant) events and prevent zirconium oxidation. Moreover, the project aims to develop a method for determining the mechanical properties of materials by means of nanoindentation performed continuously, which will allow the study of properties of extremely thin layers.

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Are multi-unit High-Temperature Gas-cooled Reactors safe?

In recent years, the number of multi-unit reactors has increased significantly. They allow sharing of resources and infrastructure, thus reducing overall construction and operating costs. However, these reactors face the risk of simultaneous systems failures in different units due to common causes such as initiating events, component failures and human error. To address these risks, researchers are performing extensive safety assessments. This type of work will also be performed at NCBJ as part of Mina Torabi's project under the MINIATURA grant, which will focus on the analysis of multi-unit high-temperature gas-cooled reactors (HTGRs) using the multi-unit probabilistic safety assessment methodology. The exact focus of the research will be the design of the HTTR high-temperature test reactor, an experimental Japanese high-temperature reactor designed and operated to demonstrate HTGR technology.

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Concept design of the HTGR-POLA research reactor

In June 2023 the conceptual design of a new Polish research high-temperature reactor was presented to the public for the first time at a conference organised by the Union of Polish Employers. Developed at NCBJ, the helium-cooled HTGR-POLA reactor will provide 30 MW of thermal power and the helium temperature at the outlet of the primary cooling circuit will reach up to 750°C. The project has been prepared by a team from NCBJ's Division of Nuclear Energy and Environmental Studies, led by Mariusz Dąbrowski, in collaboration with the Japan Atomic Energy Agency (JAEA). The conceptual design is the starting point for work on the basic design, which will also include safety analyses and testing of reactor construction materials.

▸ *Full Article* ◂

Polish high-temperature research reactor "HTGR-POLA" designed at the National Centre for Nuclear Research in Świerk

Based on experience with the MARIA research reactor which has been operating at Świerk for 50 years and the Japanese HTTR high-temperature research reactor, a team of experts from NCBJ has developed the concept of the Polish HTGR-POLA (POLish Atomic) high-temperature research and demonstration reactor. The project is currently at a high level of technological readiness, covering the basic design together with a significant part of the so-called Preliminary Safety Report, necessary for its licensing and further design work, construction and commissioning. The HTGR-POLA reactor project is the first step in the application of high-temperature reactors in the Polish chemical and petrochemical industries, which will contribute to the reduction of national greenhouse gas emissions. Due to the significant intellectual contribution of Polish scientists and designers, as well as the involvement of Polish companies in the design and construction, the HTGR-POLA reactor could represent a breakthrough for Polish industry, as well as become an export product for our country.

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HTGR-POLA research reactor presented during the 67th IAEA General Conference

The conceptual design of Poland's HTGR-POLA high-temperature gas-cooled reactor, unveiled for the first time in Warsaw, was presented at the International Atomic Energy Agency's annual General Conference in Vienna in September 2023. One of the side events of the conference was a meeting entitled "HTGR Contribution towards Carbon neutrality," organized by Japan. During the event, Japan, Poland and the UK presented the status of ongoing activities concerning high-temperature reactors and the further vision for their continuation. The main element of the panel discussion was the presentation of the conceptual design of the HTGR-POLA reactor by NCBJ's Representative, Director for HTR Development Józef Sobolewski. Of the three countries Poland is at the most advanced stage in the construction of a new block HTGR reactor, which generated much interest and discussion with the audience.

▸ *Full Article* ◂

GEMINI4.0 summer school on high-temperature reactors for industry held in Świerk

As part of the GEMINI 4.0 project, a Summer School was held at NCBJ in September 2024. It brought together 70 participants to learn about high-temperature gas-cooled reactor (HTGR) technology and, above all, its application to the generation of 300 to 550°C process heat, electricity, low-temperature district heat, hydrogen, etc., so-called polygeneration. The school's lecturers were prominent European specialists in HTGR technology, as well as Polish specialists and local NCBJ representatives, who presented the progress of the technical design of the Polish HTGR-POLA research reactor and the pan-European situation regarding industrial decarbonisation in Poland and Europe. During the school, attention was paid to the advantages of HTGR technology, including its passively regulated safety systems governed by the laws of physics, as well as issues related to the design, systems and elements of reactor construction and equipment, safety analyses, polygeneration, including steam and hydrogen production, and socioeconomic aspects related to the implementation of this technology.

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NCBJ has joined the European industry alliance for Small Modular Reactors

The call for candidates for the SMR Industry Alliance, established by the European Commission, ended in April 2024. The alliance aims to facilitate and accelerate the development and deployment of the first SMR/AMR Small/Advanced Modular Reactor projects in Europe, with the goal of having the first reactor operational in the early 2030s. NCBJ will be mainly involved in the alliance in work related to AMR (Advanced Modular Reactors). Joining the alliance is a prestigious step for the Institute, mainly due to its involvement in the preparation of the design and construction of the HTGR-POLA high-temperature research reactor. This reactor was accepted in early 2024 and listed in the OECD's NEA Bulletin as one of the SMR technologies proposed for the market.

▸ *Full Article* ◂

Scientists predict wind turbine power generation using machine learning methods

The role of renewables-based power generation is growing every year. However, due to the variable level of power generated and the strong dependence on weather conditions, maintaining a stable energy system requires tools to predict the performance of renewable sources. Such systems are developed on the basis of weather forecasts and historical data and with them it is possible effectively to predict the power that, for example, wind farms will generate, both in periods of minutes or hours or for longer, even a few days. Research into the creation of such tools is being conducted by employees of the Interdisciplinary Department of Energy Analyses of NCBJ and the Silesian University of Technology. Using data from the control systems of wind turbines and available commercial forecasts of weather conditions, the researchers determined the accuracy of the predictions using, among other things, machine learning methods. The optimal solution turned out to be the random forest model, which matches the precision of neural networks with much shorter training times. In the long term it is also beneficial to combine different models.

▸ *Full Article* ◂

The first collective prosumer in Poland is already operational!

Individual energy production is very popular in Poland. More than 1.3 million individual prosumers are already producing energy for their own needs. Thanks to the definition of a collective prosumer proposed in 2022, residents of multi-tenant buildings can also produce energy and jointly account for revenues from a common installation. The first collective prosumer in the country was established in Ryki, Lubelskie Voivodeship, involving the employee company Enercode Sp. z o.o., which is part of NCBJ's Interdisciplinary Department of Energy Analyses (IDEA). The start-up process required expertise and a combination of many supporting tools previously developed by IDEA specialists, such as an energy optimisation system (Chronos) and a tool indicating the size and configuration of the necessary installation (Aura). The definition of a collective prosumer is something completely new in Polish law. It represents an important step towards the popularisation of local and distributed energy.

▸ *Full Article* ◂

Credit: Lubelska Agencja Wspierania Przedsiębiorczości

Optimal mix in the "Energy Transformation Observatory" project

Energy transformation is one of the biggest challenges many countries are currently facing. A new project in which NCBJ is participating will allow the creation of an Observatory for Energy Transformation, which will support optimal decision-making in this area, monitor the status of transformation progress, as well as model and analyse the effects of implemented solutions. As a member of the consortium, NCBJ will provide tools developed by the Interdisciplinary Department of Energy Analyses, such as Zephyr, to optimize the energy mix. Zephyr is a set of analytical tools to support investment decisions in the areas of heating and electricity. The system takes into account the adopted criteria for energy transformation and can be used to perform analyses with hourly resolution, which, combined with automatic data collection, will make it possible to provide up-to-date and reliable knowledge on the progress of the transformation. Such a system also makes it possible to test the effects of potential changes before they are actually implemented.

▸ *Full Article* ◂

NCBJ scientists study the structure of materials using a new microscope

An integral aspect of materials research in nuclear applications is understanding the effect of radiation defecting on material structure, as this knowledge is fundamental to understanding the degradation of materials during their service life. A transmission electron microscope (TEM) has recently been installed and commissioned in one of the NOMATEN Centre of Excellence's laboratories. The primary use of the microscope is to study radiation-induced changes in materials at the nanoscale, as well as to determine the crystallographic relationships of defects, phases and other microstructural elements. In addition, comparison of TEM results of controlled deformation of materials with data obtained with other equipment available at NOMATEN laboratories will help understand which elements of the microstructure are responsible for its strengthening. This will make it possible to design materials with optimal mechanical properties. The use of the TEM technique contributes to the understanding of many scientific problems that are the subject of intensive research in materials science.

▸ *Full Article* ◂

NCBJ Materials Research Laboratory prepared to test construction materials for the HTGR reactor

The development of new power generation technologies requires specialised engineering expertise and excellent knowledge of the functional properties of structural materials. This is especially true for nuclear installations, where the safety aspect is extremely important. Current testing methods allow precise determination of the properties of a given material from the scale of single atoms. This type of work is the speciality of scientists at NCBJ's Materials Research Laboratory (LBM), where a recently completed modernisation opens new opportunities for the analysis and testing of structural materials. The new research infrastructure makes it possible to study the strength of materials at high temperatures, up to 1250°C, in a specific atmosphere. The laboratories have also been enriched with equipment for destructive and non-destructive testing of materials. At the same time the newly-equipped labs are accredited by the PCA for mechanical, non-destructive and structural testing, so LBM is authorised to conduct accredited tests in accordance with international standards for certifying materials and testing methods.

▸ *Full Article* ◂

Concentrated solid solution alloys as candidate materials for fusion reactors

Increasing global demand for energy requires the development of new, advanced energy generation technologies, such as Generation IV reactors and future fusion reactors. However, the efficiency of the reactors themselves will depend on the materials used in their construction. Key structural components will be exposed to unprecedented conditions - extremely high temperatures, enormous thermal stresses and significant radiation damage. The goal of many studies, such as NCBJ's "Multicomponent CSA-type alloys - a novel approach to developing radiation-resistant materials for fusion applications" led by Damian Kalita under the SONATA grant, is to find materials that will be capable of long-term operation under the conditions of a fusion reactor. One prime candidate is metals containing concentrated solid solution alloys (CSAs). In such materials, the random arrangement of atoms manifests itself in the form of unique properties, such as strength or corrosion resistance. The research will contribute to the understanding of the processes occurring in the structure of materials exposed to extreme conditions and the identification of the mechanisms determining resistance to radiation.

▸ *Full Article* ◂

Is order always better than chaos? – research into disordered metal alloys as a possibility for safer nuclear and thermonuclear reactors

Generation IV nuclear reactors and fusion reactors require special structural materials with excellent high-temperature mechanical properties. These stringent requirements can be met by so-called high entropy alloys (HEA), but the origin of such unique properties is not fully understood. In addition, research work is needed to verify the possibility of their industrial production. Therefore, NCBJ scientists want to develop a technique for manufacturing such materials and understand the mechanisms responsible for their functional properties at high temperatures. As part of the project under the SONATA BIS grant led by Łukasz Kurpaska, different types of alloys with controlled amounts of chromium, nickel, iron and magnesium will be studied to understand the impact of the complexity of the chemical composition as it changes. The project will contribute to the formation of a single-focused, young research group that can create a pathway to a better understanding of the still-open issues surrounding newly developed high entropy alloys.

▸ *Full Article* ◂

Credit: EUROfusion

NCBJ scientists study the evolution of defects in graphite for Generation IV nuclear reactors

Thanks to its high resistance to radiation damage and stability at high temperatures while retaining mechanical parameters, graphite is used in current-generation nuclear reactors as a neutron moderator. Application in next-generation reactors places higher demands, due to temperatures of the order of 1000°C, intense neutron beams, high pressure and very long plant operation times. Learning how radiation affects graphite is crucial, because in the case of HTGR reactors it will act not only as a moderator but also as a structural element. Work towards a detailed description of the kinetics of graphite degradation under irradiation has been carried out by researchers from the NOMATEN Centre of Excellence led by Magdalena Wilczopolska, who compared the mechanisms of defect formation in commercially available graphite and material from NCBJ resources. Based on the results, it can be concluded that NBG-17 graphite has the highest radiation resistance among the materials tested. The higher quality of the commercially available graphite currently obtainable shows the significant technological progress and increased safety of materials operation driving the development of nuclear technology.

▸ *Full Article* ◂

A promising candidate for a material for extreme tasks

Intense and prolonged neutron bombardment, high temperature and high pressure create an extremely hostile environment for any material. A promising candidate for a material for “special tasks” has recently been identified by a team of NCBJ scientists led by Łukasz Kurpaska. In recent years, considerable attention has been paid to high entropy alloys, formed from at least five components of similar concentrations and often of similar atomic weights. Materials of this type are characterised by high yield strength, high-temperature hardness and very good radiation resistance, and by modifying their chemical composition the desired characteristics can be easily improved. For this reason, NCBJ physicists focused their attention on alloys of two metals: nickel and iron. Their analysis and simulations show that as the iron content increases, the radiation resistance of nickel alloys also increases. For this reason, a nickel alloy with 62% iron content appears to be a promising candidate for a structural material for fourth-generation nuclear reactors and may form the basis for further research.

▸ *Full Article* ◂

Mechanisms leading to hardening of alloys exposed to radiation have been identified

Microscopic damage and cracks can appear over time in a material that is regularly exposed to intense stresses and fluctuating conditions. Such processes also take place in materials used in nuclear reactors, so it is an extremely important task to understand exactly what changes neutrons, alpha particles and other types of radiation cause in the structure of a material. This will make it possible to find ways to produce stronger and more durable alloys. Cooperation between the Institute of Fundamental Technological Research of the Polish Academy of Sciences, NCBJ and the Warsaw University of Technology has made it possible to develop an atomic-level model for such materials, which sheds new light on the processes of strengthening of chromium-rich alloys under the influence of nuclear radiation.

▸ *Full Article* ◂

Disorder in metallic alloys fascinates the world

Perfection is not always the best solution. In the case of materials, some stochastic disorder in the internal structure can favourably affect their mechanical properties. Articles on the role of such disorder in the atomic structure of alloys are attracting worldwide interest. Such research at NCBJ is being conducted by the MASIF (Materials Structure, Informatics and Functions) group at the NOMATEN Centre of Excellence, led by Stefanos Papanikolaou. Using informatics tools, the team seeks to understand the mechanisms responsible for the formation of disorder, among other things, in multicomponent alloys. Such accumulated knowledge makes it possible to design materials that are better than existing ones, combining their most desirable characteristics. One of the latest results of the group is the open-source Materials Informatics package. The software is designed for researchers using scanning electron microscopes and is based on machine-learning methods. With it, researchers can perform rapid statistical analysis and interpretation of photographs of material samples, including identification of defects.

▸ *Full Article* ◂

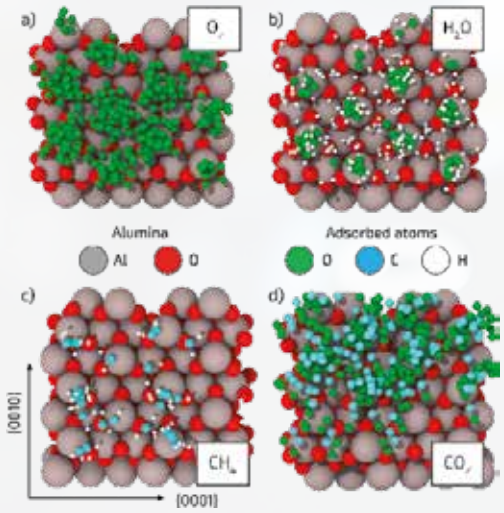
Machine learning helps understand the behaviour of magnesium alloys

Magnesium alloys are attractive for structural applications because of their low density and high strength-to-weight ratio. However, they are susceptible to a number of defects, mainly dislocations, that alter their mechanical properties. In a recent study, researchers including Stefanos Papanikolaou from NCBJ used machine learning to map the distribution of dislocations in Mg alloys and predict their properties. They used a deep learning algorithm in the form of a convolutional neural network to train the model on a data set of images of magnesium alloys with different dislocation densities, making it possible accurately to predict dislocation densities in new images. Magnesium alloys have excellent mechanical properties, but their microstructures are extremely complex, so the development of databases to classify possible microstructures could lead to new materials with optimised parameters. In the future, the authors plan to use machine learning to map the distribution of dislocations in alloys with a wider range of compositions, loading and processing conditions, as well as their interaction with other types of defects.

▸ *Full Article* ◂

Simulations help understand adsorption of molecules on α-alumina surface

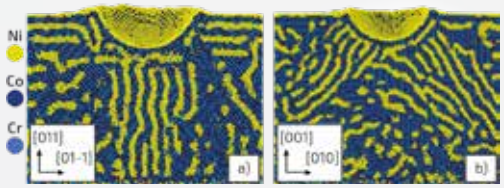
The most common aluminum oxide is Al_2O_3, especially one of its natural forms, corundum. In addition to gem varieties, this oxide has also found wide use as a ceramic material due to its properties. Alpha-alumina, as the compound is called in materials research, is resistant to high temperatures, radiation damage and corrosion. The adsorption of molecules on α-alumina, which is hindered by its complex crystal structure and surface defects, has become the subject of research by NCBJ scientists led by Javier Dominguez. To understand the mechanisms operating in this process, simulations at the level of single atoms are very important. The often-used DFT method requires very large computational resources, so the work of the team from the NOMATEN Centre of Excellence employs a combination of the classical approach and electron structure theory, SCC-DFTB. This method requires far fewer computational resources than DFT and is now a versatile tool in both materials research and chemistry. Studies of the interactions of α-alumina with various molecules - oxygen, water, methane and carbon dioxide - have shown that the SCC-DFTB method can be successfully used to model adsorption mechanisms.



▸ *Full Article* ◂

Simulations reveal surprising reorganisation of the short-range order in nickel-cobalt-chromium alloys

Standard modelling of metal alloys assumes that the atoms of the various elements that make up the alloy are randomly distributed in the crystal structure. At the same time, the short-range regions of ordering that occur, covering a few or a dozen interatomic distances, can be the source of key properties such as hardness, strength or ductility. This is because the ordered structures can make it difficult for defects to move through the material. Through simulations of a hardness test on a nickel-cobalt-chromium (NiCoCr) alloy, a team of researchers including Amirhossein Naghdi from NOMATEN Centre of Excellence discovered that nickel atoms can form chemically ordered structures through such a process. A similar phenomenon has so far only been observed under thermal treatment, but simulations have indicated that point pressure with a diamond blade (indenter) is sufficient to achieve the effect. This discovery provides insight into the possibility of manipulating alloy properties at the atomic level. Future research may resolve whether the observed atomic distributions affect properties relevant to materials engineering.



▸ *Full Article* ◂

NOMATEN Innovation Days 2024

The NOMATEN Innovation Days aimed to engage in dialogue with representatives from industry and learn about their needs for joint projects with the scientific sector. The conference featured panels and lectures inspiring R&D cooperation, as well as sessions related to materials research in broad applications (including the chemical, energy, automotive and metallurgical industries) and other areas of expertise, such as industrial radiography and nuclear techniques for engineering applications. The meetings were a very valuable opportunity for the exchange of experiences between scientists and representatives from industry, who attended the conference in large numbers. The event was co-organised with partners from France (CEA - French Alternative Energies and Atomic Energy Commission) and Finland (VTT Technical Research Centre of Finland).

▸ Full Article ◂

Organising the European research community on nuclear materials

NCBJ is participating in the European ORIENT-NM project. The goal of the project is to explore the feasibility and assess the value of establishing a co-funded European partnership to support the development of a coordinated nuclear materials research and innovation programme. The concept is based on the creation of a jointly managed package of research projects selected, coordinated and evaluated by an international scientific committee. This structure will allow better use of EU funds, avoid duplication of work and centralise organisational activities. The project is based on cooperation conducted within the Joint Nuclear Materials platform of the European Energy Research Alliance programme. At NCBJ the project is headed by Jacek Jagielski.

▸ Full Article ◂

NCBJ for WOŚP – the smallest heart up for auction!

NCBJ joined in supporting the 32nd Grand Finale of the Great Orchestra of Christmas Charity (WOŚP) by auctioning a silver heart on which the world's smallest WOŚP heart was “sculpted with atoms” at the NOMATEN Centre of Excellence. The heart was sculpted using the Focused Ion Beam technique from a layer of platinum applied to a silver substrate and is approximately 10 micrometres (0.01 mm) in size. The silver heart was accompanied by a framed print of an image of the engraved artwork, made using a scanning electron microscope. The winner also received a visit to NCBJ combined with a tour of Poland's only nuclear reactor, MARIA.

During the auction we managed to raise a total of 4371 PLN. We would like to express our gratitude to all those who participated in this noble action, whether by spreading the word or generously bidding.

▸ Full Article ◂

NCBJ – one of the few manufacturers of linear accelerators in the world

At NCBJ, accelerators and systems incorporating accelerating structures are designed and built within the Nuclear Equipment Division, HITEC (ZdAJ) and the Particle Acceleration Physics & Technology Division.

ZdAJ specialises in designing, manufacturing, selling and maintaining equipment centred around linear electron accelerators for the industrial and medical sectors. Its flagship product is LILLYPUT, an industrial accelerator tailored for non-destructive testing via the radiographic method, with a broad energy range up to 15MeV. The division provides customized radiographic systems featuring different types of digital imaging detectors and specialised manipulator systems. These systems have been exported and are in operation globally for non-destructive testing.

Additionally, ZdAJ offers dual-energy linear accelerators for cargo inspection, which, when integrated into complete scanning systems, enable discrimination of materials and are instrumental in border protection against the smuggling of contraband and hazardous materials.

In the medical sector, ZdAJ has developed the AQURE intraoperative radiation therapy accelerator. This electron accelerator boasts a broad spectrum of emitted radiation energy and a wide range of motion in the operative field. AQURE precisely targets the surgical site immediately after tumour removal, reducing overall treatment time and potentially improves patients' quality of life. The device is versatile, suitable for treating breast cancer, abdominal tumours, sacromas and pediatric diseases. Its new variant, AQURE FLASH (RT) is capable of delivering a therapeutic dose of radiation in the order of milliseconds, which better protects healthy cells while destroying tumours.

ZdAJ's achievements stem from its modern infrastructure, production facilities and bunkers essential for working with ionising radiation-emitting devices. The Division has modern equipment, including digital machine tools, furnaces of appropriate dimensions and technological lines for chemical processing, as well as advanced measuring and diagnostic devices. It also uses the research stand of accelerating structures of the NCBJ's CentriX Centre for Information and Implementation of Industrial Radiation Techniques. ZdAJ has implemented an integrated, certified quality management system and an internal control system for handling dual-use technologies and services.

As part of NCBJ, ZdAJ participates in various scientific projects and maintains collaborations with leading global scientific laboratories. Notably, it has collaborated with CERN and contributed to the modernization of the Large Hadron Collider. Such involvement in scientific projects serves as a valuable source of inspiration and ideas for the development of ZdAJ's next-generation products.

▸ *Website* ◂

NCBJ is building a station generating an ultra-high dose electron beam (FLASH)

The first of its kind in the world, a station for studying the effects of FLASH-type beams on cells is being set up at NCBJ. The technology involves delivering a large dose of ionising radiation to tumours in a very short time (a fraction of a second). This distinguishes it from conventional radiation therapy techniques, where the dose is delivered over a longer period. Studies indicate that FLASH therapy can effectively target tumours while minimising damage to healthy tissues and organs. The main accelerator component of the FLASH stand is an accelerating structure designed and built at NCBJ's Department of Nuclear Equipment, with the participation of the Department of Nuclear Techniques and Equipment. The entire station is designed on the basis of the AQURE mobile intraoperative accelerator. Thanks to the wide range of motion of the accelerator, it will be possible to place samples in different positions. The mobility of the accelerator also makes it possible to use it in different locations.

▸ *Full Article* ◂

Accelerator in search of new cancer therapies

FLASH therapy may be a promising method for destroying tumours while better preserving healthy cells. Built at NCBJ, the AQURE FLASH (RT) accelerator is the first of its kind in Poland and one of the few in the world to generate an electron beam with the ability flexibly to modulate the radiation dose pulse. Such capabilities are indispensable for research on the Flash effect, which by definition means protection of healthy cells while maintaining full efficiency in eliminating cancer cells. The device, constructed by NCBJ's Department of Nuclear Equipment and Department of Nuclear Techniques and Equipment, was transferred in early 2024 to the Greater Poland Cancer Centre, where radiobiologists are studying the Flash effect. The innovative therapeutic solutions that will be discovered thanks to this device will be able to be put into clinical use in the intraoperative accelerator.

▸ *Full Article* ◂

Polish borders protected even better

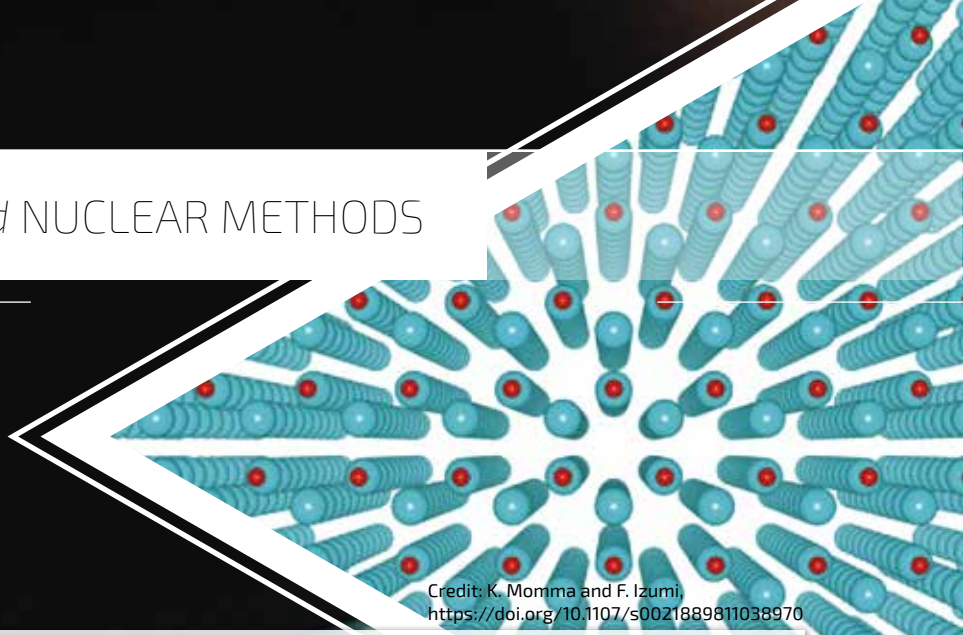
The third comprehensive scanner for non-invasive inspection of large-size goods to detect threats or smuggling attempts has been delivered to the Polish border. The new MultiControl CanisMatic Rail device will operate at the railway border crossing in Hrubieszów. Like the two already in operation in Kuźnica Białostocka and Korsze, it is the work of the Polish company MultiControl sp. z o.o., and was developed with advanced technology from NCBJ. The heart of the device, the industrial Lilliput 6/9i accelerator, was manufactured at NCBJ's Department of Nuclear Equipment, HITEC. The dual-energy accelerator, combined with a detection system, makes it possible to detect cargo of different densities. The complete technology of the accelerator and the entire system was developed in Poland, and the system is a 100% Polish product and a winner of the "Teraz Polska" competition. The system will contribute to better protection of our borders against attempts to import dangerous goods and smuggling of undeclared cargo, thus improving security and protecting economic interests.

▸ *Full Article* ◂

NCBJ representatives discussed innovations during the Science for Society Congress

In June 2024, the Warsaw University of Technology hosted the 2nd Science for Society Congress under the theme "How science in Poland affects everyday life." During the Congress representatives of NCBJ presented one of the Institute's latest implementations, the AQURE FLASH (RT) accelerator with ultra-high dose power. This unique device is capable of delivering a therapeutic dose of radiation in the order of milliseconds. This allows the study of the Flash effect, which better protects healthy cells while destroying tumours. At the NCBJ booth visitors could also learn about other areas of activity of the Institute's scientists. Employees of the Department of Nuclear Energy and Environmental Studies presented 3D printed models of elements of the HTGR-POLA high-temperature reactor, which is being developed at NCBJ. Specialists from the Radiation Detection and Plasma Diagnostics Division presented detection techniques they have developed, as well as technologies to increase the efficiency of raw materials use within the REVaMP project. Scientists from the NOMATEN Centre of Excellence talked about achievements in materials research.

▸ *Full Article* ◂



Credit: K. Momma and F. Izumi, https://doi.org/10.1107/s0021889811038970

Bright future for scintillation detectors

Matter can be ionised by particles with a very wide energy spectrum, making precise radiation detection a difficult task. Among the instruments currently used for this purpose, scintillation detectors stand out. A series of fundamental studies on instruments with thallium-doped cesium iodide crystals carried out by Zuzanna Mianowska and late Marek Moszyński has recently been completed at NCBJ. The results of the measurements form the experimental foundation for a new generation of scintillation detectors. In order for a scintillation detector to be usable, the crystal within it should be able accurately to distinguish radiation energy values. Most modern scintillators suffer from a disproportionality effect - they emit a different number of photons for low and high radiation energies. This effect must be artificially corrected. With the use of a digital circuit with time gates dynamically adjusted to the energy of gamma quanta, in detectors built as part of the new work this effect practically disappears. The possibility of eliminating the disproportionality effect means that in a few years it will be possible to talk about a new generation of scintillation detectors of ionising radiation.

▸ *Full Article* ◂

The McChasy code aids in the study of defects in semiconductors for special applications

Gallium nitride is a semiconductor that allows the creation of electronics that operate at high voltages, high temperatures and under radiation exposure conditions, i.e., in outer space or nuclear reactors. To enhance some of the properties of devices based on it, ion implantation is often carried out, but this causes defects and stresses in the material. The effects of ion implantation in gallium nitride have been studied in a collaboration between NCBJ and Universidade de Lisboa. An important part of the joint work comprises Monte Carlo simulations performed with the McChasy software, which was developed at NCBJ as a tool for analysing experimental data of ion channelling. The challenge for correctly interpreting ion channelling results is separating signals from different types of defects. Through simulations with McChasy it has been possible to extend previous findings on the types of defects formed in gallium nitride, as well as to determine the concentration of defects as a function of depth in the material. The McChasy software continues to be developed and made available to the international research community.

▸ *Full Article* ◂

Will the electronics in Eagle Eye survive the space mission? NCBJ scientists conducted radiation tests of the microsatellite's systems

Electronics that are part of space missions are exposed to ionising radiation, which can cause damage to the entire system. For this reason it is important to select components with adequate radiation resistance. While in the case of rad-tolerant components testing is carried out by the manufacturer, in the case of commercially available components verification of radiation resistance rests with the satellite designers. In new research conducted at NCBJ, tests were performed on the effect of total ionising dose on parts of the Polish EagleEye microsatellite. The systems tested were on-board computers, exposed to X-rays from a linear electron accelerator. The results indicated that most of the serious errors occurred only after the dose exceeded more than 3 times the expected dose for the EagleEye satellite's mission. The research was conducted by a team of NCBJ scientists led by Tomasz Rajkowski in cooperation with the creators of the EagleEye microsatellite, as well as Sławosz Uznański, an astronaut of the European Space Agency, who is expected to become the second Pole in space.

▸ *Full Article* ◂

Research into radiation- and chemical-resistant semiconductors at the NCBJ Nuclear Microanalysis Lab

Currently, materials research is driven by new technologies, resulting from the never-ending need to miniaturise devices and replace them with cheaper and more efficient counterparts. For several decades, new technologies have been based on semiconductor compounds, which are proving indispensable in optoelectronics, for the production of detectors, lasers, displays or LEDs, where the ever-present silicon cannot be used due to its intermediate and not very wide energy gap. At NCBJ's Nuclear Microanalysis Lab a group of researchers is currently working on using Ga_2O_3 gallium oxide for this purpose. The study concerns the analysis of defects induced by ion bombardment. Using various research techniques, such as Rutherford backscattering (RBS/c), X-ray diffraction (XRD) and transmission microscopy (TEM), the group confirmed two layers with different types of defects. This discovery united the scientific world, previously split between "amorphisation" and "structural self-ordering" as a result of radiation. NCBJ scientists showed that under certain conditions both phases can exist simultaneously.

▸ *Full Article* ◂

Credit: Creotech Instruments S.A.

Wood industry could benefit from ion implantation

Implanting nitrogen onto the surface of materials has been used for decades to improve the performance of metal tools. In recently completed industrial tests it was possible to demonstrate that in the case of saw blades used in the woodworking industry, nitrogen ion implantation causes favourable physico-chemical changes, revealed during the operation of the modified tool with the wood-based material. The study found that during operation with the material the surface of the nitrogen-modified tools was covered with secondary structures containing amorphous carbon (carbon without a crystalline structure). According to NCBJ researchers, these structures were the main factor responsible for reducing the friction coefficient of the cutting surface, translating into a significant increase in tool life, by as much as three times that of the reference blades. In addition, the tool lifespan remained constant, which in an industrial setting would optimise the replacement of worn tools and production processes.

▸ *Full Article* ◂

Ions as a chance for artefacts containing cellulose

Wood is one of the most important structural elements. Unfortunately, it has a significant drawback: limited durability. Cellulose, its main component, has the ability to bind water, which promotes the growth of fungi. In an effort to increase the durability of valuable wood products and wood-based materials, scientists from NCBJ and SGGW have initiated research into the possibility of increasing the durability of cellulose using ion implantation. The goal is to verify whether implantation can reduce the tendency of cellulose materials to absorb water, and to determine whether it can protect the modified surface from the growth of harmful fungi. In all cases, the modified sections of the sample showed significantly lower wettability than the unmodified areas. Biological tests showed that silver ions implanted on the cellulose surface had a biocidal effect on one of the more important fungi responsible for cellulose decomposition. In addition, the implantation appeared not to endanger the samples - the surface temperature did not exceed a safe value for organic materials. Given the promising results, this research direction will be continued.

▸ *Full Article* ◂

NCBJ scientists explore the use of multiphoton PET tomography for industrial imaging

Positron Emission Tomography is used primarily in medicine. However, the technique's properties may also prove useful in industrial applications. As part of a new project IMPET at NCBJ, researchers are investigating the suitability of multiphoton PET tomography, with high temporal resolution, for industrial applications. The use of this type of imaging allows the determination of a spatial image of the lifetime of positronium (a bound electron-positron system). This provides a comparable imaging capability to other industrial methods, enriched with spatial information. PET tomography can also be used to track the trajectories of multiple radioactive tracers and dynamically shaped tracers (e.g., fluids), expanding the capabilities of current methods. The improvements in PET image reconstruction and correction methods developed in the project will simultaneously improve the quality of imaging for medical applications. Improved resolution will allow observation of smaller cancerous tumours in the early stages of the disease, thus allowing earlier diagnosis.

▸ *Full Article* ◂

How to measure low tritium concentrations in river and marine waters?

Tritium is a radioactive isotope of hydrogen that can come from both natural and man-made sources. Monitoring its concentration, as the predominant radionuclide in releases from nuclear facilities, is important to ensure that tritium levels are kept within safe limits. Due to the continuous decline of tritium activity in the environment, methods are needed to measure lower and lower activity concentrations. Therefore, work is underway at NCBJ's Radiation Protection Measurements Laboratory to improve methods for determining tritium levels or to develop new methods that are even more sensitive. Recently studied methods include a modification of the standard method with different measurement conditions and a method using electrolytic enrichment. Using these, the researchers have tested samples of seawater, as well as river water, including water taken near NCBJ. The modified standard method allowed the detection limit to be reduced by a factor of two. In comparison, the electrolytic method yielded five times lower minimum concentrations and smaller measurement uncertainties, but its use involves longer sample preparation time.

▸ *Full Article* ◂

Viking period amulet research reveals trade routes across Poland

With the possibilities of modern materials research, the discoveries of archaeologists can provide much valuable information. Recent analyses of unique artefacts made of silver led by Ewelina Miśta-Jakubowska from NCBJ, have not only brought closer the craft techniques of the Viking period, but also indicated possible routes by which goods were transported across Poland. The research concerned a silver hoard discovered in the village of Piaski-Dramino. Samples of the find were subjected to material tests, and it was determined that the artefacts included in the hoard were made from various types of materials, including silver from the melting of coins - dirhams. Some of the samples examined differed significantly in their silver isotope composition, which may mean that a single ornament could have been created from silver from different sources or subjected to different processing methods. The results of the study indicated that the ornaments included in the Piaski-Dramino treasure were made by Czech craftsmen and the silver used to make them came from local trade in the territory of the Vistula tribes, as well as from raw material mined in the Silesian Highlands and Kraków.

▸ *Full Article* ◂

NCBJ hosted the kick-off meeting of the WEKTOR project

In February 2024, NCBJ hosted the kick-off meeting of the project "Detection and Combat of Unmanned Aerial Vehicles by means of a high-power microwave pulse generator with directional emission - WEKTOR." Under the project, implemented by a consortium consisting of Wrocław University of Technology, the Military Academy of Technology, Zakłady Mechaniczne "Tarnów", POL-SPEC-TECH-SERVICE, the Military Institute of Armament Technology and NCBJ (in the role of leader), a technology for generating high-power microwave pulses will be developed. Research using simulation tools will also be carried out, and a model and demonstrator of the microwave pulse signal compression system will be made. The expected benefits and effects of applying the results of the WEKTOR project are to increase the operational capabilities of air defence troops and to enhance the security of critical infrastructure facilities (refineries, gas pipelines, power plants, etc.).

▸ *Full Article* ◂

Community education

The National Centre for Nuclear Research actively engages in educational initiatives aimed at fostering knowledge and understanding of nuclear energy. It conducts workshops on nuclear energy for high school students, providing valuable insights into this field. Additionally, NCBJ organises student seminars to encourage the exchange of ideas and promote scientific discourse. The Institute's educational program, "Detectors for Schools", offers schools the opportunity to borrow radiation detection kits, enabling hands-on lessons on various aspects of radiation, including cosmic radiation.

NCBJ actively participates in popular science events such as science festivals and science picnics held throughout the country. It provides educational activities and lectures, engaging the public with captivating demonstrations and informative presentations. Moreover, NCBJ organises the "Physics Paths" competition, promoting scientific exploration through essay writing, innovative demonstrations and young researchers' contributions.

The Institute also offers specialised courses and training programs. It provides radiation safety training for NCBJ employees working in radiation-exposed environments. Furthermore, NCBJ conducts radiation-related training programs, including certification courses, for public institutions and businesses seeking to enhance their knowledge and expertise in radiation-related topics.

NCBJ facilitates visits and internships for individuals interested in exploring the Institute's research and educational facilities. It also contributes to the dissemination of knowledge through the creation of comprehensive reports, analyses, presentations and publications on nuclear energy and technologies employed in nuclear power plants.

In order to make scientific concepts more accessible to the general public, NCBJ produces popular science films the provide insight into the work carried out in various departments within the Institute. These films showcase applications of and advances in nuclear research.

The educational department of NCBJ boasts specialised laboratories that allow for hands-on experiments and exercises related to radiation and nuclear physics for both students and teachers. With a highly qualified scientific staff and twenty five years of experience in educational endeavours, the Institute collaborates closely with educational institutions, organisations and the public, sharing its expertise and promoting the understanding of nuclear energy.

NCBJ's lecture and demonstration halls are equipped with state-of-the-art resources, enhancing the audience's comprehension of ionising radiation and nuclear energy. Through these educational activities, NCBJ aims to inspire and educate individuals of all ages, fostering a broader understanding of nuclear energy and its applications.

▸ *Website* ◂

Take a virtual tour!

Not everyone can visit NCBJ in person, but now almost all will be able to do so virtually. As part of the project "Virtual Open Days of NCBJ and the Świerk Nuclear Facility" carried out by the Education and Training Division, a series of 10 videos has been created, showing various divisions and facilities of the Institute, including the Materials Research Laboratory, the Radioisotope Centre POLATOM, the MARIA reactor and the Radioactive Waste Disposal Facility. The authors of the project were inspired by the Open Days organised by NCBJ and attracting great interest, during which NCBJ and the Świerk Nuclear Facility were open to the public. The videos prepared as part of the project are modelled after the tours offered during the Open Days. This provides an opportunity for people who cannot see the Centre in person to take a virtual tour. All videos are available on NCBJ's YouTube channel.

▸ *YouTube* ◂

Physics Paths Competition

The Physics Paths competition is organised annually by NCBJ and the Institute of Physics of the Polish Academy of Sciences for students in the final grades of elementary schools and high school students. The name refers to the three paths followed by modern physics - theoretical considerations, experimental exploration and mechanical design. These are the competitions in which participants can submit their work in the form of an essay, scientific work or demonstration of a physical phenomenon. Each edition of the competition is very popular with students, as evidenced by dozens of entries from all over Poland. The winners present their achievements during a final seminar held at NCBJ. Winners selected by the Jury are rewarded with, among other things, indexes to universities.

Organised in 2023, the 18th edition of the Competition returned to the stationary formula after a break of several years. Participants presented impressive physical phenomena, induced artificial lightning, and presented the physics ... of cooking dumplings. The highest accolade of the judges went to the authors of the demonstration "Marx generator or the production of artificial lightning," the scientific paper "The effect of continuous dielectric exchange on the capacitance of a capacitor," and the essays "Why is it a physicist who can solve a great mathematical puzzle?" and "Laboratory with sliding walls."

The 19th edition of Physical Paths once again attracted a large number of participants, who submitted more than 110 competition entries. During the final seminar those in attendance were able to see how to convert mechanical energy into electrical energy and a self-made Wilson chamber which detects charged particles of cosmic radiation, as well as the effect of magnetic and electric fields on their flight path. The highest prize went to the authors of the Wilson chamber, ex aequo with the designers of a model of a wind-powered vehicle that can move faster than the wind itself, the author of an essay that attempted to answer the currently important question "can a robot replace a physicist?" and the author of a scientific work on determining the average heliographic width of sunspots.

Also presented at the final seminar is the Ludwig Dobrzyński Award, named after a distinguished solid state physicist, lecturer and populariser of science, creator of the Physics Paths competition. The award is given to teachers and scientific supervisors of the competition participants, who with exceptional commitment support the development of their pupils.

▸ *Full Article* ◂

▸ *Full Article* ◂

Scientific Picnics and Festivals

The Education and Training Division carries out its mission to educate the public and popularise knowledge of nuclear physics and ionising radiation not only through lectures and workshops organised at NCBJ, but also by meeting with participants of picnics and science festivals. The NCBJ stand prepared by the Education Division is a regular feature of the Polish Radio and Copernicus Science Centre Science Picnic, where, during the 26th and 27th editions, visitors could learn what ionising radiation is and where it comes from, as well as examine various objects for radioactive contamination. Employees of the Education and Training Division were also present at the XXII "Science with the Palace in the Background" Festival in Jabłonna, which is the largest event popularising science among children and young people in the northern part of Mazovia.

Framatome and NCBJ to collaborate on education

Framatome has announced the signing of an agreement with NCBJ to explore and develop opportunities for cooperation in nuclear education and research. The institutions will collaborate on topics of mutual interest, including structural mechanics, thermohydraulics, EPR technology and safety analysis of nuclear components and systems. The agreement will enrich NCBJ's scientific programme for training nuclear industry specialists, as well as enable a joint research project. The cooperation between NCBJ and Framatome will strengthen Poland's nuclear power programme, attracting and training students for long-term careers in nuclear power. Lectures and other educational opportunities, joint research initiatives and internships at Framatome will contribute to the development and success of the Polish nuclear industry.

▸ *Full Article* ◂

NCBJ and the International Institute of Nuclear Energy to cooperate in the field of education and training

In May 2024, NCBJ and the International Nuclear Energy Institute I2EN signed a Memorandum of Understanding on the scope of cooperation in nuclear education and training. The agreement will facilitate access for NCBJ trainees to education and training programmes in France as well as the use of I2EN partners' resources, such as training reactors and simulators. An important element of the established cooperation will be the organisation of exchanges of scientists and experts for training purposes, as well as Train-the-Trainers programmes in France and Poland and other training sessions, workshops and seminars. The agreement opens up new opportunities for international cooperation in nuclear education and is a step towards global nuclear security. The exchange of experience between top NCBJ and I2EN experts will further enhance their skills.

▸ *Full Article* ◂

CERN as proof of the high level of competence of Polish physics

Polish institutions are capable of training scientists of the highest competence, but also of producing research infrastructure of the highest level. This is evidenced by our participation in building the capacity of the European Organisation for Nuclear Research, CERN. Polish scientists have made a huge contribution not only to CERN's scientific achievements, but also to the construction of the apparatus responsible for the most important discoveries in modern physics. As part of CERN's 70th anniversary celebrations the "Accelerating Science" exhibition was available in June 2024 in the Auditorium of the Faculty of Physics at Warsaw University of Technology. Visitors could learn about the appearance of the universe from its earliest moments to the present day, the workshop of a particle physicist, the secrets of the largest accelerator in Europe and many other topics. The exhibition was organized by NCBJ, the Institute of Physics of the Polish Academy of Sciences, Warsaw University of Technology and the University of Warsaw.

▸ *Full Article* ◂

Polish Centres of Excellence in receipt of funding from Horizon 2020 summarised their 5-year activities

The concept of Centres of Excellence envisages building strong, well-funded scientific teams to take advantage of the existing research infrastructure of the establishing institutions and open laboratories. Polish Centres of Excellence in receipt of funding from Horizon 2020 recently summed up their 5-year activities at a conference dedicated to the "Teaming for Excellence" competition. Among them is NCBJ's NOMATEN Centre of Excellence, established through partnerships with two leading research organisations: CEA of France and VTT of Finland. The centre's research topics focus on the design, fabrication, research into and potential applications of new classes of materials resistant to extreme environments, such as radiation, high temperatures, and various types of corrosion. In parallel, NOMATEN conducts research on new types of radiopharmaceuticals for the diagnosis and treatment of diseases, especially cancer. NOMATEN scientists have secured 16 individual research grants in recent years, as well as published more than 90 papers. The centre has also established cooperation with entrepreneurs in various sectors of the economy.

▸ *Full Article* ◂

NCBJ has joined the EURAXESS European network

The Network EURAXESS - Researchers in Motion is an initiative designed to support the career development of scientists who wish to conduct research abroad. NCBJ became a member of the EURAXESS Poland network in 2024 and actively participates in its initiatives. The EURAXESS Poland program is coordinated by the National Agency for Academic Exchange, ensuring strong support for researchers at various stages of their careers. As a part of EURAXESS Poland - Researchers in Motion, NCBJ focuses on promoting the international mobility and career development of scientists who wish to conduct research in Poland. It fosters collaboration through the exchange of knowledge, experience, and good practices among network members. By participating in European projects, initiatives, and events, we build connections with the global research community, creating opportunities for collaboration and growth. At NCBJ, we are committed to supporting our researchers by providing comprehensive information and training. These resources focus on mobility opportunities, international research programs, and collaboration strategies. Our goal is to equip scientists with the knowledge and tools they need to successfully advance their careers and contribute to the global research landscape.

▸ *Full Article* ◂

ORGANISATIONAL STRUCTURE

- Scientific Council
- **Director General** — D
  - Assistant of DG — DAt
  - Secretary's office — AIS
  - Human Resource Management Division — DHR
  - Human Resources Division — DP
  - Legal Division — DRP
  - Analysis and Project Settlements Division — DA
  - Spokespersons — DRz
  - Occupational Safety and Health Division — DBHP
  - Internal Auditor — DAW
  - Proxy for Integrated Management System — DZSZ
  - Quality Management Division — DZJ
  - Inspector of Personal Data Protection — IODO
  - Proxy for Classified Information Protection — DOIN
  - Classified Information Protection Division — OIN
  - Director Proxies — DPm
  - Interdisciplinary Division for Energy Analyses — DIZ
  - NOMATEN - International Scientific Agency — NOMATEN
  - Radioisotope Centre POLATOM — OR
- Nuclear Safety Commission

- Deputy NCBJ Director for Innovation and Commercialisation — DI
  - NCBJ Nuclear Equipment Division (HITEC) — ZdAJ
  - Project Management Division — IZ
  - Science and Technology Park — PNT
  - Communication and Promotion Office — IK
- Deputy NCBJ Director for Scientific Matters — DN
- Deputy NCBJ Director for Nuclear Safety and Health Protection **Safety & Radiation Protection Department** — DJ
  - Nuclear Centre Emergency Squads — JA
  - Radiation Protection Officer — IOR
  - Fissile Materials Accounting Office — JE
  - Radiation Protection Measurements Labolatory — LPD
  - Civil Defence /Defensive Measures Squad — JO
  - Internal Security Guard — WSO
  - Fire Prevention Division — JP
- Deputy NCBJ Director for Economy **Economics Department** — DE
  - Financial Controller — EF
  - IT Division — IT
  - Procurement Division — EZ
  - Administrative Division — EA
  - Public Procurement Division — EZP
- **Chief Accountant** — EK
  - Financial Accounting Division — KF
  - Payroll Division — KR
- DBP Director **Fundamental Research Department** — DBP
  - Nuclear Physics Division — BP1
  - Theoretical Physics Division — BP2
  - High Energy Physics Division — BP3
  - Astrophysics Division — BP4
- DFM Director **Material Physics Department** — DFM
  - Material Research Lab — LBM
  - Nuclear Methods in Solid State Physics Division — FM1
  - Plasma/Ion Beam Technology Division — FM2
- DUZ Director **Complex Systems Research Department** — DUZ
  - Information Technologies Division — UZ1
  - Software Engineering Division — UZ2
  - Nuclear Energy and Environmental Analyses Div. — UZ3
- DATJ Director **Nuclear Equipment & Technology Department** — DTJ
  - Particle Acceleration Physics & Technology Div. — TJ1
  - Electronics and Detection Systems Division — TJ2
  - Radiation Detectors and Plasma Diagnostics Division — TJ3
  - Radiological Metrology and Biomedical Physics Div. — H2
- Scientific Secretary **Research Support Department** — DS
  - PhD Studies / Doctoral School — SD
  - International R&D Projects and Cooperation — SW
  - Education and Training Division — SE
  - Library — SB
- DEJ Director **Nuclear Facilities Operations Department** — DEJ
  - MARIA Reactor Operations Division — EJ2
  - Reactor Technologies Division — EJ3
  - Reactor Research Division — EJ4
  - MARIA Reactor Quality Assurance Specialist — EJZJ
  - Irradiation Coordinator — EJN
  - Documentation Division — EJD
  - Contracts and Administration Division — EJA
  - Renovation and Modernization Division — EJR
- Technical Matters Department Director **Technical Matters Dpt.** — ET
  - Chief Technical Engineer — TN
  - Electric Infrastructure Division — TE
  - Sanitary Division — TS
  - Technical Service Division — TO
  - Investment and Renovation Division — TI
  - Planning and Settlement of Investments, Renovations and Operations Division — TP
- Bus Transport Division — ZTS

NCBJ IN BRIEF

The Institute's profile of basic/applied research combines studies related to nuclear energy and various fields of subatomic physics (elementary particle physics, nuclear physics, hot plasma physics, etc.) with non-nuclear applications using various forms of radiation. The center is deeply involved in the development of nuclear technologies and the promotion of practical applications of nuclear physics methods. The main market products produced at the Centre are radiopharmaceuticals and a range of particle accelerators for science, various industries, and medicine.

The National Centre for Nuclear Research is one of the largest scientific institutes in Central Europe. The Centre operates the MARIA research nuclear reactor and has a number of advanced research instruments and laboratories, particularly useful in materials research and modification, as well as radiography. It also has its own computing center. New research infrastructures are currently being developed at the institute: the CERAD Laboratory, already equipped with a world-class cyclotron for the production of radioisotopes, the superconducting PolFEL free-electron laser, and the Maria Neutron Laboratory using neutron beams from the MARIA reactor. There is also ongoing work on a pioneering high-temperature gas-cooled research reactor HTGR-POLA at the Centre.

A particularly important area of NCBJ's activities is basic research in the fields of high energy, nuclear, and atomic physics, as well as astrophysics, astronomy, and cosmology. These are mostly conducted within broad international collaborations, including participation in the conception, analysis, and construction of apparatus for large international experiments.

The Institute's activities result in a high publication output (over 500 items per year) of high quality confirmed by the number of citations (Hirsch index H>213), as well as numerous accreditations, certificates, awards, and distinctions. This also results in a high interest from foreign students in the opportunity to undertake doctoral studies at the institute (currently, we have about 30 foreign students studying with us).

NCBJ employs around 1,200 people. The scientific staff consists of about 70 professors and holders of habilitation (Dr. Hab.), as well as over 150 PhDs.

The potential and assets of NCBJ predestine the institute to serve as a Technical Support Organization (TSO) for the Polish nuclear program. The first step towards this goal was the granting of authorization in three areas of TSO tasks by the national regulator - the State Atomic Energy Agency (PAA).

NCBJ is located in Otwock, near Warsaw, occupying the well-guarded forty-hectare Świerk nuclear center. The Institute's fundamental research divisions are also located on the "Ochota" university campus in Warsaw.

As a research institute with the legal status of a state scientific unit, NCBJ inherits its traditions from the Institute of Nuclear Research, founded in 1955, then continued by the Sołtan Institute for Nuclear Studies and the Institute of Atomic Energy.

RESEARCH COLLABORATIONS