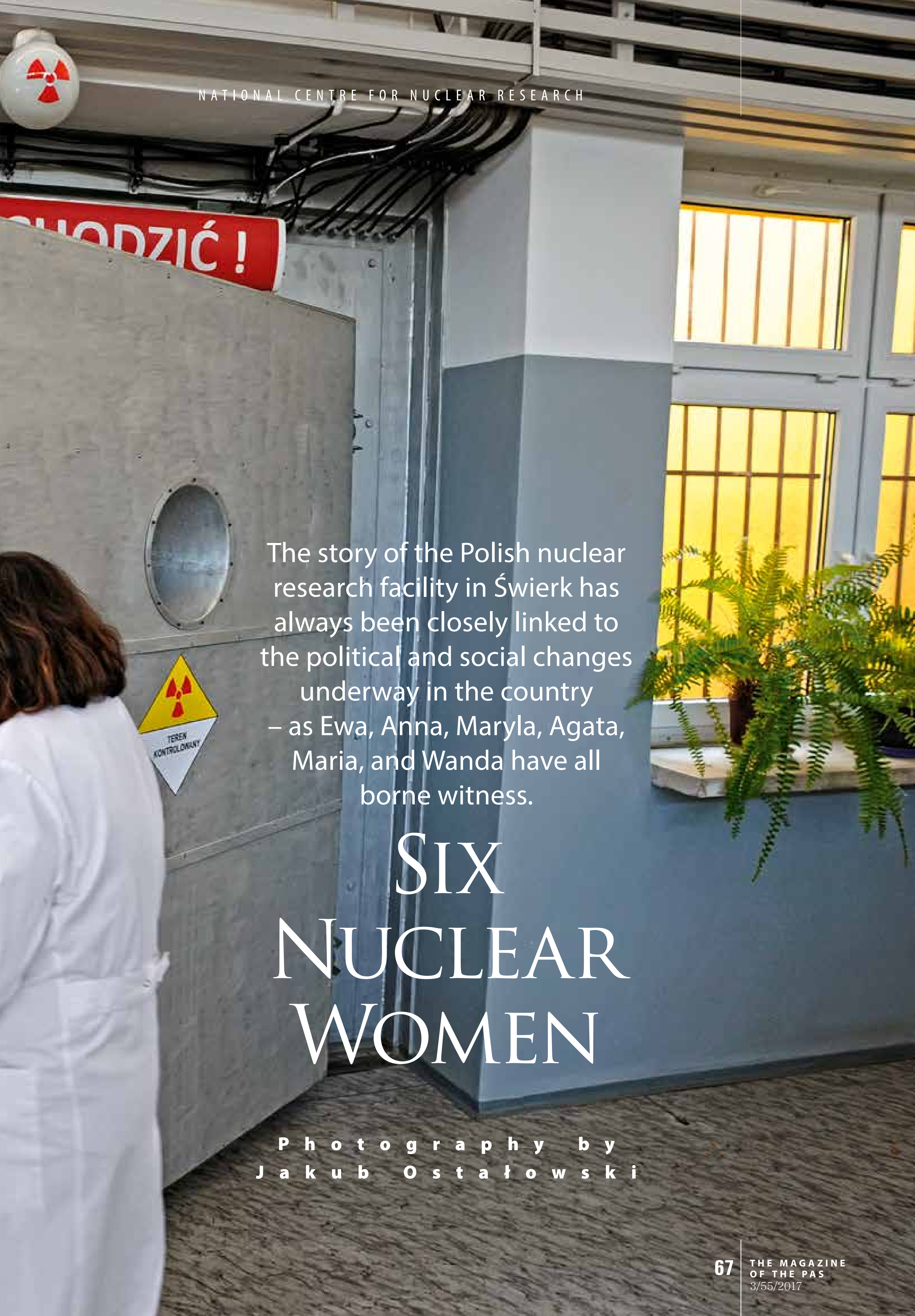

The story of the Polish nuclear research facility in Świerk has always been closely linked to the political and social changes underway in the country – as Ewa, Anna, Maryla, Agata, Maria, and Wanda have all borne witness.

Six Nuclear Women

Photography by Jakub Ostałowski

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This story began over 60 years ago. Amidst the ruins of a war-ravaged country, on 45 hectares of wetlands not far from Warsaw, people with a passion and inexhaustible energy managed to create a unique place: the Institute for Nuclear Research (now known as Poland's National Centre for Nuclear Research – NCBJ). In the small town of Świerk, they and their successors built six nuclear reactors, several dozen types of accelerators, hot plasma installations, and countless equipment and devices. Despite endless economic and political obstacles, the physicists in Świerk were able to establish research and engineering collaboration with the best institutions around the world, and their publications have made the institute part of an exclusive elite circle of Polish research centres. The first medicines containing radionuclides were produced in Świerk 55 years ago. Today, the NCNR's radiopharmaceutical production facility ships its products to 80 countries, saving the lives of millions of patients.

It started with EWA

For most people, a nuclear reactor is a mystifying device, but making it is really quite simple. All you need to do is take an isotope of any element whose nuclei can break down into smaller fragments, such as uranium 235, and then slightly accelerate this process. The products of their breakdown will carry energy that can be harnessed. If we weighed our material before and after the reaction, the mass of the final products would turn out to be slightly less than the initial mass, and Einstein's formula $E = mc^2$ links this loss of mass to the energy obtained. When constructing a reactor, we must still ensure that the reaction rate can be controlled and energy can be captured as it is released. Although it is not always energy we're after: the six nuclear reactors in Świerk were mainly constructed in order to capture speeding neutrons. Neutrons, the electrically neutral particles, are products of fission occurring in the reactor. By using them to bombard certain atomic nuclei we can create new elements or isotopes, and by studying how neutrons are scattered by crystalline materials we can understand their structure.

The first nuclear reactor in Świerk, called EWA, was purchased from the USSR and launched in 1958. It was operational until 1995 and was used to research materials and produce isotopes. Polish scientists modified it several times, including adapting it to use fuel highly enriched with uranium 235. Later the reactors were built domestically. ANNA was created in 1963, and after it was modified it made it possible to obtain fast neutrons. That same year the MARYLA reactor was constructed, as a prototype of a low power training reactor that did not require active cooling. MARYLA was operational for 20 years, serving mainly as a test site for EWA reactor modifications. 1973 saw the launch of AGATA, a zero power reactor, which was a pilot project for the Maria reactor, and then served as a training device for its operators.

Maria, in turn, was launched in 1974 and operates to this day. After being modernized it is one of the best active research reactors in Europe. It has a thermal power of 30 MW and can produce radioisotopes, modify materials and conduct neutron research. Work

Fig. 1, 2, 8
Every year thousands of high school and college students visit the Maria reactor. The biggest attraction of visiting Świerk is the opportunity to see the reactor core in action.

Fig. 3
Control room of the Maria reactor.

is almost completed on using a neutron stream for medicinal purposes. Thanks to a contract signed with the Helmholtz Institute in Berlin, modern research equipment will be coming to Świerk over the next few years. The experiment hall is being rebuilt to house the equipment.

In the early 1980s, a UR-100 reactor (WANDA) was constructed in Świerk with the idea of building a series of these for university centers. Currently, there are talks about building a high-temperature reactor in Świerk, but no decisions have been made yet.

Sołtan's namesake

The founding of the Institute for Nuclear Research is usually seen as linked with the political decisions of the Krushchev Thaw period in the 1950s. This is of course true, but we must remember that although the institute was built in the middle of nowhere, its creators were excellent physicists with years of experience in subatomic physics and radiation. Many of the devices built at the institute were designed long before the political decisions, which only created more favorable conditions for implementing the projects. The man responsible for leading the Świerk Institute was Prof. Andrzej Sołtan. As the Institute's first director was a world renowned specialist in building particle accelerators, they became the hallmark of the Institute.

Professor Sołtan established four priorities. The first was a Van de Graaff electrostatic accelerator, which accelerated protons, deuterium and alpha

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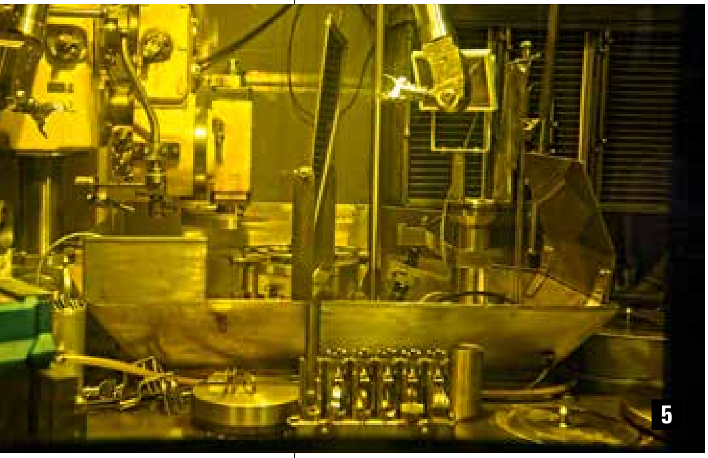

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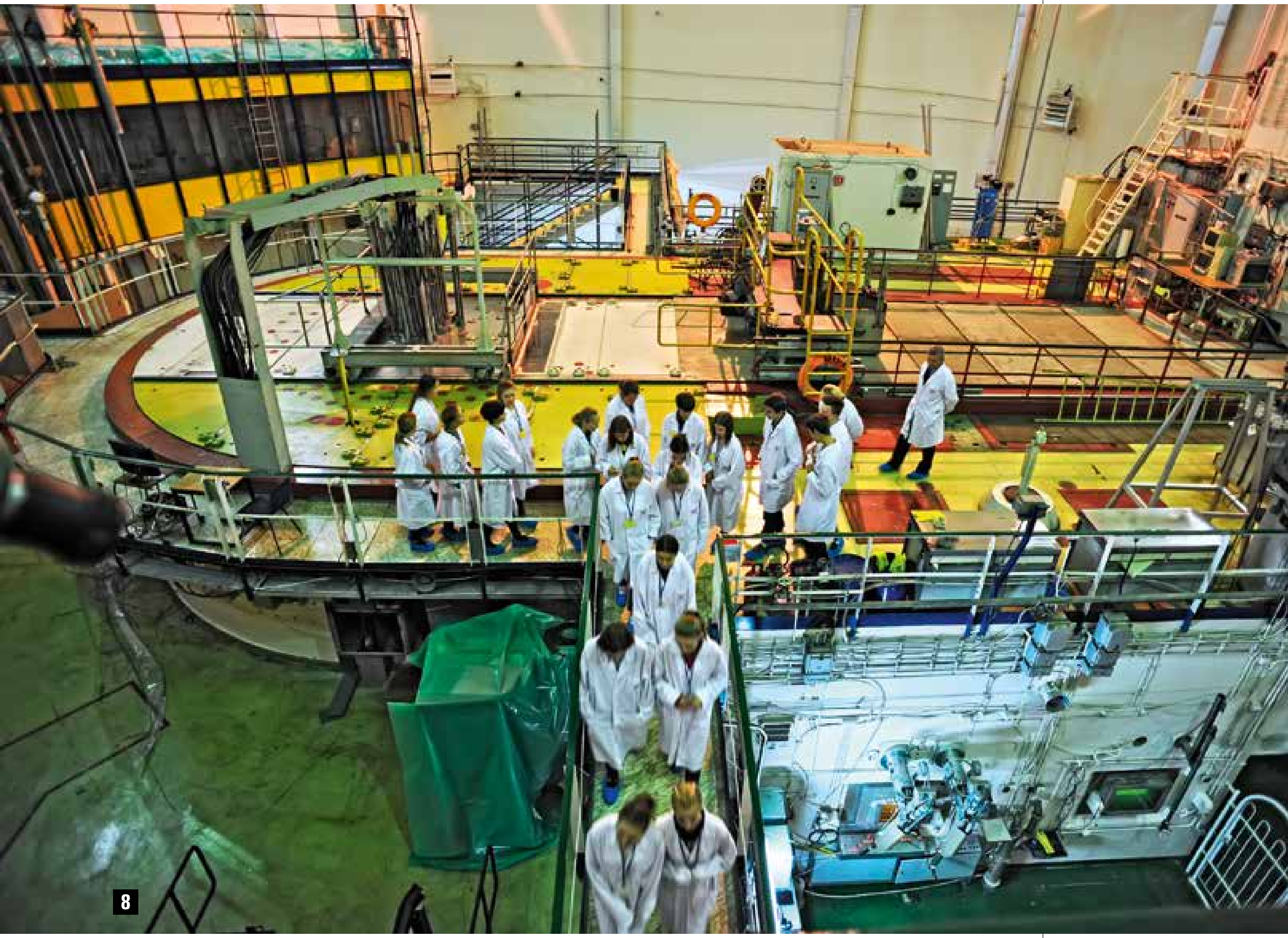
particles. Work on it began in Warsaw in the early 1950s. The "Lech" accelerator was launched in 1961 in a facility that was at the time located at the Faculty of Mathematics and Physics of the University of Warsaw. It was operational until 2014 and was used to test materials and their surfaces. The second priority was the construction of a linear proton accelerator. "Andrzej", named in honor of Andrzej Sołtan, was launched in 1970. It accelerated protons to a speed of 10 MeV using the Alvarez concept, which at the time of designing the device was a new solution, only having been used in several facilities around the world. "Andrzej" was used for basic research in nuclear physics.

Next were neutron generators, designed in the 1950s. Neutrons can be obtained not only in a reactor, but also through the nuclear reactions occurring as a result of bombarding deuterium or tritium with deuterons. Generators with horizontal accelerators, and later vertical ones were launched at the Institute in 1964 and 1965, respectively.

The fourth priority established by Sołtan was the construction of an electron accelerator based on the betatron design. Its prototype was designed in 1962 and in the following years three more models were developed, including a mobile device. The models sold to industry were used to study the quality of metal ores and for non-destructive tests of steel structures.

By the end of the 1970s, thanks to collaboration with French partners, the Institute began specializing in linear electron accelerators. Many medical radiotherapy accelerators and radiographic accelerators were developed. Świerk became a well-known manufacturer of these devices, not only for the European market. Currently, thanks to EU funds, new modern constructions have been developed. In total, approximately 30 types of accelerators have been developed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in Świerk to date, including proton cyclotrons, ion implanters, accelerators for food sterilization, testing electronic materials, impulse accelerators, etc. The Institute has also supplied parts for devices built in Poland and abroad, and many of the products developed in Świerk have been patented.

Open to the wider world

From the very beginning, the physicists at the Institute were able to maintain international contacts allowing them to play an active part in cutting-edge research. This was thanks to the renowned international reputation of Andrzej Sołtan and other creators of the institute, such as Marian Danysz and Jan Paweł Nowacki, as well as the reputable position of Polish physics, especially the physicists communities in Warsaw and Kraków, from which most of the leading Institute figures originated. Interns from the Institute were able to travel not only to Dubna in Russia, but also to the West, in particular to CERN, where young Polish researchers quickly gained an excellent reputation. Researchers in Świerk were extremely valuable in analyzing the huge amount of data from accelerator experiments. Materials were also sent to Poland, and there were so many of them that a special table for viewing photographs from abroad was built at the Institute's workshop.

Świerk›s participation in CERN's research was not limited to analytical work. Detector parts were being produced in Świerk since the 1970s, including for WA1, Compass, Delphi, CMS, and LHCb experiments. It was clear that the Institute's competence in accelerator technology was recognized when the center received orders for accelerating and beam forming elements for the LHC accelerator complex, as well as an accelerator for the GBAR experiment. In addition, the NCBJ's Świerk Computing Centre, launched in

Fig. 4, 5
Work on materials irradiated in the reactor is performed in hot chambers.

Fig. 6, 7
Ibis-2, the latest NCBJ research device, allows hot plasma to be studied inside a vacuum, producing conditions similar to the ones near stellar coronae.

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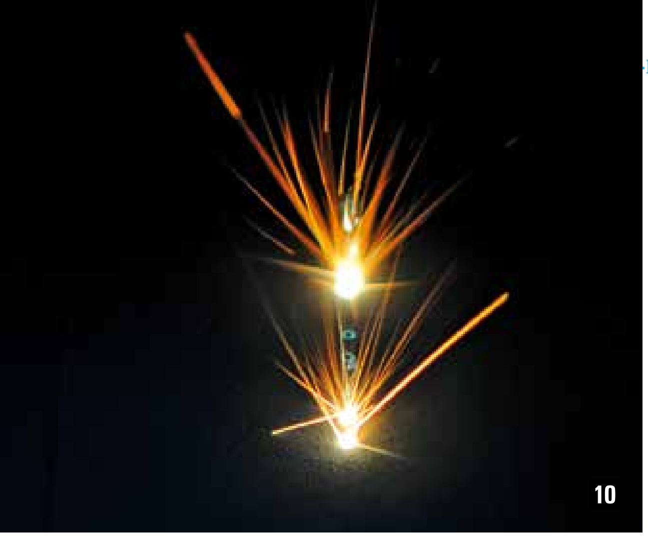
2015, became an important hub for processing and collecting data for the LHCb experiment.

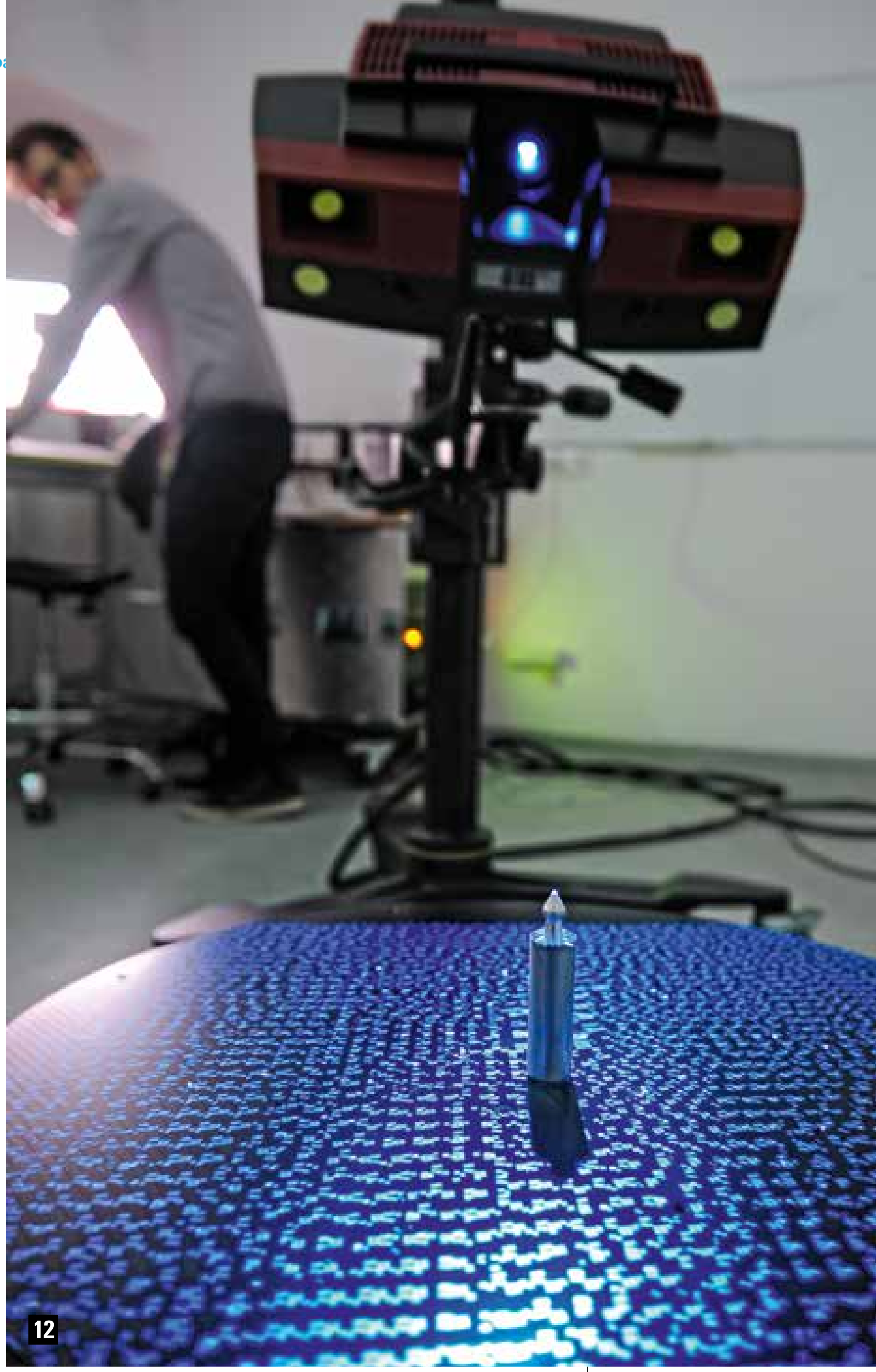
The DESY center in Hamburg is another important international partner of the institute. The NCBJ is a co-owner of the European XFEL free electron laser built there. The Institute coordinated all Polish shipments and itself provided several thousand accelerator parts. Similar orders are currently being fulfilled for the international ESS installation being built in Lund, Sweden. In addition, NCBJ and the Polish company Kubara Lamina are collaborating on contributing to a free-electron laser under construction at Stanford University in the United States.

The NCBJ is currently collaborating with several dozen partners around the world, some of which can boast of Noble Prizes. In addition to CERN this includes the T2K neutrino experiment in Japan, where physicists from Świerk are responsible for the operation of a close detector, as well as the LIGO and VIRGO experiments involving the observation of gravitational waves, where physicists from NCBJ are making important contributions to signal identification and noise analysis.

Energies of the future

I can only touch on the many aspects of the institute's 60-year activity in this piece and there isn't enough space here to list all of them. However, I must mention the research on new energy sources, including thermonuclear fusion, seven original plasma-focus devices created in Świerk, the participation of the Institute in the construction of W7X stellarator in Greifswald, and its contribution to other devices and plasma experiments around the world. When it comes to the energy of the future, the Institute is engaged in research on new materials and testing new generations of nuclear reactors, which may be built in Poland.





Another source of pride and satisfaction for the Institute is the successful production of radiopharmaceuticals, which have been manufactured for over 50 years. Despite the huge challenges of operating in the pharmaceutical markets of 80 countries, POLATOM is continuously growing. Thanks to EU funds, it will soon acquire a cyclotron for radiopharmaceutical production, as well as state-of-the-art research laboratories. Nearly every day for the past 20 years classes have been held for school children at the Institute's educational center. Visitors are interested in seeing the Maria reactor, but the Education and Training Department created by Prof. Ludwik Dobrzyński ensures that guests not only see it, but also understand it. The centre has a unique nuclear physics lab equipped for conducting workshops for high school and undergraduate students.

A Science and Technology Park was established in Świerk in order to shorten the path from the lab to the business world. It has seven specialty labs and a qualified staff of advisors. Several dozen companies have used the Park's services in its first two years.

The Institute in Świerk has always been closely linked to political and social changes underway in the country. During the period of martial law in the 1980s, due to the rebellious behaviour of its employees, the Institute was split apart, divided into the Institute of Nuclear Studies, the Institute of Atomic Energy, and other institutions outside of Świerk. During the wave of atomic scepticism it gradually lost funding. Currently, with the help of EU funds, it has once again become a single united institution, now known as the National Centre for Nuclear Research, and is patiently awaiting further decisions on nuclear energy, which will most likely impact its future development.

Marek Pawłowski
Katarzyna Żuchowicz

Fig. 9
The work of physicists is supported by the powerful Świerk Computing Centre.

Fig. 10
New technologies in Świerk include 3D laser printing.

Fig. 11
Innovative ecotechnologies are used to cool the Świerk Computing Centre servers.

Fig. 12
The labs at the Science and Technology Park in Świerk offer high-precision 3D scanning capabilities.