

Ideas at work





Cutting-edge research for society

The Helmholtz-Zentrum Dresden-Rossendorf is renowned throughout Germany as well as abroad for its cutting-edge research in the areas of Energy, Health, and Matter. Its approximately 1,100 members of staff work at finding solutions for the major challenges faced by modern-day industrialized society. Their achievements range from discovering basic principles in the natural sciences to generating ideas for new products and innovations.

As a member of the Helmholtz Association, the largest science organization in Germany, the HZDR contributes to the maintenance and improvement of the basic conditions of human life. Our research generates added value – for society, the economy, the region, and for healthcare and environmental

protection. Effective technology and knowledge transfer is needed to enable optimum exploitation of this added value. We established our Technology Transfer and Legal Affairs Department, our subsidiary HZDR Innovation GmbH, the DeltaX School Lab, and our Department for Communications and Media Relations for this very purpose. Together with our researchers, they have made major contributions to our various transfer activities in recent years.

The aim of this brochure is to present different examples that demonstrate where new ideas are put into action and how the results of our research make their way from the laboratory to the people, the factory buildings, the schools and hospitals, and politics.

The Board of Directors
Helmholtz-Zentrum Dresden-Rossendorf

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Ideas at work – research meets business

Through its research, the HZDR makes an important contribution to improving the imaging and treatment of different cancers, the sustainable use of resources, and the better understanding of matter. In order to ensure that our insights and ideas are applied, we cooperate with industrial partners and hospitals, license technologies to companies, and establish spin-offs. We also make our knowledge and expertise available through the shared use of our research facilities, granting access to data, and providing consultancy services for public authorities and politicians.

The Technology Transfer and Legal Affairs Department provides all of the vital expertise and support services for the HZDR's transfer activities – from patenting, innovation, and contract management to technology marketing. As part of the department's services, innovation managers work off-site at several of the HZDR's institutes. Thanks to this proximity to the scientists, they have direct insight into current research topics. This enables them to identify research findings that are suitable for application and to support the entire transfer process.

Another key element of the HZDR's technology transfer is its subsidiary HZDR Innovation GmbH, which was established in 2011. It realizes manufacturing orders from industry and – working in close cooperation with the HZDR – promotes the exploitation of research results and their conversion

into marketable products. External partners and the HZDR Innovation Fund also provide crucial support for technology transfer. Based on this we have succeeded in profitably marketing many ideas and developments in recent years – a win-win for all stakeholders: the HZDR, the inventors, the economy, and society.



Dr. Björn Wolf
Head of Technology Transfer and Legal Affairs at the HZDR





Cooperation WITH INDUSTRY



The HZDR's cooperation with industry is a worthwhile process for both. This is clearly demonstrated by many successful cooperative ventures, particularly in the areas of health research and measurement technology. Such ventures provide industry with access to the very latest technologies while also advancing research.



Cooperation for the benefit of patients

Close cooperation between ROTOP Pharmaka GmbH and the HZDR on health research is a win-win situation.

Patients reap the greatest benefits when ROTOP and the HZDR join forces on research projects. By combining their strengths, both partners work on improving the quality of diagnostics in human medicine and thereby facilitate the tailoring of therapies to individual patients.

ROTOP specializes in the production of active pharmaceutical ingredients and kits for the preparation of radiopharmaceutical products based on Technetium-99m (^{99m}Tc). These diagnostic products are required for nuclear medicine tests involving the imaging of organ function and bone metabolism, as well as tumor localization. The company, which is located on the HZDR research campus in Dresden, offers suitable radioactive preparations for almost all organs. The main component of its kits is active ingredients that are produced by ROTOP and that dock at the organ to be examined or a particular pathognomonic target structure. Prior to use, the nuclear medicine specialist adds a radioactive liquid to the kit which binds to the active ingredient it contains and renders it visible under a special camera (SPECT).

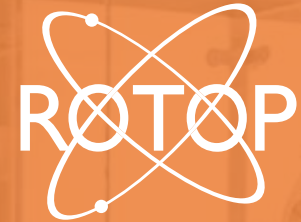
“The vast majority of our ^{99m}Tc kits are generics,” explains Jens Junker, the company’s CEO. “Their production can be compared to the task of cooking a complicated dish, for which only the ingredients are known. We have to discover the quantities and method ourselves.” It takes two to three years to develop

the complete ‘recipe’. This is also because ROTOP not only reconstructs the original substance but also improves it if possible - for example to allow faster handling during use.

This would be almost impossible for the company to achieve on its own. “During development, we work intensively with the Helmholtz Center and have access to its infrastructure and expertise in radiopharmaceutical production,” explains Jens Junker. “Moreover, some of the indispensable scientific tests

“Research results should filter through to people, so they will also benefit from them. For this reason, applied research is just as important as basic research.” Professor Jörg Steinbach

and analysis procedures using radioactive substances can only be carried out at the HZDR Institute of Radiopharmaceutical Cancer Research, headed by Professor Jörg Steinbach.” The cooperative venture extends beyond pure product-oriented development. The partners describe many of their projects as applied basic research. ROTOP also markets licensed radioactive drugs developed by the HZDR.



ROTOP Pharmaka GmbH

ROTOP Pharmaka GmbH embarked on the commercial production and sale of radiopharmaceuticals in the year 2000 with the MAG-3 renal diagnostic agent developed in the HZDR. Today, its product range includes around a dozen ^{99m}Tc kits and other products. The active ingredients and kits are produced in modern cleanrooms in strict compliance with GMP (Good Manufacturing Practice) regulations. ROTOP supplies customers all over the world through its own sales team and international partners. Its owners, Jens Junker and Dr. Wilhelm Zörgiebel, took over the company from its founder Monika Johannsen in 2014.

In late 2016, ROTOP joined forces with the companies Biotype Diagnostic GmbH, Biotype Innovation GmbH, and qualitype GmbH to form the biotechnological-pharmaceutical group Molecular Diagnostics Group (MDG). The aim of this competence network is to develop innovative detection processes and diagnostics to meet the complex challenges of personalized medicine.

Optimum conditions for production and research

Industry is set to benefit from cooperation with the Center
for Radiopharmaceutical Cancer Research.

▮ The Center's new complex with the vault containing the cyclotron at the front. ▮

The HZDR Institute of Radiopharmaceutical Cancer Research has been developing and testing radioactive drugs for cancer diagnostics and treatment for many years. A new research complex will provide its scientists with excellent conditions to continue this important work into the future. The new particle accelerator (cyclotron), radiopharmaceutical production, and laboratories for radio-chemical and bioscientific research are all united there under one roof and closely connected with the already existing laboratories of the Institute. "For example, there is a separate area for species-appropriate rearing of laboratory animals and small animal imaging," explains Professor Jörg Steinbach, Director of the Institute.

The more powerful cyclotron will benefit the production of radiopharmaceuticals, which the Institute provides, in particular, for joint research projects with the Carl Carus University Hospital in Dresden – especially the OncoRay Center – and for other research partners and nuclear medicine facilities. Furthermore, the modern particle accelerator can generate radionuclides that could form the basis for new radioactive drugs for the treatment of cancer.

"ROTOP is also interested in some of these topics," says Steinbach. "But we also cooperate with further partners from industry." Along with other local companies, these include global players like General Electric, Bayer and Glaxo-Smith-Kline. "The cooperation always pays off for both sides," as he emphasizes. "We advance our research and industry acquires expertise, access to which it would otherwise be unlikely to acquire. The radiation protection alone would be simply unaffordable for most companies."



The Center for Radiopharmaceutical Cancer Research at a glance

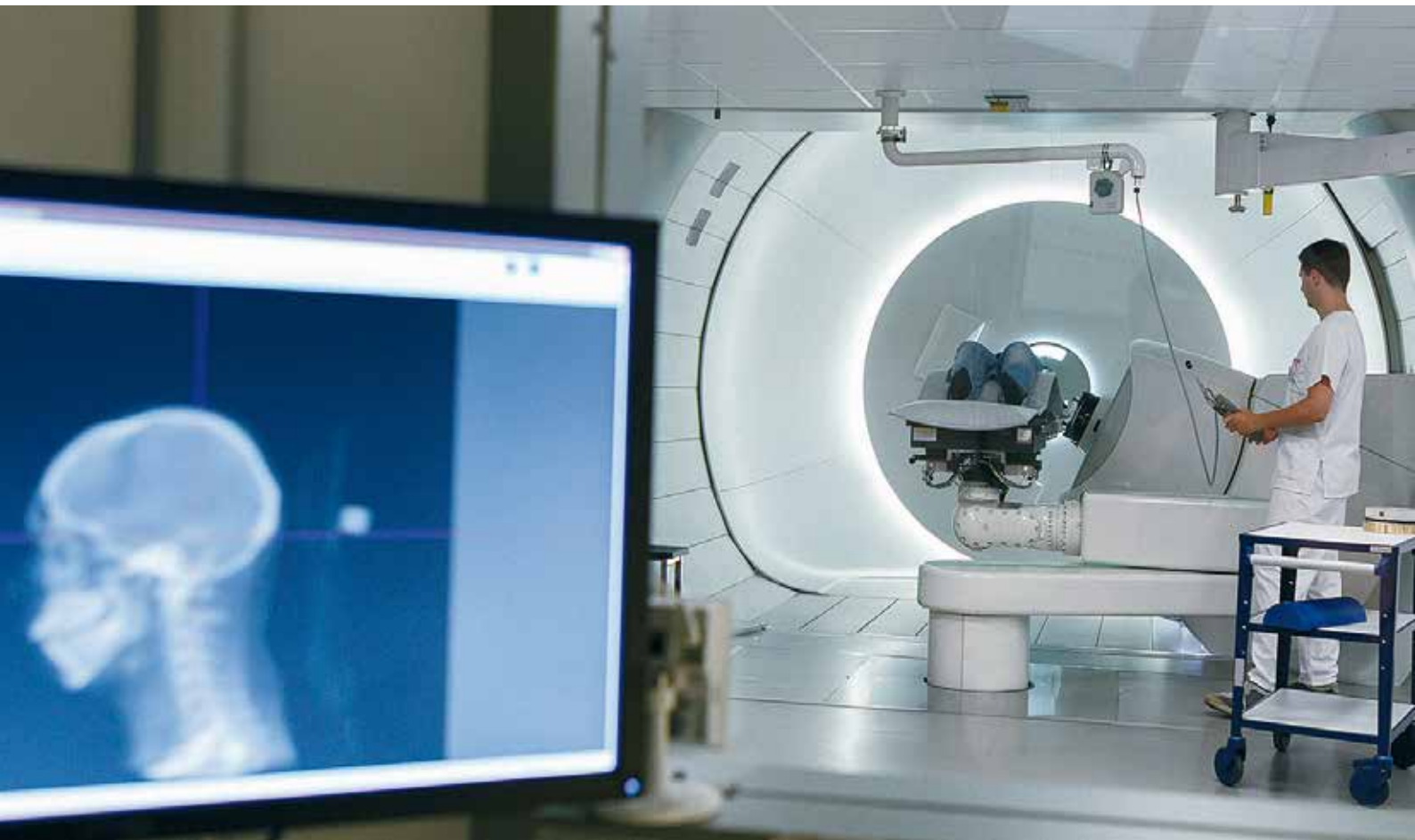
- Production of radionuclides using a powerful cyclotron
- Production of radiopharmaceuticals under cleanroom conditions (GMP: Good Manufacturing Practice)
- Radiopharmaceutical chemistry
- Bioscientific research, including small animal imaging
- Development of special software for improving tomographic imaging

Treatment verification

A team of researchers from the OncoRay Center in Dresden, the HZDR and the company IBA Ion Beam Applications have found a solution for determining the proton range during irradiation. To do this, they use a camera system developed by IBA.



▮ Cancer patients have been receiving particle beam therapy at the University Proton Therapy Facility Dresden (UPTD) since the end of 2014. ▮



Proton beam therapy is a particularly precise form of radiotherapy used in the treatment of cancer. In the past it was not possible to measure how deeply the protons penetrate a patient's body in real time. This limits the advantages of proton beam therapy in clinical application considerably. A solution has been found using a Prompt Gamma Slit Camera, developed by the company Ion Beam Applications IBA. The camera was further optimized to enable its clinical application by a team of researchers from Dresden and clinically applied for the first time. The aim here is to irradiate as little healthy tissue as possible during radiotherapy and to destroy the tumor with greater accuracy than was previously possible.

Protons cause the emission of energy-rich electromagnetic waves, known as prompt gamma rays, at the sites in the patient's body where they stop and discharge their destructive forces. The researchers can now detect this radiation with the new slit camera. "The camera detectors measure the spatial distribution of the prompt gamma emission in the patient. At depths which the protons do not reach, no radiation is emitted. Hence, we can conclude from the measurement of the spatial gamma ray distribution the site where the proton beam comes to a halt," explains Dr. Christian Richter, head of the High-Precision Radiotherapy research group at the HZDR.

Unlike other methods, the IBA slit camera already indicates the range of the proton beam during treatment. During the first clinical measurements carried out on a patient in 2015, the researchers succeeded in pinpointing the range of the protons in the body. As a result, the uncertainty regarding proton range can be significantly reduced with the help of the camera and also the safety margin around the tumor. This means that it is possible to cause less damage to healthy tissue while administering the same dose of radiation to the tumor.

"With the help of this technology, we aim to make proton beam therapy more effective and less damaging to healthy tissue in the future," says Christian Richter. "One possibility, for example, would be to enable the camera to transmit its measurement data automatically to the control system and to halt the irradiation if the proton beam possesses a range that is too high or too low. Patients would benefit directly from this." The OncoRay research platform, which is jointly operated by Dresden University Medical Faculty and Hospital as well as the HZDR, provides ideal conditions for realizing these ambitious goals.



More productivity for metal casting



The HZDR is developing integrated measurement technology for hot melts on behalf of Primetals Technologies, a plant construction concern.

The measurement of flow rates in hot melts is an issue of major interest for the steel industry. Such measurements are indispensable when it comes to optimizing the casting process. With Contactless Inductive Flow Tomography (CIFT), researchers at the HZDR have invented a method for obtaining the desired information. Primetals, a leading manufacturer of plants for the continuous casting of steel, aims to incorporate this technology into its production. The HZDR and Primetals Technologies have been collaborating on making the patented process suitable for industrial use since late 2016.


Steel is usually manufactured using a process known as continuous casting. The molten metal is poured from a casting ladle via a distributor into a water-cooled, continuous casting mold where it solidifies. The flow rate of the hot steel melt plays an important role here. If it is too fast, turbulence can arise which has a negative impact on the quality of the steel. If it is too slow, there are implications for productivity costs. The potential for improving these processes is enormous. However, due to the high temperature of the melt – up to 1,600 °C – and its opacity, it is almost impossible to control the flow during casting.

The CIFT process is based on the fact that when an electrically conductive liquid is exposed to a magnetic field, electric currents are induced which deform the magnetic field. This can be measured externally and provides information about the liquid's flow state. Researchers at the HZDR have been

commissioned by Primetals Technologies to work on the adaptation of these technologies to the industry's specific requirements. Coils and sensors for the integrated measurement technology have to be installed directly at the mold. The coils are necessary for generation of the magnetic field. The sensors record the flow-related changes in the magnetic field and thus reveal what is going on inside the mold.

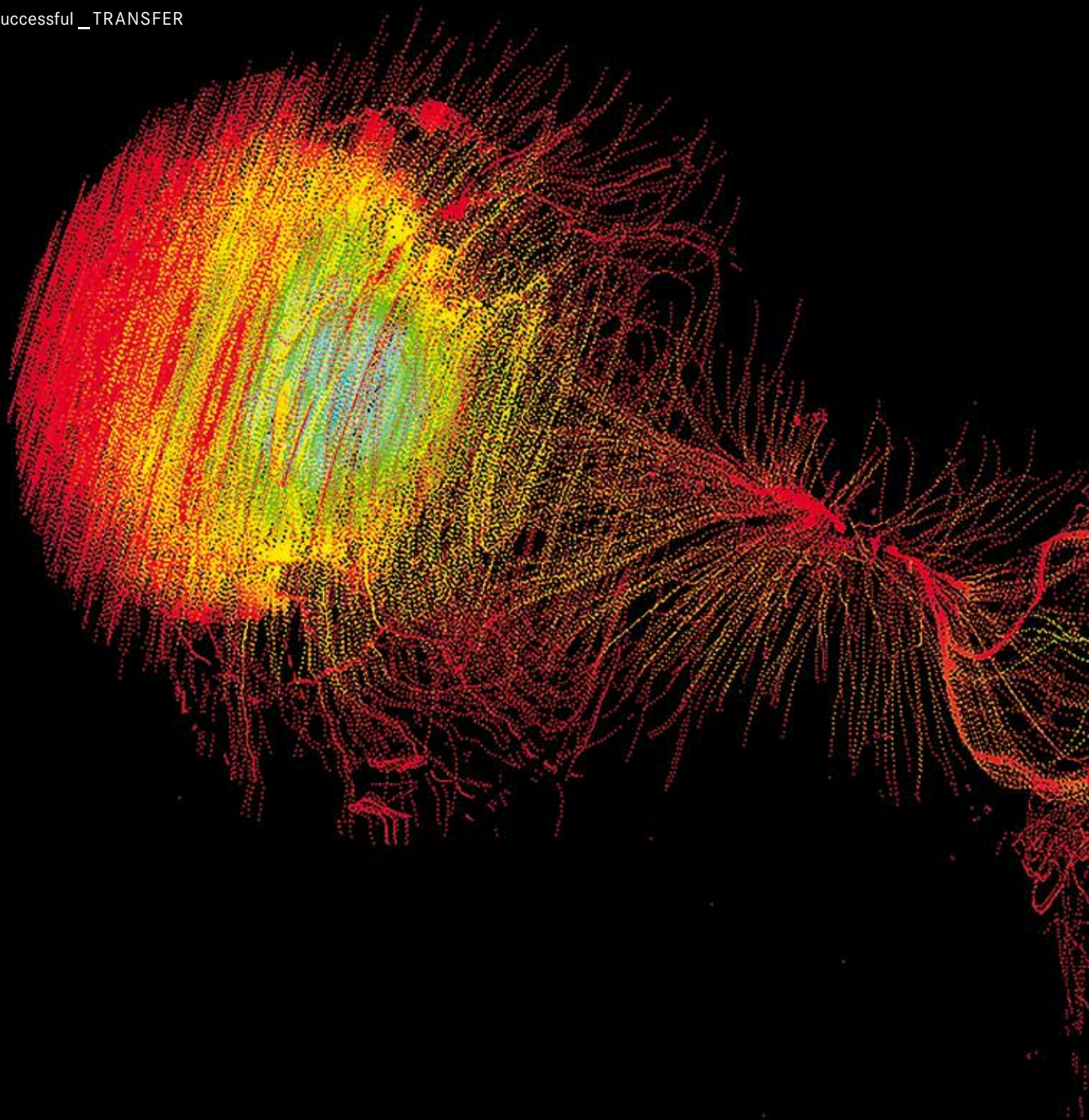
Magnetic flow control for liquid metals

In addition to measurement applications, magnetic fields can also be used to influence the flow of melts. Examples here include electromagnetic stirring or braking. In aluminum casting the stirring supports formation of a high-strength, fine-grained structure. It also helps to prevent instabilities and turbulence which can give rise to impurities and gas inclusions. In cooperation with a partner from industry, it was possible to achieve considerable quality improvements in the aluminum investment casting of special parts for aircraft construction. Air inclusions had formed during casting due to turbulence. With the help of magnetic flow control during mold filling, it was possible to prevent this and to reduce the reject rate considerably.



“This measurement method represents a major advance towards greater productivity and safety for our customers in the steel industry,” says Dr. Peter Wimmer, Project Manager at Primetals Technologies. “We expect the technology to be ready for use in three to four years.”

■ Successful_TRANSFER



Successful TRANSFER



Many scientific disciplines require special research equipment, measurement technology, and software that cannot simply be obtained off-the-shelf and often has to be developed by scientists themselves. Some such innovations developed at the Helmholtz Center prove to be suitable for broader applications than originally planned, and some even end up being marketed as products.



Super-fast and free of charge

Young scientists at the HZDR opted for the particle-in-cell method in developing PConGPU, the most advanced computing code currently available for 3-D plasma simulations. The program is suitable for many applications in research and industry.

Innovative compact particle accelerators that work on the basis of ultra-intense lasers could act as radiation sources for cancer treatment in the future. When this kind of laser pulse strikes a target, a plasma – a mix of electrons and ions – is formed. The electromagnetic fields that arise in the plasma can be used to accelerate the particles. Researchers at the HZDR use computer models to study movements and complex interactions in the

plasma and experiment with different targets. Their aim is to be able to control the energy, divergence and stability of the beam – all of which are basic conditions for the application of radiation sources in medicine.

In order to enable such simulations, Dr. Michael Bussmann's team developed the PConGPU program code. The program not only harnesses the computer's normal processors (CPUs) but also the processing units on the graphics cards (GPUs), which can complete the computing processes much faster. Depending on the number of GPUs available, a computation that would normally take one week can be shortened to just a few

▮ HZDR researchers already use one of the world's most powerful computers at the Oak Ridge National Laboratory in Tennessee, USA, for their projects. ▮



hours. Even with the help of the optimized code, however, only supercomputers are able to model the laser acceleration on the level of the individual electrons and ions.

Versatile modules

Although the researchers originally only focused on optimizing the accelerator technology, an increased number of applications soon emerged for their program. “We solved other problems almost incidentally,” explains Michael Bussmann. “The code can also be used for simulations in astrophysics, for example to help in the understanding of cosmic acceleration processes. We also developed successful individual solutions for many important problems that arise in supercomputing, such as computing on different computing architectures and the writing, reading, and analysis of large data volumes that can also be used independently of the simulation code.”

The program and the accompanying libraries are available free of charge as open source code to both scientists and commercial enterprises. They can use the complete program or individual modules without special contracts, build the source text into

their own products, and further develop the code for their own purposes. Whoever needs help in adapting the code to their requirements can purchase the service from the HZDR. The open source program has spread rapidly – much to the delight of the developers. This means that they can also incorporate improvements made by other users into their own research.

PIConGPU

Particle-in-cell (PIC) code for graphics processing units (GPUs): PIC describes the interaction of charged particles with electromagnetic fields in a virtual spatial lattice. The code was mainly developed by students from the Computational Radiation Physics group at the HZDR in cooperation with the Centre for Information Services and High Performance Computing at the TU Dresden.



Research software with potential

Many disciplines need special software for their scientific work which they frequently have to develop themselves. Some such programs that were developed in the context of research projects at the HZDR are now being put to excellent use all over the world.

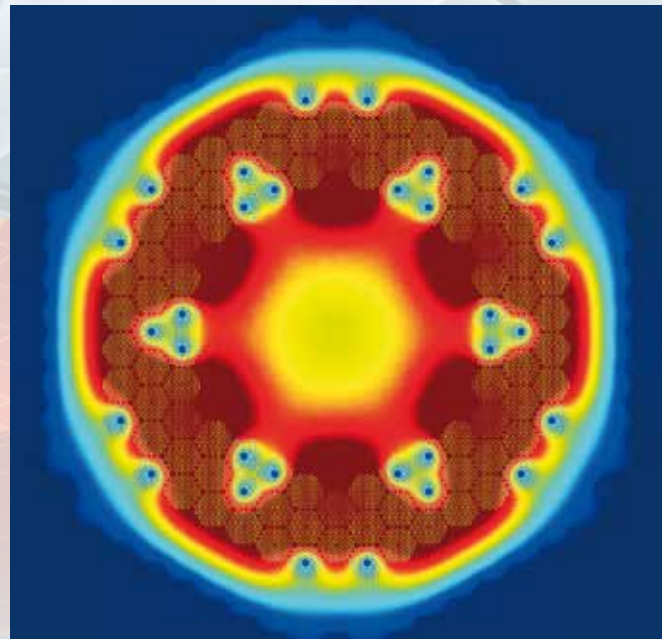
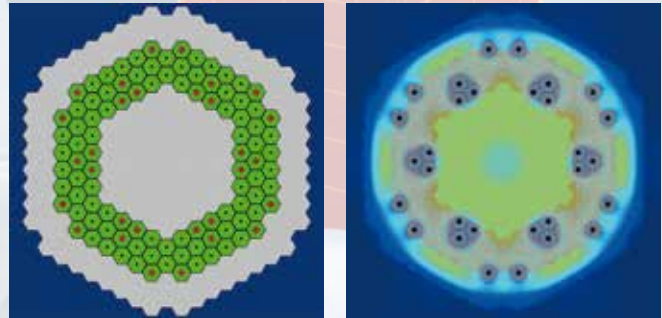
These solutions can benefit not only the original scientific research itself but also hospitals, public authorities, and commercial enterprises. For the developers this represents an incentive to maintain the codes, further improve them or adapt them for new areas of application.

Software for more safety

The DYN3D simulation program is used to analyze nuclear power plants.

As far back as the late 1980s, scientists in Dresden developed the software code DYN3D, which enables the simulation of accidents in nuclear reactors using three-dimensional models. They have continued to work on further development of the code ever since and on adapting it to the latest developments in research and technology.

DYN3D has the capacity to analyze Western and Russian light-water reactors and future reactor designs. Supervisory authorities and scientific institutions in Eastern Europe, in particular, use the code for safety analyses. The HZDR cooperates in this research with the TU Dresden and some 20 further partners throughout Europe. Given that various countries that border Germany are planning to construct new nuclear power plants and are developing innovative reactor designs, the topic of reactor safety will continue to be relevant for Germany – even after its own phasing out of nuclear power.



Better cancer diagnostics

ROVER software enables the quantitative analysis of PET data and is used throughout the world.

Positron emission tomography (PET) can make metabolic processes visible. Researchers at the HZDR developed the powerful computer program ROVER to enable the easy and fast processing of PET data. The main purpose of the program is the quantitative evaluation of PET images, but it also allows the combining of PET images with data from magnetic resonance

imaging (MRI) and with computed tomography (CT). The scientists constantly update ROVER to adapt it to ongoing developments. The program, which is distributed by the company ABX Advanced Biochemical Compounds in Radeberg in Saxony, is used in hospitals and clinical research throughout the world.



▮ Screenshot from ROVER showing a PET/CT scan of a patient with lung cancer. ▮

Innovative sensor technology for flow analysis

The wire-mesh sensor provides cross-sectional information about multi-species and multiphase flows inside pipes which is of considerable interest to process industry and energy research.

The marketing of research findings is one of the main tasks of the HZDR's innovation managers. Uwe Pöpping is responsible for the transfer of new technologies developed at the Institute of Fluid Dynamics, such as special measurement systems for multiphase flows. "The wire-mesh sensor was the first product I was intensively involved in that provides marketing support," Uwe Pöpping recalls. "When I started here in 2010 the technology was already so advanced that considerable market demand existed for it."

Harnessing the wire-mesh sensors developed and patented at HZDR, multiphase flows can be analyzed rapidly and at a high resolution. The sensors, which consist of an electrode mesh or grid consisting of transmitter and receiver electrodes, measure the electric conductivity at the crossing points in the mesh. "The system provides cross-sections of the flow in a pipe. At up to 10,000 images per second, it also records very rapid flows," explains the innovation manager. "It can also be used for measuring the flows of mixtures of substances containing different liquids and gases."

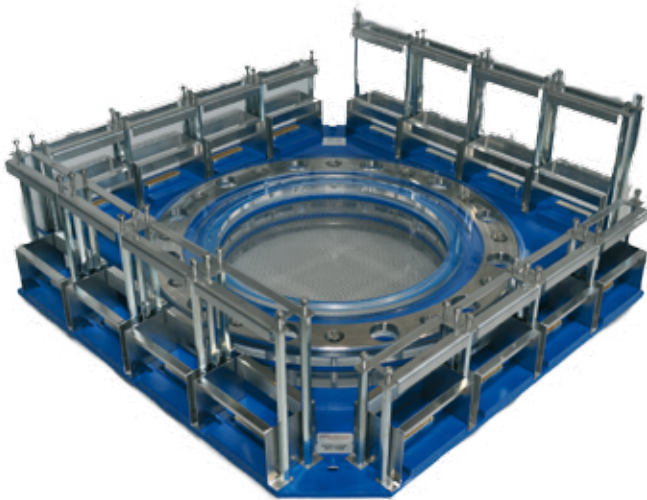
The sensors are manufactured on a user-specific basis and marketed by HZDR Innovation GmbH. "Most of our customers are still from the research sector," says Uwe Pöpping. "However, my colleagues are currently working on a wire-mesh sensor that could be integrated into industrial processes." This will open up new markets, as flowing mixtures arise in many sectors, including the chemical industry and power plants. The innovation manager is already working on establishing contact with potential customers.



Uwe Pöpping, Innovation Manager, Fluid Dynamics

He is one of five managers at HZDR who tests and evaluates inventions and technologies with respect to their potential for application, develops exploitation strategies for commercial use, establishes and maintains contacts with business, and supports projects in the process of technology transfer. Through his close association with the HZDR's Institute of Fluid Dynamics, he is always informed of the latest innovations.

Contact: u.poepping@hzdr.de



Flow measurement technology by HZDR

Experiments on multiphase and molten metal flows require special measurement technology that cannot simply be purchased off-the-shelf. For this reason, the Institute of Fluid Dynamics develops proprietary sensors for the imaging of measurement processes as well as fast local sensors for use in aggressive environments. Some of these patented technologies – manufactured under license and marketed – are already being deployed in research and industry. In addition to the wire-mesh sensor and CIFT (Contactless Inductive Flow Tomography) technology, they include:

■ Needle probe for gas holdup measurements

Local gas holdup in multiphase flows can be measured without difficulty using the HZDR's needle probes. The probes work on the basis of an electrical measurement principle and are robust and temperature-resistant up to 300 degrees Celsius. The high sampling rate enables safe analysis of even fast multiphase flows.

■ Ultrasonic waveguide for hot melts

A sheathing for ultrasonic sensors developed at the HZDR makes the sensor suitable for use at temperatures of up to 1,000 degrees Celsius. This enables the ultrasonic waveguide to measure flows in metal melts. The Swiss company SP Signal Processing manufactures this measurement technology under license.

■ Flow meter for liquid metal

This product, which is licensed to the Saxon company SAAS Systemanalyse & Automatisierungsservice, can be used to measure the mean flow rate of metal melts. The velocity is determined from the phase shift between two receiver coils using a contactless method.



▮ Wire-mesh sensors developed and patented by the HZDR. ▮

Research equipment as a marketable commodity

Scientists at the HZDR have developed superconducting accelerator technology for the Radiation Source ELBE. The company RI Research Instruments GmbH adopted the technology and enhanced its portfolio by adding this highly specialized area.

The HZDR has a unique radiation source at its disposal: the ELBE (Electron Linac for beams with high Brilliance and low Emittance). With the help of a pulsed electron beam, ELBE generates wide-ranging secondary beams for research purposes. External users from all over the world come to the ELBE Center to carry out research using gamma, X-ray, infrared, and terahertz radiation, as well as positrons and neutrons.

A superconducting particle accelerator developed by the HZDR and partners is a central element of ELBE. It delivers short electron pulses to almost the speed of light. Thanks to the superconductivity there is no heat deposition. This eliminates the need for cooling pauses and enables continuous operation.

Following the successful startup of ELBE, the company RI Research Instruments GmbH

in Bergisch Gladbach (formerly ACCEL Instruments) acquired the license for the newly developed accelerator module and other components belonging to the accelerator. This proved to be a good decision, as RI has since received orders for the construction of accelerator modules in Great Britain, at the University of Ankara in Turkey, and at the University of Mainz. RI Research Instruments and the HZDR collaborate closely on these projects, as the modules have to be further developed and modified for each user.

RI Research Instruments is also interested in the superconducting gun technology from Dresden which marks a major advance for future accelerator projects. With this innovative electron gun in its portfolio, the company can not only supply individual components, but is also able to provide entire accelerator systems. This all goes to show that even highly specialized research devices have market potential that can be profitably exploited by companies.



▮ Superconducting gun technology developed by HZDR. ▮

At the limits of feasibility

Large research equipment cannot be simply ordered from catalogues. Every installation represents years of intensive development work involving the cooperation of numerous partners. The HZDR's technical needs often exceed the limits of feasibility, and suppliers must achieve peak performance to fulfill them. This enables some companies to gain highly specialized knowledge that translates as competitive advantages or access to new markets.

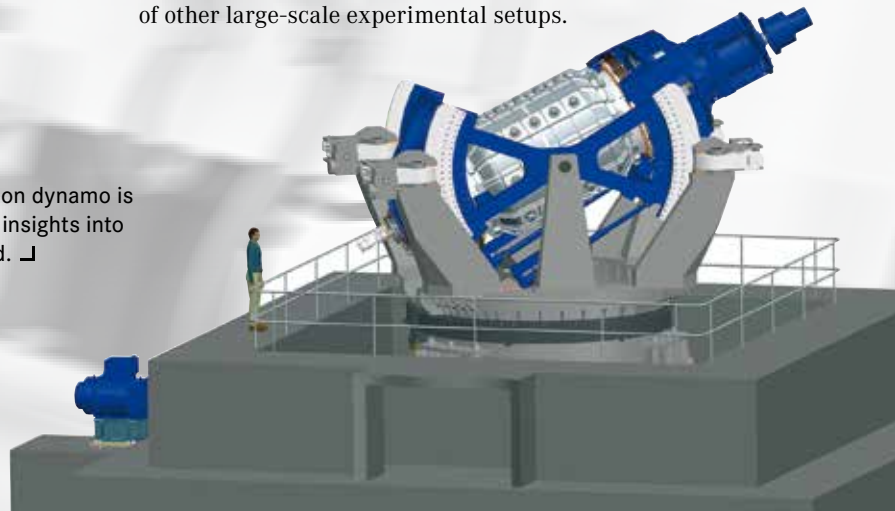
The capacitor bank challenge

High magnetic fields can bring hidden material properties to light - discoveries that are of fundamental importance for the development of new materials. The Dresden High Magnetic Field Laboratory at the HZDR is able to generate very strong magnetic fields with ultra-high, short energy pulses. A gigantic capacitor bank stores the energy necessary for this and transmits it in pulses to the magnetic field coil. The Rheinmetall Group in Düsseldorf accepted the challenge of producing this capacitor bank, which is the most powerful in the world. Together with experts from the HZDR, Rheinmetall succeeded in overcoming the huge technical challenges presented in this context. The project also led some of the individual suppliers to new insights, as they frequently had to exhaust all possible physical options in the manufacture of the capacitors, coils and fuses.

The giant dynamo challenge

As part of the DRESDYN project, the company SBS Bühnentechnik GmbH is building a unique research dynamo. Scientists plan to use the dynamo to study geophysical and astrophysical phenomena, and the use of liquid metals in energy technology. The heart of the experiment consists of a two-meter-long cylinder filled with liquid sodium. Powerful alternating forces and pressures are generated through its rotation around two different axes. The dynamo's construction and material must withstand these conditions and meet very stringent safety requirements. This poses a major challenge for the Dresden-based company – a challenge to which it has risen in cooperation with the HZDR. Through the project and collaboration with the scientists, the company has gained valuable expertise that it can use for the construction of other large-scale experimental setups.

▮ The world's first precession dynamo is expected to provide new insights into the Earth's magnetic field. ▮



DeltaX laboratory for young researchers

The HZDR launched the DeltaX school lab in 2011 with the aim of quenching children's and young people's thirst for knowledge and fostering young scientists from an early age. Since then, over 15,000 school pupils from the 5th class up (approx. 12 years) have carried out exciting experiments in DeltaX that would not be possible in school laboratories.

An annual in-house training event on the HZDR's current research topics is held for teachers in the Saxony region – it usually attracts between 80 and 120 participants.





Knowledge TRANSFER



Whether through educational projects, lectures, policy consultation, or access to research findings on the Internet – knowledge transfer takes place in many ways. The THEREDA database, the DeltaX laboratory for young researchers, and participation in consultations on important social and economic issues are just a few of the ways that insights and expertise created at the Helmholtz Center reach the general public.



Base data for nuclear repository research

HZDR researchers are working with partners to compile the THEREDA central database. It contains important information for geochemical modeling carried out in the quest for nuclear waste repositories. The freely accessible database is also a valuable resource for contaminated site remediation and landfill design.

By 2031, the aim is to identify a site in Germany where highly radioactive waste can be stored underground, as safely as possible, for over a million years. The potential host rocks for the storage site are clay, granite and rock salt. “The safety of a site depends, among other things, on the interactions that can arise between the stored material and the environment – particularly when saline waters are involved,” says Dr. Vinzenz Brendler from the HZDR Institute of Resource Ecology. “To be able to provide long-term predictions, we need reliable scientific information about the possible chemical reactions.”

With a view to providing such predictions, over ten years ago, Dr. Brendler and colleagues established the central THERmodynamic REference Database, THEREDA. The aim of the cooperative project is to provide a comprehensive and quality-assured database of geochemical model calculations. The databases previously used were incomplete and often incomparable or not sufficiently reliable. “There is a problem with the high saline content of the groundwater in many sites that were identified as potential repositories,” explains Vinzenz Brendler. “Reactions and interactions can arise with the radioactive elements here and they must be examined in detail.” THEREDA provides evaluated thermodynamic data for



▮ Vinzenz Brendler is one of the initiators of THEREDA. ▮

all compounds of elements that are known to be relevant to such repositories based on the latest research. The project has been allocated funding by the federal German authorities since 2006.

Transparent and freely accessible

The database includes both information from the literature and current research findings from work carried out at the HZDR and the partner institutes. The teams collect, view and evaluate the content. The original sources and processing stages of the data are also presented transparently and comprehensively. Internal consistency checking, test calculations, and other criteria guarantee that only verified values are included. The critical views and feedback of external users also contribute

to the quality assurance. The central database is freely accessible. Anyone – whether they are a member of a federal authority, scientific institute, engineering office, environmental association or simply a private individual – can access it upon completion of a simple registration process.

Although THEREDA is already being used, the database will really come into its own when a preliminary choice of potential repositories has been made and the exact composition of the host rock is known for each site. Geochemists will then be able to retrieve the relevant data with a view to analyzing which site offers the best safety conditions.

THEREDA project partners



Highly regarded expertise

Professor Thorsten Stumpf is a specialist in the area of nuclear waste disposal. As a consultant he makes his knowledge and expertise available to politics and society.

Whether it involves calls from a government department in Berlin or interview requests from television stations, when it comes to questions relating to repository research, Thorsten Stumpf's expertise is in constant demand.

The Director of the Institute of Resource Ecology at the HZDR is among the few established experts in Germany who are up-to-date on the very latest developments in this area. "Sometimes there's a need for basic information, for example about nuclear repository research in general," says Thorsten Stumpf describing the focus of political and public concern. "In other cases, very concrete issues are involved." He can rely on the extensive expertise of the approximately 140 employees at his institute as well as up-to-date research findings – which is not

exclusively focused on the disposal of highly radioactive waste. "We also act as a source of information and contact with regard to reactor safety," as Thorsten Stumpf states. "Through our research on the safety of nuclear power plants, we are playing a leading role in this area at the European level."

Around ten percent of the Director's work time is devoted to consultancy and responding to media enquiries. He sees this as an important task, as the HZDR ultimately carries out research on behalf of society. Nuclear repository research is very topical and, despite Germany's phasing out of nuclear power, reactor safety remains a very important issue, as the last German nuclear power plant will not be decommissioned until 2022 and some of the neighboring countries are actively pursuing plans to build new ones



▮ Thorsten Stumpf is Director of the Institute of Resource Ecology at the HZDR and Professor of Radiochemistry/ Radioecology at the TU Dresden. He is a member of the Committee on Radioecology of the German Commission on Radiological Protection, which acts as a consultative body for the legislative process. ▮

Safeguarding raw materials

Due to Germany's energy transition, its needs with regard to metals are changing. Together with colleagues, Professor Jens Gutzmer developed recommendations for an active raw materials policy.

The German economy is very reliant on high-tech metals like rare earths as well as steel, copper and aluminum. These raw materials are particularly indispensable for the development of a climate-friendly energy regime with wind and solar plants, storage systems, and intelligent networks. Given that these materials are not currently produced domestically, Germany's already considerable dependence on raw material imports is set to increase further in the future.

To reduce the risks associated with this import dependency, the German National Academy of Science and Engineering (acatech) commissioned a study for the development of options for a sustainable, safe, and affordable raw material supply. The analysis, which is part of the "Energy Systems of the Future" project, was carried out by a group of experts, among them Jens Gutzmer, Director of the HZDR's Helmholtz Institute Freiberg for Resource Technology (HIF).

"As scientists we want to contribute to the success of the energy transition through our recommendations," he explains. "The process could come to a halt if an important metal increases in price or becomes unavailable on the market." It is important to reduce the dependency on imports and secure supplies from abroad in the long term. The scientists' suggestions range from recycling to mining in Europe and creation of an international raw materials policy. Other possible measures include greater raw material efficiency and greater knowledge transfer.

"While a lot of impetus has already been provided by research, responsibility for securing the raw materials supply should also be assumed at the political level," argues the geoscientist. "I am happy to make my expertise available for such an effort."



▮ Jens Gutzmer is Founding Director of the Helmholtz Institute Freiberg for Resource Technology (HIF) at the HZDR and Professor and Head of the Economic Geology and Petrology group at the TU Bergakademie Freiberg. As a Member of the steering committee of the European Rare Earths Competency Network (ERECON) and the German National Academy of Science and Engineering (acatech), he makes recommendations for an active raw materials policy. ▮



Company

FOUNDATIONS



To allow their ideas to play a role in the economy, researchers sometimes become entrepreneurs. The HZDR provides its scientists with wide-ranging support for their spin-off projects. In addition to creating its subsidiary for technology transfer, HZDR Innovation GmbH, it has also created a series of successful spin-offs.



A textbook spin-off

With its HZDR Innovation GmbH subsidiary, the Research Center is forging new paths in technology transfer.

The HZDR commands unique expertise and infrastructure in many areas. With the aim of making more effective use of the associated potential and of increasing its transfer to the economy and society, it established HZDR Innovation GmbH in 2011. As a spin-off of the HZDR, the company fulfils orders for products and services from industry and in this way contributes to better deployment of the HZDR's large-scale research equipment. HZDR Innovation also supports the transfer of research findings and their transformation into products in many different ways. Its profits are invested in technology transfer or are ploughed back into research.

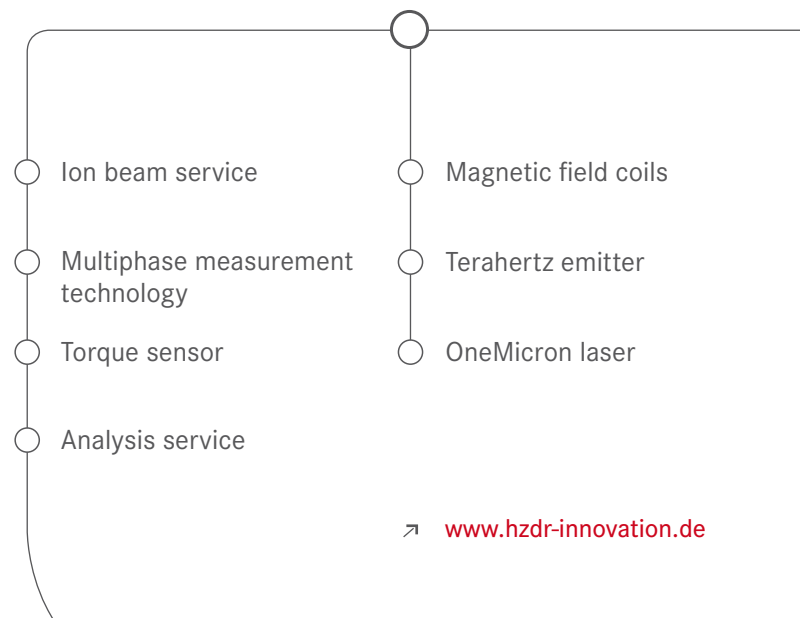
“Our main business areas are the ion beam service and wafer processing. We rent out the modern technology and ion beams available in the Ion Beam Center,” explains Professor Andreas Kolitsch, CEO of HZDR Innovation GmbH. “For example, we can make power semiconductors more efficient through high-energy ion implantation.” Customers from the semiconductor sector, in particular, rely on this technology to reduce the power loss from their components. This saves energy, thereby contributing to climate protection. The process is also of interest in the context of e-mobility, as reducing the energy consumed by components makes it possible to increase vehicle range.

Due to the access it can offer to unique infrastructure, HZDR Innovation is a sought-after partner for industry, at the international level too. Many customer requests come from



overseas as comparable technology is not available for industrial use, even in the USA. Around one quarter of the beam time in the Ion Beam Center is now taken up by industrial orders. But research always takes priority,” as Kolitsch emphasizes. “Sometimes we can only meet the demand for beam time by working in three shifts. This clearly increases the efficiency of the HZDR's expensive infrastructure considerably.” And the demand is increasing – thanks to e-mobility too.

BUSINESS AREAS



▮ Wafer processing in the HZDR
Ion Beam Center ▮



Making patents into products

As a technology transfer subsidiary, HZDR Innovation GmbH does not just provide ion implantations. It also takes care of the production and marketing of inventions and supports researchers in the establishment of their own spin-offs. CEO Professor Andreas Kolitsch describes how the HZDR's research findings make their way to the market and how scientists become entrepreneurs. He draws on detailed knowledge of this area, as he worked as a scientist at the HZDR for 40 years.



Mr. Kolitsch, what appeals to you particularly about these tasks?

I enjoy seeing research results not only in publications but also in the form of products I can hold in my hands. Even when I was working as a scientist, it appealed to me to be able to bring new developments to the application stage. I acquired a lot of industry contacts and experience from this which I can now take advantage of for my current job.

Which products does the company offer?

For example, we produce and market measurement technology for multiphase flows, a special torque sensor, and a terahertz emitter – all patented developments from the HZDR. Our main product at the moment is a wire-mesh sensor for the measurement of flow profiles. We also supply needle sensors, an ultrasound waveguide, and other measurement technology. Separate spin-offs were established for other innovative technologies developed at the HZDR.

▮ Andreas Kolitsch,
CEO HZDR Innovation GmbH ▮

How do research findings become new products?

It's a long process. When a research team has a pioneering idea, it must first and foremost be protected by patent. The Technology Transfer and Legal Affairs Department at the HZDR is the first port of call here. The respective innovation manager advises the inventors and explains the environment. Our role is to evaluate the research results and analyze their possibilities for practical application. If we can identify market opportunity, we take charge of the further development and adaptation of product. As soon as it is ready for application, we decide whether we will manufacture it ourselves, whether we will license it to another company, or transfer it to a spin-off. This all involves close collaboration between the scientist, the Technology Transfer department, and our company. Spin-offs, in particular, also receive support from external service providers like "Dresden exists".

What about the inventors – what is their role in the process?

Needless to say, they are at the center of it all, particularly when it comes to product development and application strategies. Nobody is forced to establish a spin-off. Some scientists prefer to continue working in research rather than take a risk on a commercial venture. In this case, we at HZDR Innovation GmbH can place the product on the market. We have developed flexible models for this with the HZDR, ranging from secondary employment and part-time work with us to permanent positions. If the start phase is successful, the participants can still opt to establish a spin-off.

Do you also help with spin-offs?

If we think it makes sense, we may become involved in a new spin-off as a holding company. We also provide financial support by investing our profits from other areas or applying for funding, for example from the Helmholtz Association's Helmholtz Enterprise Fund (HEF).

Help is often needed with regard to business management and price negotiations. Some young entrepreneurs have to learn that the crucial factor in terms of the price of an innovative product is not the manufacturing costs but the added value it offers to the customer. As soon as the start-up is on solid ground, we withdraw from the process.

Do many promising inventions with a potential for application arrive on your desk?

There are one to two key concepts per year that we see as having a chance on the market. Out of these, five spin-off projects have emerged thus far, and the same number of technology areas which we market through the company. Other research institutes are also interested in our model. There have even been requests for us to market a product for such external partners through HZDR Innovation GmbH. This would be possible as we are very flexible as a company.

Spin-offs established with the help of HZDR Innovation GmbH

- | | |
|--------------------------|--|
| ■ Biconex GmbH | www.biconex.de |
| ■ i3 Membrane GmbH | www.i3membrane.de |
| ■ THATec Innovation GmbH | www.thatec-innovation.de |
| ■ ERZLABOR Services GmbH | www.erzlabor.com |

HZDR Innovation GmbH itself was established by the HZDR and the technology transfer company GWT-TUD GmbH in 2011.

➔ www.hzdr-innovation.de

Intelligent chemistry for surface finishing

Researchers from the HZDR established the company Biconex GmbH based on an idea for environmentally-friendly electroplating technology.



Underneath many of the shiny metallic surfaces found in cars and bathrooms lie plastic components which are finished with a layer of chrome. To ensure that the metallic layer remains firmly in place, the surface structure of the plastic must be roughened. Up to now, chromosulfuric acid, an extremely toxic chemical which is harmful to health and the environment, was used by industry for this purpose. A new electroplating technology developed at the HZDR achieves the same effect without any need for the harmful acid.

With the aim of launching this technology as an industry-ready process, in mid-2015, scientists from the HZDR and HZDR Innovation GmbH (HZDRI) established the company Biconex GmbH. Just a few months later, the start-up found an investor in Ceterum-Holding, which took over the HZDRI's shares and provided more than one million euros in finance.

Companies operating in the electroplating sector, for example in the finishing of car parts and bathroom fittings, are set to benefit as soon as the technology is ready for serial production. The Biconex process offers an alternative to chromosulfuric acid, the main component of which Cr(VI) is subject to use restrictions in the EU from September 2017. Conversion to the environmentally-friendly process is easy, as it can be seamlessly integrated into existing processes. Users will also make energy savings thanks to lower processing temperatures.

“We believe that Biconex’s development is an outstanding technology which has excellent market prospects. It solves the long-standing problem of plastic-electroplating.”
Constantin zu Wittgenstein, Ceterum-Holding GmbH

Functional surfaces

While Biconex aims to establish cooperation with industry in the area of decorative plastic electroplating, it also produces smaller product series for niche applications at the request of customers. The main emphasis is not the shiny appearance but a particular, special function. For example, plastic housings for electronics need functional surfaces to shield the electromagnetic radiation.

“Brilliant ideas alone are not enough, however. Application will only succeed if the inventors themselves are completely behind it,” as Biconex CEO Dr. Jürgen Hofinger points out. “Fortunately, this works very well for us – particularly in cooperation with the HZDR.”

▮ Biconex CEO Jürgen Hofinger (second from the right) and co-owner Tobias Günther (right) with research colleagues at the HZDR. ▮



➤ www.biconex.de

Digitalization of separation technology

The company i3 Membrane GmbH aims to revolutionize filter technology using multifunctional membranes. The idea and spin-off are the product of the cooperation with HZDR Innovation GmbH.

Whether deployed for applications in medical technology, industry, or water treatment – i3 Membrane's innovative membrane technology succeeds in making biological processes simpler and more effective. "Our separation technology consists of the application of ultrathin metallic layers on standard commercial polymer membranes," explains CEO Dr. Stephan Brinke-Seiferth. "While the traditional membranes available thus far have filtered particles and biological substances on a purely mechanical basis, our invention offers additional separation features by means of digital control. It also catches the 10 to 100 times smaller viruses and cytotoxins."

Biologically active compounds like proteins, viruses, and DNA usually have an electric charge. If the metallic membrane has the opposite charge, substances adhere to it. This process, which was previously only possible using permanently installed charge carriers on membranes, can now be regulated digitally by computer. All it takes to release the substances again is to toggle the voltage. In addition to electrical conductivity, the high-tech membranes are also chemically resistant, flexible and very durable.

Combining different areas of knowledge

The controllable technology is based on a combination of membrane and ion technology. Stephan Brinke-Seiferth and Professor Andreas Kolitsch from HZDR Innovation GmbH (HZDRI) came up with the idea. They then established the company i3 Membrane GmbH in 2013 with the participation of HZDRI. An ion-based process developed by HZDR researchers with which pores can be generated in metal foils, made an important contribution to the development of the technology.

The company launched its first product in 2016 – a particularly compact sterile filter with a titanium-coated membrane, which protects hospital patients against pathogens in tap water. Other products followed, and just one year later the company is about to break even. The development of applications for digital bioseparation is now progressing full steam ahead. "What is involved here is not an individual product but a platform technology for many areas of application," reports Brinke-Seiferth. "For this reason we are collaborating on five simultaneous research projects with different partners."

The company has also succeeded in attracting four investors. High-Tech Gründerfonds from Bonn, Innovationsstarter Fonds from Hamburg, Mittelständische Beteiligungsgesellschaft Sachsen mbH from Dresden and a private investor from the USA are providing a seven-figure euro sum to finance the further growth of the company.



➤ www.i3membrane.de

▮ Material surfaces with nanopores are produced at the HZDR by way of a special plasma process. ▮



Products already launched by i3 Membrane GmbH

- Sterile filters and accessories for the medical sector
- Aluminum oxide membrane for the preparation of analytical samples
- Gold-coated polycarbonate membrane and accessories for environmental analytics

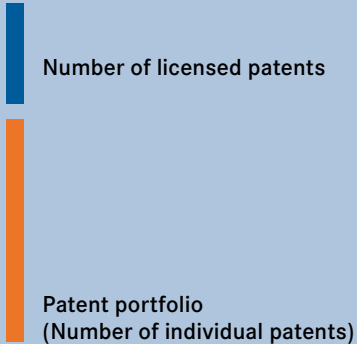
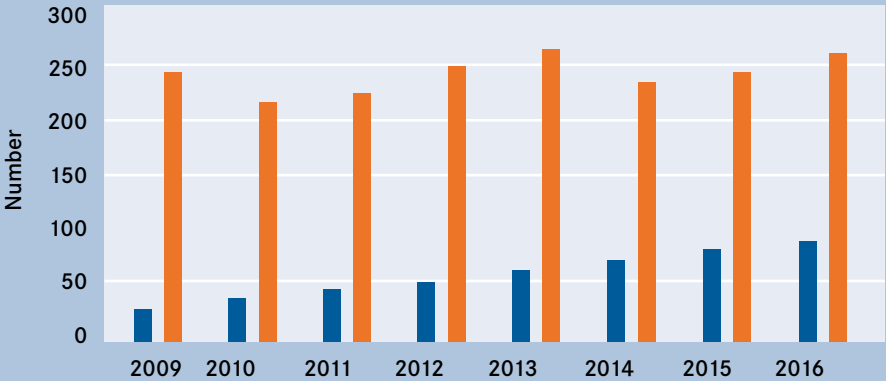
Key performance indicators



New license agreements with business sector per year

2017	Erzlabor Services GmbH
2016	Thatec Innovation GmbH
2015	Biconex GmbH
2013	i3 Membrane GmbH
2011	Saxray GmbH
2011	HZDR Innovation GmbH
2009	Nanoscopix GmbH

Spin-offs

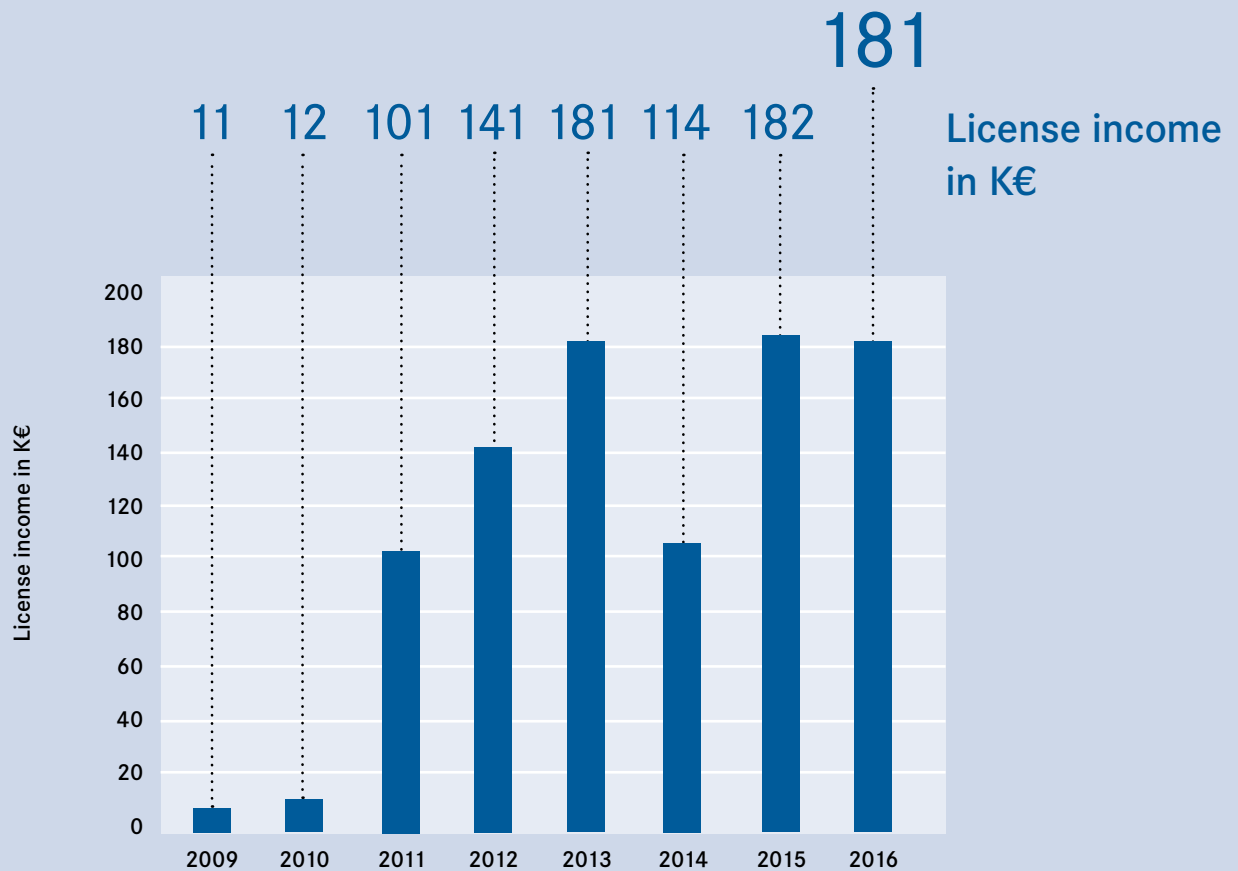


~ 1.4 million €

HZDR
Income from industry 2016 *

~ 2 million €

HZDR Innovation GmbH
Revenue 2016



*Income from contracts / commissions / use of infrastructure by private sector concerns

A strong team: the Technology Transfer and Legal Affairs Department

Do you have any questions about technology transfer, possible cooperation with the HZDR, or particular projects?

Do not hesitate to contact us. ➔ www.hzdr.de/technologytransfer

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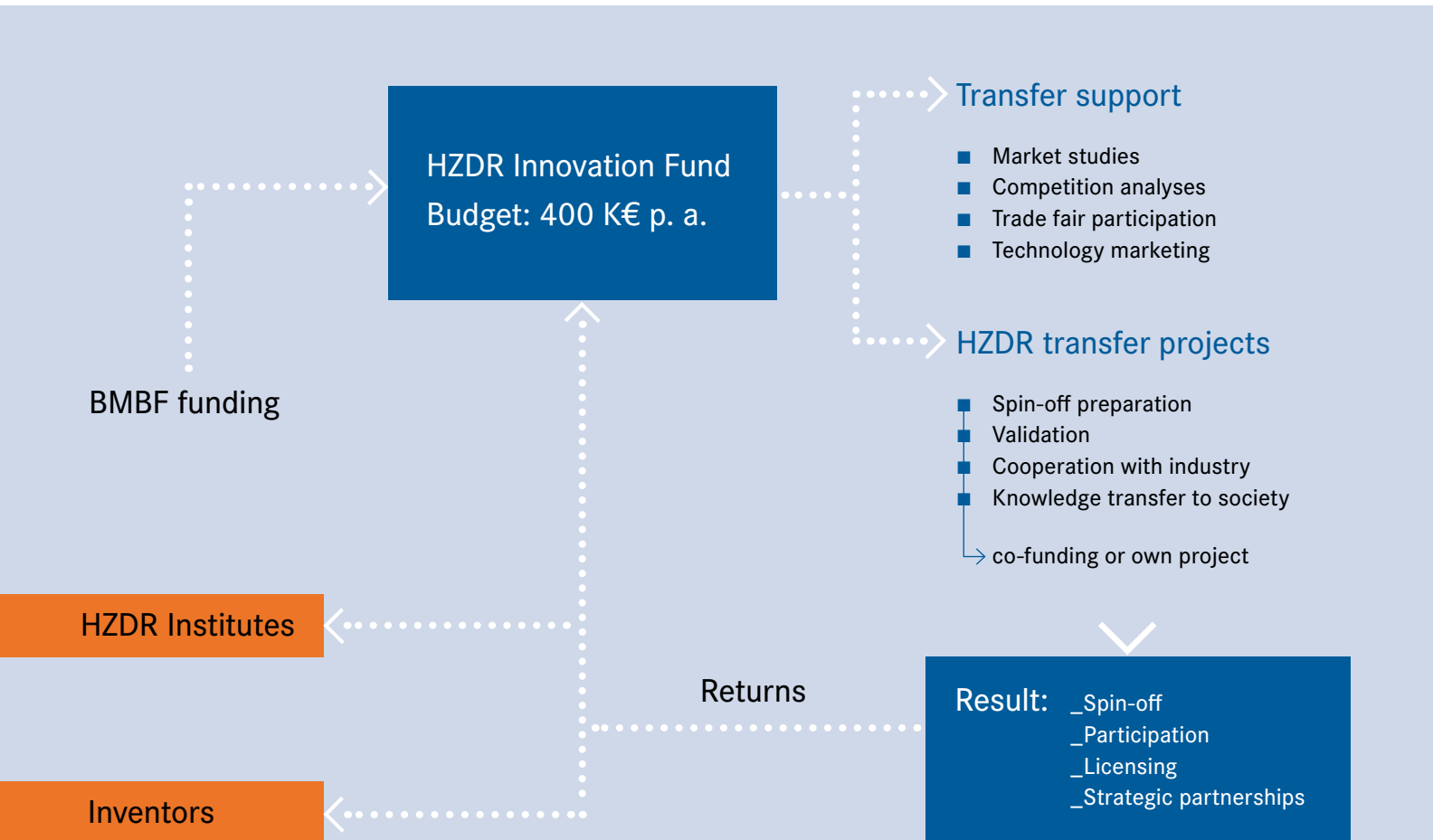
Legal issues and contracts

Martina Moravcikova, Merit Grzeganeck, Karina Sattler

HZDR Innovation Fund

The HZDR established the HZDR Innovation Fund in 2016 based on the model of other Helmholtz centers. The purpose of the internal fund – which is financed by the Federal Ministry of Education and Research (BMBF) and the HZDR itself – is to provide support for validation and spin-off projects. Its annual allocation is EUR 400,000. This is mainly used to finance HZDR

contributions to other public funding programs. The selection criteria and fund management processes are defined by an internal funding directive. The fund should mainly refinance itself in the medium term through revenues from successful transfer projects, i.e. license income and participation profits.



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