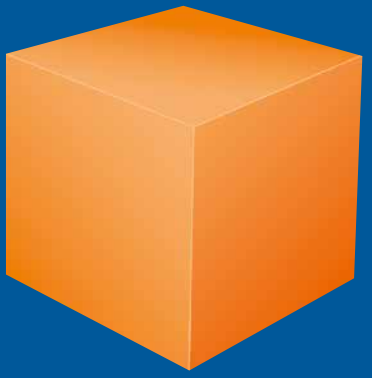


HZDR

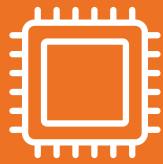
HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF


JOURNEY TO
THE HEART OF
KNOWLEDGE

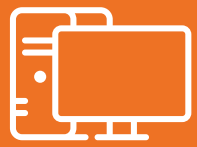
HZDR

HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF

On the basis of our acquired knowledge, we generate solutions and products:



Low-energy-consumption microchips for electronic devices



Novel computer concepts based on quantum materials and nanotechnology

Radioactive drugs for cancer diagnosis and therapy

Robust sensors for demanding environments

Plastic coating and processing procedures

Biotechnological methods for recycling high-tech metals

Non-invasive exploration methods for the mining sector

Battery systems as buffer storage for “green” energy

Intelligent measurement technologies for energy-efficient metal casting and chemical process engineering

THE HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF

Five questions to the Board of Directors, Prof. Sebastian M. Schmidt and Dr. Diana Stiller

In a nutshell: what does HZDR actually do?

A comparison with an exploratory expedition describes our work pretty well, focusing as it does on a definite goal that we strive for through our application-oriented basic research. We may slip up on the way, a team might get bogged down and have to go back to the beginning and start again. All in all, the crew is the most important success factor for our voyage of discovery in space and time. It only all works if we cooperate – with trust and respect in international teams.

The crew comprises our own research groups as well as our collaborative partners and, of course, the entire team without whom a huge center like HZDR couldn't function – the beamline scientists, for example, who keep our large-scale equipment running, the technical colleagues, the administrative and infrastructure departments, the support staff and IT departments. They all play a role in our repeated success at transferring research insights to business and society.

What major future issues does the research center address?

We are convinced that by uncovering fundamental phenomena we can find answers and solutions that will make life easier and better for us and our descendants. Without research that investigates substances in the tiniest possible dimensions there would be no future materials for the next generation of computers or the energy and climate transition. Today, across the world, our umpteen electronic devices use vast amounts of power. In industry, for example in the production of basic chemicals, many processes have not yet been understood well enough to launch the necessary energy-saving measures.

At the same time, our modern society is dependent on the available resources and raw materials. Here, we address the major issues of sustainability and circular economy. And our society is constantly aging. Many of us will suffer from cancer at some point. Only when we manage to understand the origins and spread of cancer cells in detail will medicine be able to fight the disease effectively. As a multi-program, large-scale research center, we tackle these complex topics from several perspectives, using complementary approaches – and we do so from the fundamentals through to technological and medical applications.

What distinguishes HZDR from other research institutions?

We focus on selected topics of major scientific and social relevance – programmatically, long-term and with perseverance. Our complex infrastructures are one of our hallmarks, such as our unique light and particle sources for research under extreme conditions. Or the labs in which we experiment with radioactive substances.

These exciting opportunities, together with our first-class scientists, attract research groups from around the globe, which means that we function in a highly connected way. To return to the idea of an expedition: Our research equipment is the gear for the journey, but we only reach our goal thanks to unique people and their unique abilities.

How important are collaborations for science?

Today, we are confronted with major issues of human life: energy, health, materials and technologies for coming generations. Since these issues are global, we need to create global teams with whom we can meet these challenges – either by recruiting the best researchers ourselves or by cooperating with them. Being connected to excellent institutions worldwide brings added value and saves resources. At the same time, we build bridges across national and ideological borders. That is why we at HZDR ascribe such great importance to the values of internationality and cosmopolitanism.

Where do we encounter HZDR research results in our everyday lives?

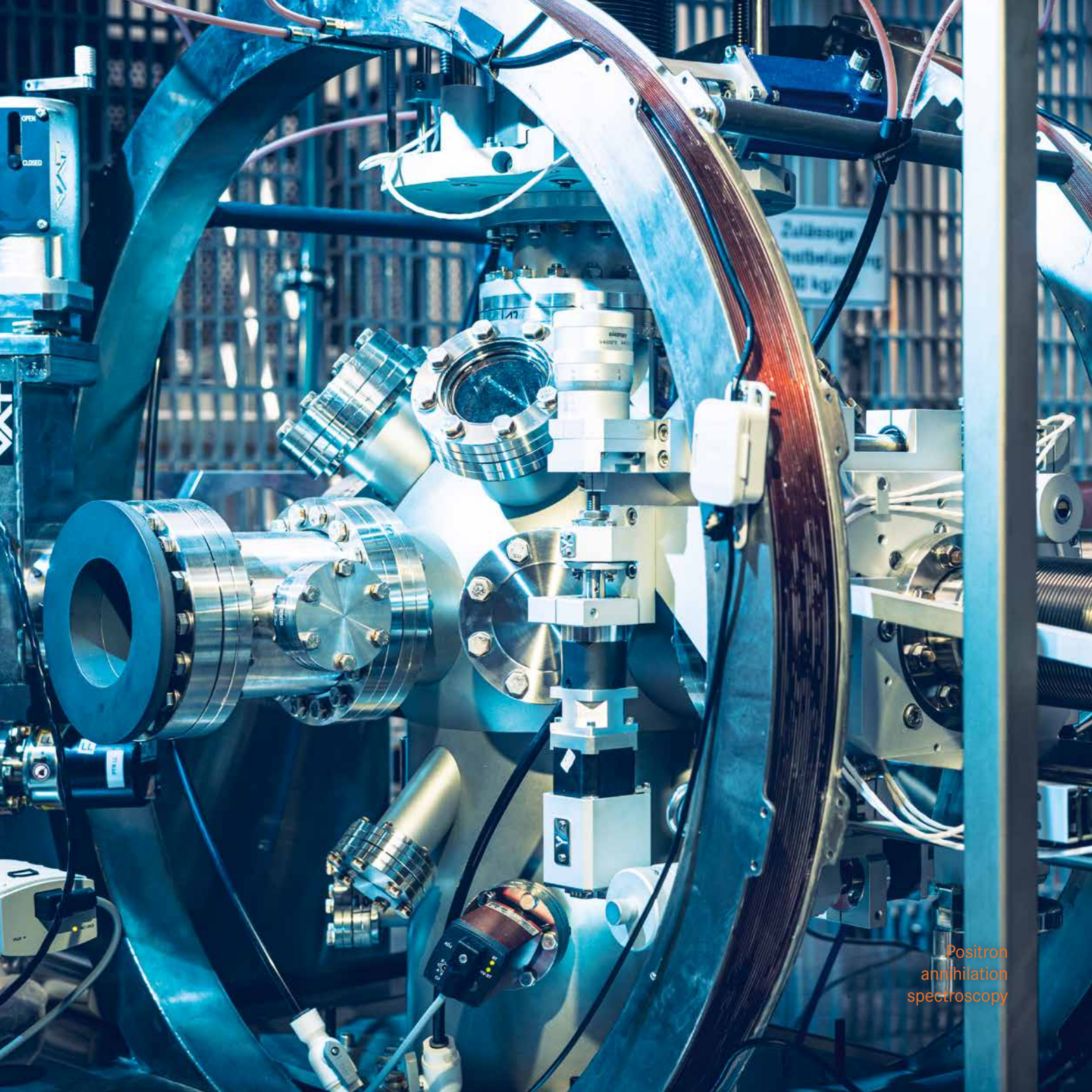
In hospitals, for example. We produce radioactive drugs for the precise diagnosis of cancer, and our knowhow also flows into high-precision proton irradiation. Or think of the many products we use in our daily lives. They all contain valuable minerals and high-tech metals. We make sure that scarce resources are used sustainably, whether they are recycled from scrap or extracted from the ground. And the people we train also ensure that there are improvements in our everyday lives. We empower all our undergraduates, doctoral candidates and trainees to draw up and implement potential solutions in science, business or society.

The crew is the most important success factor for our voyage of discovery in space and time.

Prof. Sebastian M. Schmidt,
Scientific Director

They all play a role in our repeated success at transferring research insights to business and society.

Dr. Diana Stiller,
Administrative Director



Positron
annihilation
spectroscopy

OUR MISSION

For future generations: a world worth living in

The Helmholtz-Zentrum Dresden-Rossendorf strives to find answers to the major challenges of our times. Our values encompass team spirit, respect and responsibility. As a member of the Helmholtz Association with excellent collaborative partners in science and business we help to future-proof Germany and Europe. Our approach: application-based fundamental research in matter, health and energy.

The precepts of our actions

HZDR explores **fundamental phenomena in nature**. Our unique large-scale equipment allows us insights into matter under extreme conditions. The knowledge we gain feeds directly into developing innovative materials and technologies.

HZDR plays a role in the **transformation of energy systems** and the economy into a green society – by providing key technologies for the energy transition, energy-optimized material flows in industry and sustainable resource technologies.

HZDR investigates the application of radiation to develop **novel diagnostic and therapeutic procedures** in the fight against the widespread disease, cancer. It thus contributes to the health of society – from the fundamentals in the natural sciences and life sciences through to utilization in medicine.

HZDR reinforces Saxony as an economic base in Germany by systematically connecting fundamental research, innovative strength, and transfer, thus ensuring **a fair standard of living** for this and future generations.

Three examples of what we can do

We search for viable concepts for the future of information technology.

In order to reduce the immense amounts of power used by modern electronics new solutions are called for. We study the properties of ultrathin nanomaterials and generate waves using the magnetic moment of electrons, spin. This enables us to transmit signals in electronic components superfast and with high energy efficiency.

We improve the treatment of cancers.

Radioactive drugs accumulate highly specifically and selectively in cancerous tissue. We explore radio-labelled substances for imaging procedures and radionuclide therapy. If substances have strong emission intensities, they can destroy the tumor and its metastases from within the body. Our aim is to achieve optimal diagnostics and therapy for every individual patient.

We drive research on batteries and hydrogen storage.

Power for the day and the night: based on liquid metals, we develop buffer storage for solar and wind power. With the combination of fundamental research, our own bespoke measurement technologies and near-reality experiments we increase the efficiency of electrolyzers, which are the basis for hydrogen as a future energy carrier.

Our mission
is knowledge,
our motivation
a passionate
investigative spirit.

The well-being of
humans and the
Earth as an intact
habitat is our
core concern.

Our guiding values

We are a large-scale research center encompassing a diversity of scientific topics and disciplines. That is our strength. The following common values and principles are a constant presence in fulfilling our mission:

Research focus and research infrastructure
We design, build and operate unique large-scale equipment for our own application-related fundamental research as well as for users from all over the world.

Interdisciplinarity
We connect our research activities and methods at HZDR.

Sense of responsibility
HZDR is committed to taking a responsible stance on the freedom of research and upholding the demand for transparency.

Recruitment and talent management
Cutting-edge research thrives on original ideas and brilliant minds. We thus recruit outstanding researchers worldwide. We recognize and promote our staff's diverse talents – at every phase of their careers.

Corporate culture
We are open to learning from one another and value team spirit and respect.

Collaborations
Both nationally and internationally we cooperate with excellent research institutions. Our most important strategic partners are universities.

Equal opportunities and diversity
Diversity is wealth. Teams that reflect the diversity of our staff offer differing perspectives and find solutions we can all support. We practice equal opportunities for all genders and foster a balance between work and family/private life.

Transfer
Based on our own understanding of our role, we share our knowledge with society and industry – for the benefit of all.

Yvonne Matthes, International Office

Chiamaka Belsonia Opara, PhD candidate

Dr. Thomas Herrmannsdörfer, physicist

Mike Höpfinger, head of the vehicle fleet

1,500
members of staff

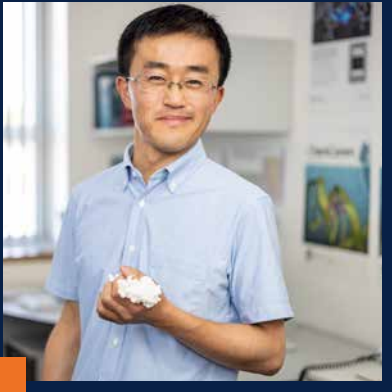
750
scientists

80
nations*

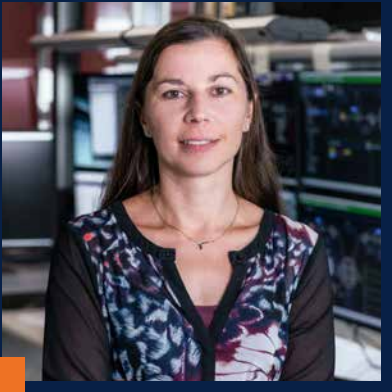
*all figures rounded

Dr. John Michael Klopf, beamline scientist

Mahnoor Tanveer, data scientist



Professor Satoru Tsushima, chemist



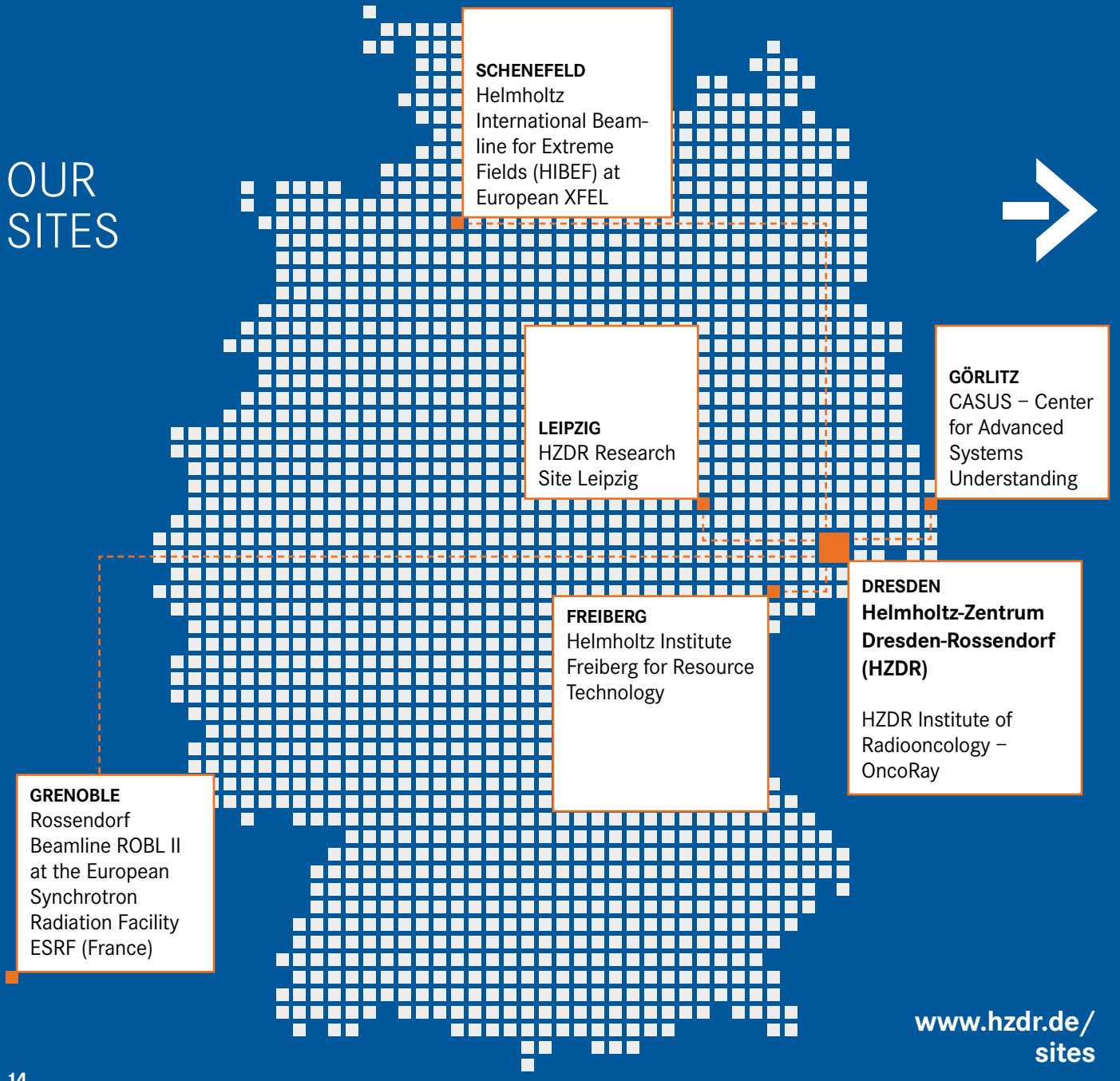
Nicole Wagner, engineer

OUR CREW

A focus on people

We promote excellence at all levels because scientific progress thrives on the engagement of all members of staff, irrespective of whether they work in research, administration or the technical field. We support academic and non-academic careers equally and provide quality-assured mentoring for both students and PhD candidates. It is our ambition to be one of the region's first-class vocational trainers.

OUR SITES



SCHENEFELD
Helmholtz International Beamline for Extreme Fields (HIBEF) at European XFEL

LEIPZIG
HZDR Research Site Leipzig

GÖRLITZ
CASUS – Center for Advanced Systems Understanding

DRESDEN
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

HZDR Institute of Radiooncology – OncoRay

FREIBERG
Helmholtz Institute Freiberg for Resource Technology

GRENOBLE
Rossendorf Beamline ROBL II at the European Synchrotron Radiation Facility ESRF (France)

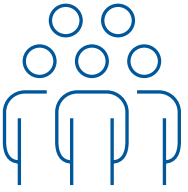
www.hzdr.de/sites

HZDR – A Place to Be

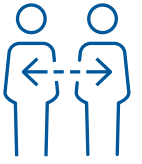
We practice a **culture of welcome** – every day at every site.

We organize and manage our six sites in the full spirit of **sustainability**.

In our teams and with our partners in science and business we cooperate in a **trusting, solution-oriented, targeted fashion**.



We foster a respectful **culture of debate and leadership** – characterized by a constructive attitude to errors and conflicts.



We create a **motivating working environment** that opens up space for creativity and active participation.

We offer attractive working conditions so that everyone can exploit their **scientific and personal potential** to the full.

Success is based on cooperation

In these times of upheaval and crisis people have great expectations of science. As a member of the Helmholtz Association, HZDR embraces its responsibility to society – from the energy and climate transition via the fight against cancer through to concepts for novel light sources, as well as communication and storage technologies. We cooperate **nationally and internationally with very strong partners**. Universities play a key role in our collaborative strategy: with our thematic focus, unique infrastructures and an emphasis on long-term projects we are in an ideal position to complement the universities' expertise and capabilities in particular.

In Dresden, we engage with science, teaching and knowledge transfer as part of the **DRESDEN-concept** research alliance, a consortium of more than 30 scientific institutions and museums gathered around the excellence university, TU Dresden. We have a close network of collaboration in the border triangle between Poland, the Czech Republic and Germany in the orbit of our data science institute, CASUS – Center for Advanced Systems Understanding in Görlitz.

Germany, Europe and the world – HZDR operates globally. Together with the Weizmann Institute of Science in Israel, we foster the development of laser-driven particle accelerators at the **Helmholtz International Lab**. And in a lab operated jointly with Monash University in Australia we create therapies designed to allow more individualized and targeted treatment of the diseases afflicting affluent societies. Moreover, the further training program for users of the new synchrotron facility, **SESAME, in Jordan**, which is coordinated by HZDR, promotes both junior researchers and understanding between peoples.

Our network

CASUS – Center for Advanced Systems Understanding

- University of Wrocław (Poland)
- Helmholtz-Centre for Environmental Research – UFZ
- Technische Universität Dresden
- Max Planck Institute of Molecular Cell Biology and Genetics

Institute of Ion Beam Physics and Materials Research

- LEAPS – League of European Accelerator-based Photon Sources
- ARIE – Analytical Research Infrastructures in Europe

Institute of Fluid Dynamics

- Air Liquide Germany Ltd.
- Mahle Ltd.

Institute of Radiooncology – OncoRay

- National Center for Tumor Diseases NCT Dresden
- German Cancer Consortium DKTK

Institute Dresden High Magnetic Field Laboratory

- European Magnetic Field Laboratory EMFL
- TU Dresden / Universität Würzburg: Cluster of Excellence ct.qmat – Complexity and Topology in Quantum Matter

Institute of Radiopharmaceutical Cancer Research

- University Medicine Dresden: OncoRay – National Center for Radiation Research in Oncology
- Monash University (Australia)
- Deutsches Krebsforschungszentrum DKFZ
- Deutsche Gesellschaft für Nuklearmedizin (DGN)

Institute of Theoretical Physics

- Collaborative Research Centre 1242 Universität Duisburg-Essen Non-Equilibrium Dynamics of Condensed Matter in the Time Domain
- Quantum Simulator for Fundamental Physics – qSimFP

Helmholtz Institute Freiberg for Resource Technology HIF

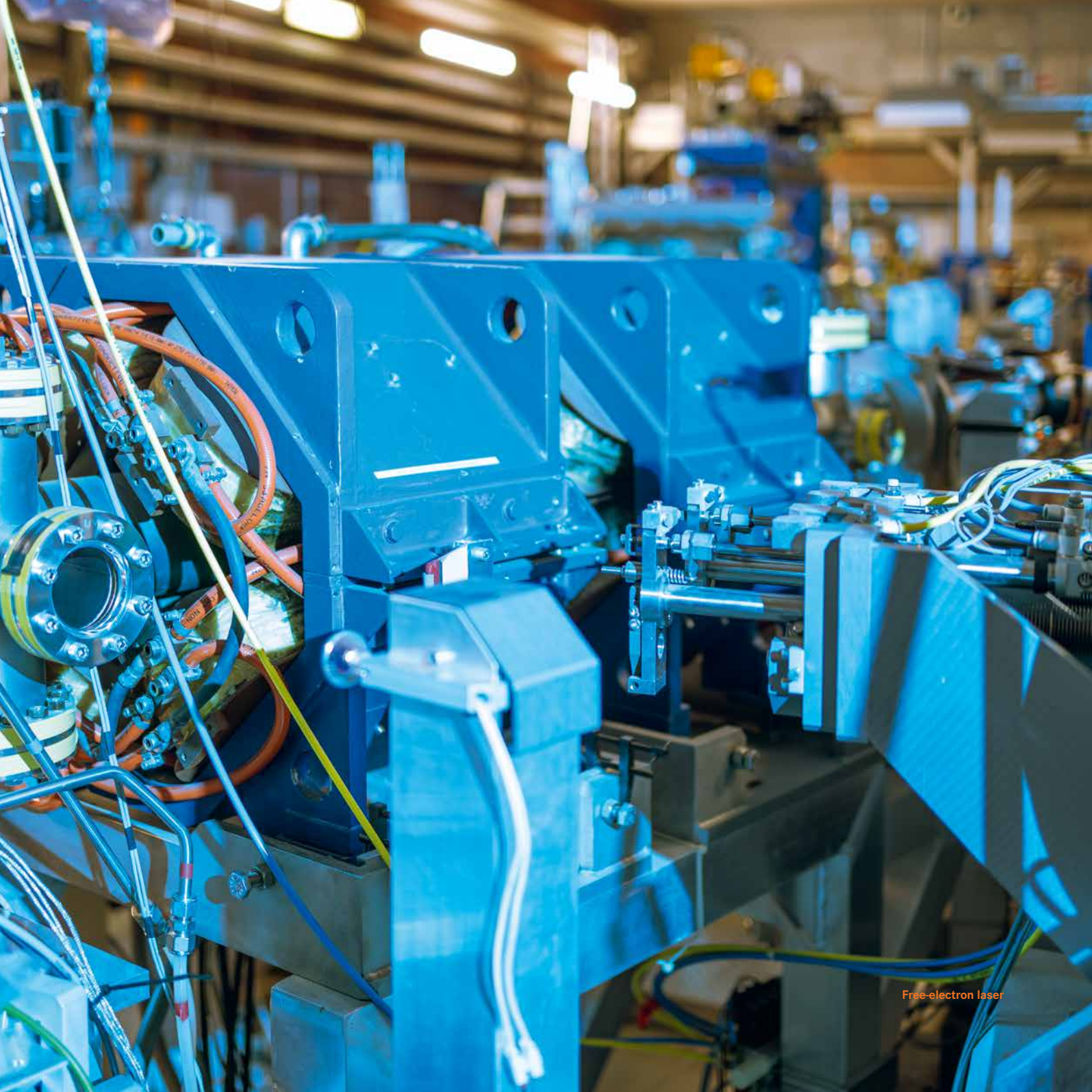
- EIT RawMaterials Ltd.
- CIMERA – DSI-NRF Centre of Excellence for Integrated Mineral and Energy Resource Analysis (South Africa)

Institute of Resource Ecology

- Rossendorf Beamline ROBL-II at European Synchrotron ESRF (France)
- German Working Group on Repository Research DAEF

Institute of Radiation Physics

- Helmholtz International Beamline for Extreme Fields at European XFEL
- Laserlab-Europe AISBL
- Extreme Light Infrastructure ELI



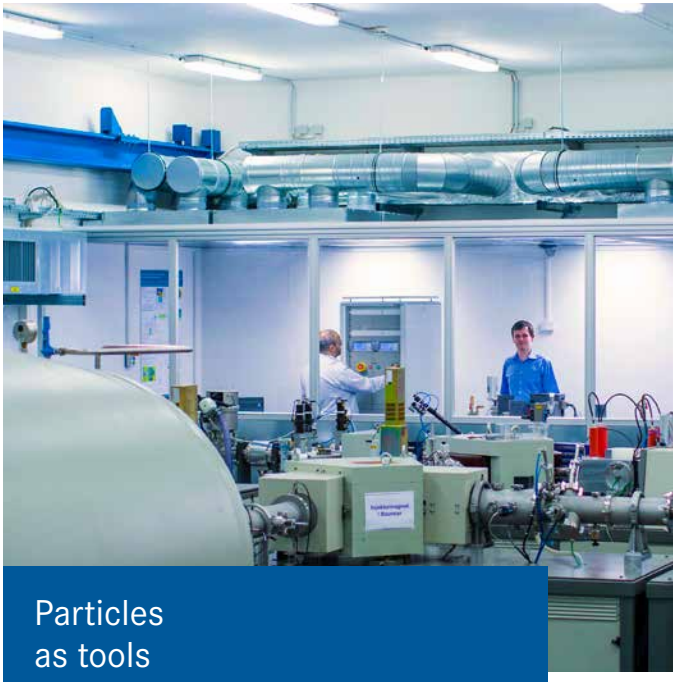
Free-electron laser

OUR EQUIPMENT

High-performance technology for the good of society

The strongest lasers, the accelerators, the high magnetic field laboratory. Our research machinery grants us insights into ultrafast processes – that are relevant, for example, for tomorrow's energy supply. They penetrate enigmatic matter or capture elementary processes in cells and molecules that may be linked to the development of diseases. HZDR's large-scale equipment provides unique experimental stations for inhouse and external scientists. We are responsible for operation, conception, setup and ongoing development.

Large-scale equipment drives progress

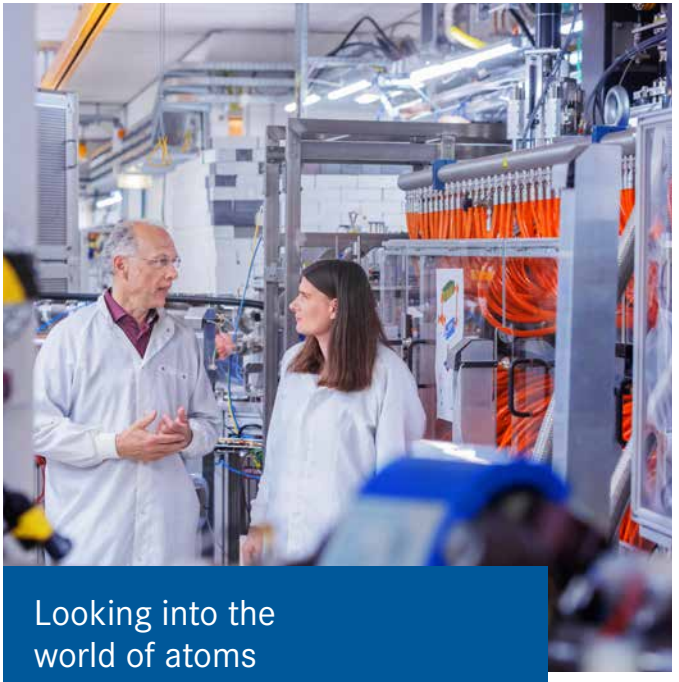


Particles as tools

The **Ion Beam Center (IBC)** is one of the highest-performance centers of its kind in Europe. With the help of ions, materials with clearly defined properties can be developed and analyzed. Our researchers focus on data storage and energy-efficient components for the information technology of tomorrow.

Combination of the extreme class

The **Helmholtz International Beamline for Extreme Fields (HIBEF)** holds the promise of new knowledge about stars, planets, special laser plasmas, quantum systems and future materials. It combines two high-performance lasers, high magnetic fields and a diamond anvil cell from the Helmholtz partner, DESY, with the world's largest X-ray laser, the European XFEL, in the Hamburg metropolitan area.



Looking into the world of atoms

The **ELBE Center for High-Power Radiation Sources** opens up a particularly broad research spectrum: The superconducting accelerator drives electrons which, in special arrangements, generate positrons, neutrons or light pulses in the infrared and terahertz range. With our two high-intensity lasers particles can also be accelerated highly efficiently.

Highest magnetic fields

Magnetic fields allow scientists to influence the properties of materials in a targeted and, above all, controlled fashion. The **Dresden High Magnetic Field Laboratory (HLD)** generates fields of up to 100 Tesla. The stronger the magnetic field, the greater the detail in which researchers can investigate and sequence modern classes of materials, such as semiconductors, superconductors and magnets.

From science to industry

To ensure that our ideas and research outcomes can be quickly implemented, we cooperate with **partners in industry and hospitals, license technologies and support HZDR spin-offs**. We pass on knowledge by providing scientific data, opening our research facilities to industry and advising decision-makers in business, politics and society. Basic results are also in demand: How precisely do natural radioactive materials proliferate in the environment? Our long-term research delivers answers that help to operate safe facilities in the mining of rare earths or in the geothermal sector.

In a public-private partnership with the firm ROTOP Pharmaka GmbH, we produce radiopharmaceutical products, and in three **Helmholtz Innovation Labs** we test technologies and fields of application in close cooperation with companies, building partnerships with a view to the long term.

Our transfer subsidiary, **HZDR Innovation GmbH**, closes the gap between research and industry. It drives future technologies to market maturity and offers bespoke products. We profitably implement the strengths of our large-scale equipment in commercial service contracts. Companies in the semiconductor sector use high-energy particles in the Ion Beam Center to refine components for power electronics. Demand is high. Since 2021, HZDR Innovation GmbH has been using a second plant for ion implantation at Trnava in Slovakia.

It’s our mission to transfer excellent research results to industry and create sustainable workplaces.

HZDR Innovation GmbH promotes and mentors scientists – from the initial idea through to the finished product, and in founding their own firms.

Dr. Björn Wolf
HZDR Chief Innovation and Transfer Officer
Managing Director, HZDR Innovation GmbH

OUR RESEARCH FIELDS

Venturing into undiscovered worlds

What are the smart materials and technologies that can help to preserve or improve the basis of our existence? How can we discover cancers even earlier and treat them more effectively? And how can we use raw materials safely, efficiently and sustainably? We work on solutions to these core questions in the three research fields: matter, health and energy.

Positron emission /
computed tomography

MATTER

Sequencing the structure and function of matter

High magnetic fields, strong laser pulses and intensive particle beams: scientists in our largest research area expose **matter to extreme conditions** and investigate it in detail.

The instruments and equipment required for this process constitute a research focus of their own:

- construction and operation of complex large-scale facilities
- development of new particle accelerators to elucidate core issues in the natural sciences and life sciences

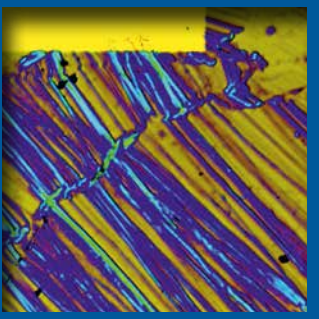
In internationally competitive first-class laboratories, employing a **diversity of scientific methods**, we discover the enormous potential of matter and translate our findings into new materials for information and communication technologies as well as for tomorrow's energy systems.

Data Science

In our digitalized age, research faces the challenge of evaluating ever larger volumes of data across topics in order to derive comprehensive approaches to finding solutions. From individual algorithms to complete software packages, from browser apps to applications for high-performance computers: the Polish-German research center **CASUS – Center for Advanced Systems Understanding** pursues the vision of achieving a better understanding of the complex phenomena in our environment using new digital methods.

As an HZDR institute, CASUS epitomizes our understanding of our role: we explore fundamental phenomena in an interdisciplinary, future-orientated and application-related fashion.

Basic research into matter and biological systems



Small, smaller, nano

Extreme pressures, temperatures and fields

Many of the technologies we take for granted today are the result of fundamental insights into the properties of the matter that surrounds us. Experiments on large-scale machines allow us to **investigate and understand substances on ultrafine scales under controlled conditions** – an essential precondition for designing new materials with tailored properties.

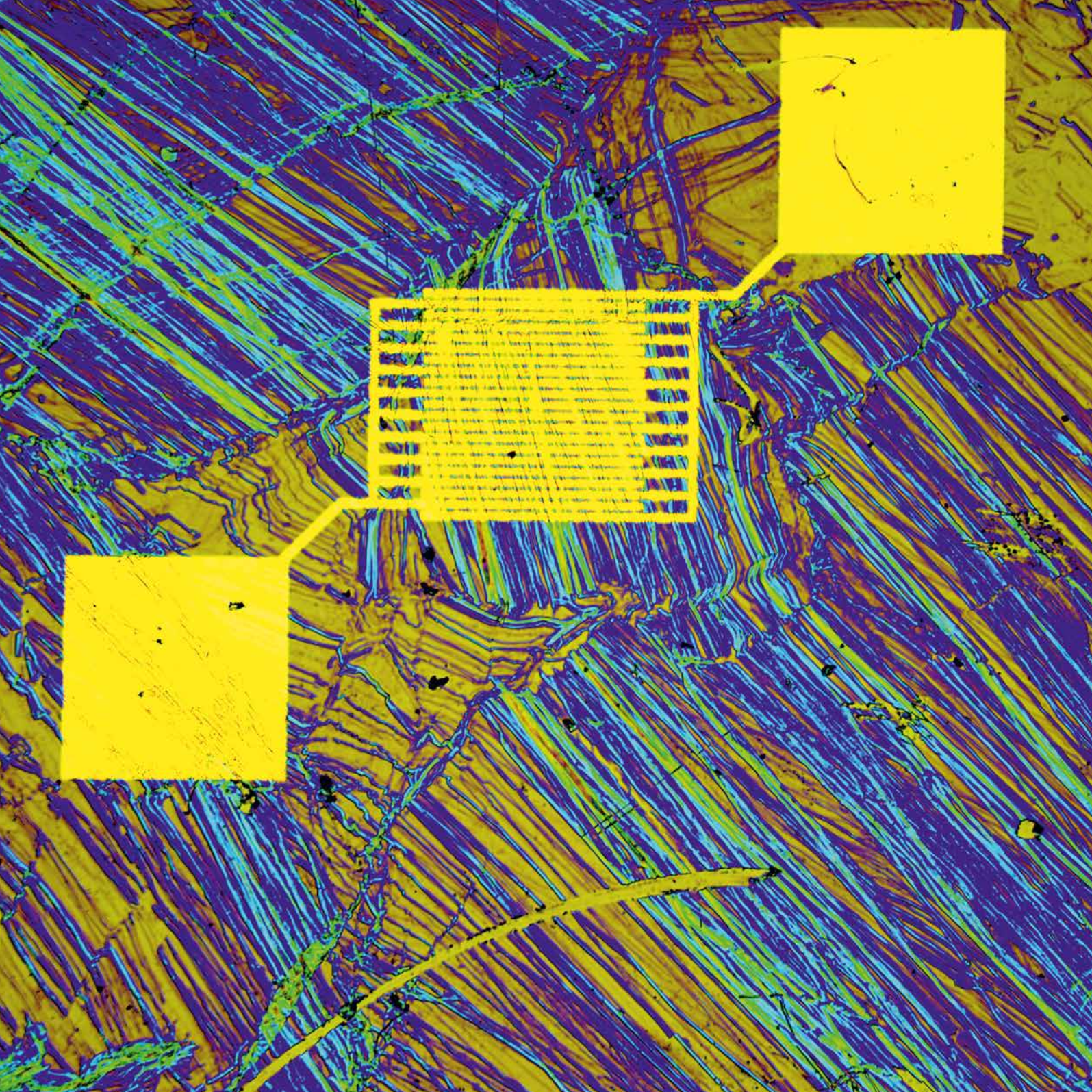
From quantum physics to quantum technologies

At and below the level of atoms, so-called quantum phenomena occur. Our scientists explore how the special properties of quantum materials are formed and how they can utilize them for innovative technologies in the **computing and energy sectors**. While activities in our High Magnetic Field Laboratory focus on basic research into novel materials, work at the Ion Beam Center concentrates on applications in sensor and information technology.

Setting the rhythm with terahertz pulses

Optimizing material properties, answering fundamental questions in biology and controlling chemical reactions – the future project **DALI – Dresden Advanced Light Infrastructure** will facilitate unique experiments in many disciplines. Its distinctive feature will be a variety of specialized terahertz labs with high-intensity, superfast laser pulses located between the wavelengths of microwaves and infrared light.

→
Nanowires in semiconductor research



HEALTH

Research for healing

How can we better recognize the major widespread diseases and treat them effectively? This is the challenge addressed by Health in the Helmholtz Association. HZDR has dedicated itself to the fight against cancer. We investigate the use of radiation to **diagnose cancers better and treat them effectively**. Our main concern is to quickly implement results for the benefit of patients.

Precise tumor irradiation in Dresden

Using protons to irradiate cancer cells is still a fairly recent method of treatment. The charged particles are highly effective and spare the healthy body tissue at the same time. However, this form of therapy cannot respond precisely enough to movement or anatomical changes. In the future project, **ProtonTherapy2030**, our aim is to create a completely automated, artificial intelligence-supported feedback circuit which will enable us to continuously monitor irradiation in real time and adjust the proton beam quickly and safely.

Drugs in a twin pack

At the Center for Radiopharmaceutical Tumor Research, we work on **radioactive drugs**. We envision a diagnostic radionuclide that delivers precise information about the irradiation dose for each individual patient; subsequently, a chemically identical substance destroys the cancer cells locally in the body with a therapeutic radionuclide. We can manufacture these theranostic drugs in accordance with the high requirements for pharmaceutical preparations which speeds up the transition to clinical practice.

New strategies for cancer treatment

Unity is strength against cancer

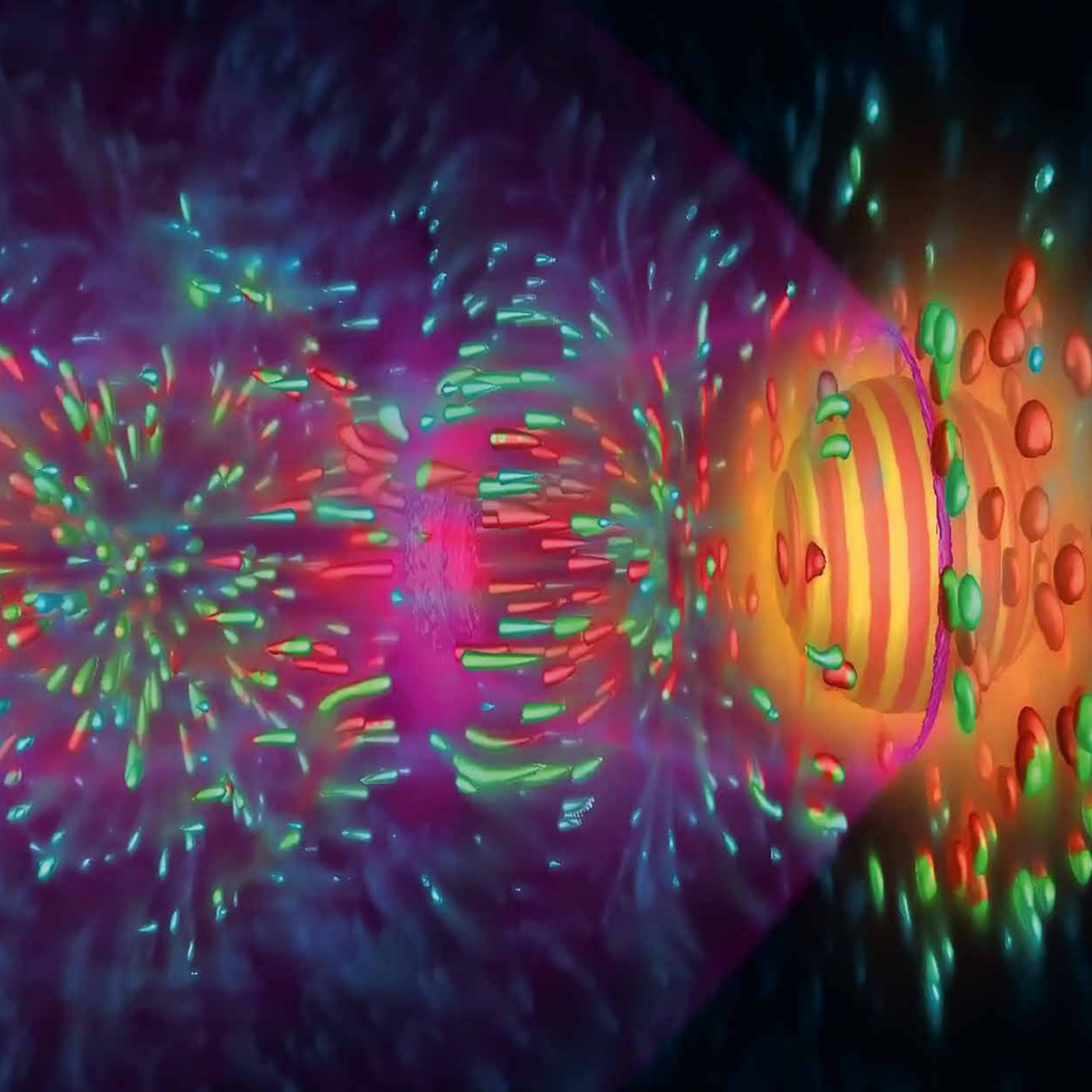
Together with the Medical Faculty at TU Dresden, we have established **OncoRay**, the National Center for Radiation Research in Oncology, a unique research platform on the site of the University Hospital. Our experts in physics, biology, chemistry, radiopharmacy and informatics benefit enormously from direct contact with experienced doctors.

In the immediate vicinity is the **National Center for Tumor Diseases (NCT) Dresden** in which we are also a stakeholder – together with the University Hospital and TU Dresden as well as our Helmholtz partner, the German Cancer Research Center (DKFZ) in Heidelberg. Dresden is thus one of the few university locations in Europe where research and the treatment of patients are conducted under one roof.

Working towards a superlaser

High-performance lasers like HZDR's **DRACO** and **PENELOPE** accelerate electrons and protons extremely efficiently and over very short distances. With improved beam quality they could advance to become the next generation of compact proton therapy accelerators.

Real-time simulation: laser-accelerated particles



ENERGY

Fashioning tomorrow's energy systems

HZDR develops key technologies for the energy transition. We help industry to **save energy and resources**. Our scientists work on methods and strategies for efficiently extracting important high-tech metals from all available sources. And they focus on protecting people and the environment from the hazards of harmful substances released when producing energy and extracting raw materials.

Efficient batteries and secure hydrogen production

The transition to sustainable energy systems involves enormous technological challenges. Our research targets high-performance, **low-cost hydrogen technologies** as well as **safe electrochemical storage** to ensure that sufficient "green" energy is available at all times. In close cooperation with partners in science and business

- we work on new materials for batteries
- explore liquid metal batteries that can store large volumes of energy at low cost
- improve the efficiency of hydrogen technologies
- develop new methods of hydrogen electrolysis

Sustainable solutions for power and raw materials supply

Using power and resources efficiently

Saving energy is more important today than ever. Dormant potential is to be found, for example, in the metal processing and chemical industries. We develop appropriate measurement technologies and optimization strategies for **hot metal smelting and complex mixtures** of substances in non-transparent pipes. But the success of the energy transition also depends on a well-functioning circular economy for recovering raw materials. In this field we focus on **sustainable exploration and processing methods** as well as on creating material cycles for mineral and metalliferous raw materials.

Ecologically sound waste management

Highly radioactive waste needs to be stored in the ground for a million years. What chemical bonds do plutonium, neptunium or americium form? How do the species react with technical barriers, the host rock or the biosphere? And how precisely do they proliferate? With a wide-ranging portfolio and internationally recognized expertise, our researchers are playing a significant role in choosing the site for the German repository. They also elucidate the **environmental behavior of radioactive substances** from the mining and geothermal sectors.

Pilot plant for raw materials processing

The challenge to be tackled by our future project FlexiPlant is enormous because nowadays our high-tech products such as electronic devices and vehicles contain nearly all the elements in the periodic table. The FlexiPlant at our Helmholtz Institute Freiberg for Resource Technology will **support the digital transformation of the raw materials industry** and help to drastically reduce our carbon footprint by employing selective, efficient mechanical processing and sorting of complex raw material flows.

→ Resource exploration by satellite using hyperspectral sensors

OUR VISION

For the health of everyone and a life-friendly Earth

We stride forward with a passion for knowledge and a compass that is clearly set to the major challenges facing humankind. Our dedicated crew strives to improve methods for treating serious diseases. They investigate and develop materials and technologies for the future. And they contribute their insights into resource- and energy-efficient processes to the energy transition through to climate neutrality. HZDR is a thought-leader, pioneer and creator. We are researchers for life.

Precession dynamo
under construction

Join our team!

We are looking forward to welcoming new crew members in all research areas and departments. Every day, **just under 1,500 employees from some 80 countries** devote their energies to meeting the major societal challenges of our time. Be on board when we write history and help us shape tomorrow's world together.

Have we sparked your interest?

Use the QR code on the back of this brochure to access a short videoclip and let us take you on an exciting journey to the heart of knowledge.

HZDR

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DRESDEN ROSSENDORF

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