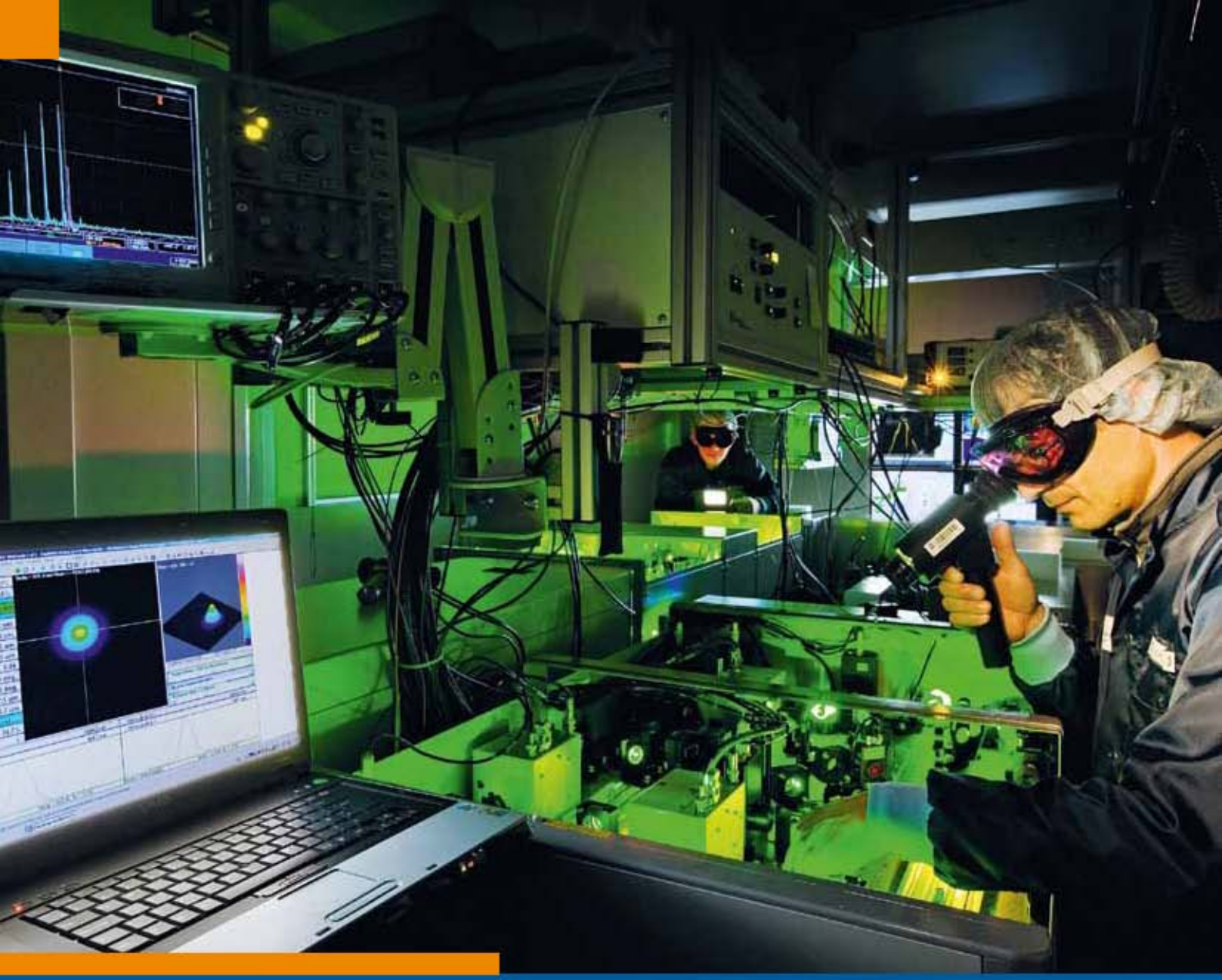


HIGHLIGHTS
2010

HZDR

HELMHOLTZ
ZENTRUM DRESDEN
ROSSENDORF

CONTENTS

HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF

OVERVIEW

NAME	Helmholtz-Zentrum Dresden-Rossendorf e. V. (Until Dec. 31, 2010: Forschungszentrum Dresden-Rossendorf e. V. / FZD)
FINANCING (As of Jan. 1, 2011)	Federal Ministry of Education and Research (90 %) Free State of Saxony (10 %)
Basic Funding	66.5 Million euros
Third Party Funding	18.4 Million euros
EMPLOYEES	Approx. 800
Proportion of Doctoral Candidates	121
PUBLICATIONS	
ISI Cited	449
Other Peer Reviewed Publications	38
PATENTS GRANTED	12
Updated:	December 31, 2010

DRESDEN
Headquarters
Bautzner Landstrasse 400
01328 Dresden, Germany

LEIPZIG
Research Site
Interdisciplinary Isotope Research
Permoserstrasse 15
04318 Leipzig, Germany

FREIBERG
Cooperation between the HZDR (ROBL) and the TU Bergakademie Freiberg for the joint establishment and operation of a national Institute for Resource Technology

GRENOBLE
Operation of the Rossendorf Beamline at the European Synchrotron Radiation Facility (ESRF)
Secteur 21
Polygone Scientifique Louis Néel
6, rue Jules Horowitz
F-38000 Grenoble, France

PREFACE BY THE BOARD OF DIRECTORS

INVESTMENTS INTO THE FUTURE

Those who visit the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) might be surprised by the many construction sites which currently dominate its appearance. Last year, for example, we commenced with the implementation of our projects for the future – that's what we call the expansion and new construction of large scientific facilities which will be a focal point of the HZDR's strategic development (please see page 19 for more details). These projects for the future are generously subsidized by the Free State of Saxony and accompany our joining the Helmholtz Association of German Research Centres. Thanks to the beneficial cooperation with partners from the Federal Government, the Free State as well as the Leibniz and Helmholtz Associations, we finally succeeded in becoming a new member of the Helmholtz Association on January 1, 2011. Considering the large number of cooperations that exist with Helmholtz centers, the founding of our own Helmholtz Young Investigators' Group, and the establishment of our own School Lab, which is supported by the Helmholtz Initiative and Networking Fund, we are already well integrated into our new scientific umbrella organization. Creating a modern infrastructure for research is also the aim of a master plan according to which the buildings and infrastructure of the research site, which looks back on a history that goes back all the way to the 1950s, are being modernized step by step. This includes, for example, the structural and energy-saving renovation of office buildings, the construction of a new guesthouse, or the new construction of our own combined heat and power plant which will supply the entire compound with energy and heat in the future.

May 2010 marked the start of the construction work on the radiation source ELBE – the first of our projects for the future – which is being expanded into a center for high performance radiation sources. The broad spectrum of radiation types generated from the electron beam of the superconducting linear accelerator is supplemented by additional opportunities for experiments: A narrow- and broadband terahertz source, a new high performance laser in the petawatt range, and the coupling of electron and laser beams. Researchers who come from other organizations will also benefit from this project; in 2010, they used about half of the entire radiation time at the ELBE source either alone or in joint projects with HZDR researchers. An even greater demand for measurement time among external scientists was reported by the Dresden High Magnetic Field Laboratory (HLD), which has been working as a user facility for only four years now. That is why the HLD is being expanded into an international user center as the second project for the future. The third construction project entitled DRESDYN revolves around the new construction of a lab for experiments with liquid metals.

Infrastructures in Demand

All told, the Helmholtz-Zentrum Dresden-Rossendorf operates six large-scale scientific facilities. In addition to ELBE and the High Magnetic Field Laboratory, the research sector materials science includes an Ion Beam Center which can be counted among the leading facilities of its kind in Europe and which is in great demand for ion implantation services particularly for the semiconductor industry. Right here, a new 6 megavolt accelerator went into test operation last year. The Rossendorf Beamline at the European Synchrotron Radiation Facility (ESRF) in Grenoble is also used for the scientific analysis of materials as well as for radiochemical tests. In its PET Center, the HZDR possesses a broad range of medical imaging procedures for cancer research and is state-of-the-art with Germany's first combined PET/MRT system for full body screenings which was installed in September. In nuclear safety research, the TOPFLOW Facility plays a decisive role when it comes to the analysis of complex flow mixtures.

PREFACE BY THE BOARD OF DIRECTORS

Matter under Extreme Conditions

Our projects for the future focus our research even more on the analysis of matter under extreme conditions, for example, under the influence of high pressure or temperature, strong electromagnetic fields, or intense radiation. At the same time, this specific focus links our diverse research programs to one another; the insights gained from this work and the resultant innovations are, thus, highly significant for all disciplines – ranging from materials science all the way to medicine. One perfect example in this is the research carried out on our high intensity laser DRACO. The scientists here are studying how charged particles can be accelerated with laser light to high energies – a phenomenon from which they anticipate to derive both brilliant research prospects in materials science and compact instruments for ion therapy in cancer. The works carried out in the laser particle acceleration sector also demonstrate the significance of interdisciplinary cooperation for successful research because the scientists also seize the opportunity of cooperating both within the HZDR and with external partners. For example, cancer cells were irradiated with laser accelerated particles for the first time ever at the HZDR (please see page 14 for more details) and subsequently bombarded with classically accelerated ions for the purpose of comparative studies at the Ion Beam Center. Last year, the close cooperation among Dresden scientists in applying radiation in the battle against cancer was further advanced by the founding of the "National Center for Radiation Research in Oncology – OncoRay." The center is jointly supported by the TU Dresden [Dresden University of Technology], the University Hospital Dresden, and the HZDR; its partner is the Heidelberg Institute for Radiation Oncology (HIRO) at the German Cancer Research Center (DKFZ). A strategically important cooperation with the TU Bergakademie Freiberg [Freiberg University of Mining and Technology] was given the go-ahead by the Federal Ministry of Education and Research (BMBF) at the end of last year. The TU Freiberg and the HZDR are setting up together a national center for researching resource technologies in Freiberg.

We are looking forward to continuing the cooperation with our partners in the region, such as the research alliance DRESDEN-concept, and beyond – especially within the Helmholtz Association!

We would like to wish you pleasant reading!

Prof. Dr. Dr. h. c. Roland Sauerbrey
Scientific Director

Prof. Dr. Dr. h. c. Peter Joehnk
Administrative Director

PREFACE BY THE BOARD OF DIRECTORS

IMPORTANT MILESTONES TOWARDS THE HELMHOLTZ ASSOCIATION

JANUARY 1, 2011
Official membership in the Helmholtz Association

NOVEMBER 3, 2010
Adoption of the bylaws of the Helmholtz-Zentrum Dresden-Rossendorf e. V. association

MARCH 23, 2010
Resolution of the Helmholtz Senate to admit the FZD as a member*

JUNE 22, 2009
Signing of the Consortium Agreement governing the FZD becoming a member of the Helmholtz Association in the presence of the Federal Minister of Education and Research, Prof. Annette Schavan, Saxony's Minister President Stanislaw Tillich, the President of the Leibniz Association, Prof. Ernst-Theodor Rietschel (rear left), and the President of the Helmholtz Association, Prof. Jürgen Mlynek (rear right)

SEPTEMBER 5, 2008
The first Helmholtz evening event is held in Dresden

JULY 4, 2008
The German Council of Science and Humanities (WR) recommends that the FZD be admitted to the Helmholtz Association

NOVEMBER 2007
Evaluation of the FZD by the German Council of Science and Humanities (WR); representatives of the evaluation committee stay at the research center for several days where they also have meetings with staff members, etc.

* This annual report for 2010 is published with the new corporate design of the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) which is why the new name will be used throughout the brochure.

CALENDAR OF EVENTS

JANUARY

New Research Site

Since January 1, the HZDR has a new research site in Leipzig. The scientists of the former Institute of Interdisciplinary Isotope Research, who will be integrated into the HZDR on the recommendation of the German Council of Science and Humanities (WR), had already been cooperating closely with the research center's Institutes of Radiopharmacy and Radiochemistry. They are developing molecular probes for the diagnosis of neurodegenerative diseases and are researching the transport of harmful substances into the geosphere.

Saxon State Minister of Science Awards Prizes

Within the scope of the annual reception on January 25, Saxony's State Minister of Science, Prof. Sabine von Schorlemer, lauds and bestows awards to last year's best performances achieved at the HZDR in the sectors research, technology, and communication with the public at large as well as the best dissertation.

FEBRUARY

Cooperation Agreement Extended

The cooperation agreement with Ankara University / Turkey will be extended. The HZDR promotes the establishment of an electron accelerator (Turkish Accelerator Center) which is currently under construction in Ankara and is comparable to the radiation source ELBE.

Appreciation of the Arts

One of the rare exterior works of the renowned constructivist Hermann Glöckner (1889 – 1987), the *Faltung* (i.e. folding), is set up in the city center again and presented to the general public. It had been created in the 1980s by staff members of the Central Institute for Nuclear Research.

New Project for the Long-Term Operation of Nuclear Power Plants

The research center assumes the coordination of a project which is subsidized by the European Union with about 2.7 million euros and seeks to examine the aging of reactor materials during extended operating times of nuclear power plants. The objective is the preparation of new guidelines for the monitoring and supervision of aging effects.

CALENDAR OF EVENTS

MARCH

10 Years Network of Competence in Nuclear Engineering

The HZDR partakes in the 10th anniversary celebration at the Karlsruhe Institute of Technology (KIT). The Kompetenzzentrum Kerntechnik, a network of competence in nuclear engineering, had been established with the objective of contributing to the improved national coordination of research and development in nuclear engineering and promoting the next generation of scientists. The research center is also a member of the Kompetenzzentrum Ost für Kerntechnik, East Germany's network of competence in nuclear engineering.

Workshop on Ion Beam Physics

The Institute of Ion Beam Physics and Materials Research hosts the annual national Workshop Ion Beam Physics between March 29 and 31. The workshop focuses on the analysis and alteration of material surfaces with energetic particle beams.

APRIL

Accelerator Planned

During a workshop held at the research center, German and foreign astrophysicists discuss the scientific relevance of installing a potential subsurface particle accelerator for astrophysical experiments in Dresden's Felsenkeller. This shallow-underground laboratory is already being used by astrophysicists as a lab and is operated by the VKTA - Nuclear Engineering and Analytics Inc.

MAY

ELBE to Be Expanded

Construction work starts at the radiation source ELBE to expand it into a center for high performance radiation sources. After the reconstruction, two unique terahertz sources, a new high performance laser as well as an experiment designed to couple the ELBE electron beam with laser light will be available to interested users.

FAIR Director in Dresden

The Scientific Director of the FAIR project, Prof. Boris Sharkov, visits the HZDR. The research center participates in the preparation of the Compressed Baryonic Matter (CBM) experiment by developing detectors for the large-scale international FAIR project. The abbreviation stands for Facility for Antiproton and Ion Research, a new accelerator system for high intensity ion beams which is currently being built at the GSI Helmholtz Centre for Heavy Ion Research GmbH.

CALENDAR OF EVENTS

JUNE

New Energy Hub

Jan Mücke, Parliamentary State Secretary at the Federal Ministry of Transport, Building and Urban Development (BMVBS), hands over a symbolic check for the new construction of a combined heat and power plant which is to supply the research site with energy and heat in the future. The plant is subsidized by the BMVBS with 4.6 million euros within the scope of Economic Stimulus Package II.

Long Night of Sciences in Dresden

On the occasion of the eighth event of this kind, the research center presents itself together with the Institute of Nuclear and Particle Physics (IKTP) at the TU Dresden [Dresden University of Technology] under the motto “The Concentrated Energy of Particles” in the university’s Auditorium Centre. Approximately 5,000 science enthusiasts informed themselves about the HZDR’s current research activities in presentations and at booths.

Terahertz Experts Convene

The application of new terahertz sources for the examination of basic material properties is in the focus of a workshop with terahertz researchers from Europe, the USA, and Japan held on June 14 and 15. Within the scope of a EuroMagNET II meeting, they also discuss the analysis of materials with terahertz radiation in high magnetic fields.

Virtual Journey into the Realm of Accelerators

How particles are accelerated to high energies in a particle accelerator is demonstrated in a unique new computer program, the ELBE simulator. Its role model is the HZDR’s radiation source ELBE. The program was jointly developed with computer science students at the TU Dresden [Dresden University of Technology].

Science Summer in London

HZDR scientists introduce a model volcano at a London exhibition which they had developed together with colleagues from the United Kingdom and Switzerland. The model volcano provides information on how the type and intensity of volcanic eruptions are affected by the flows inside volcanoes. The “Summer Science Exhibition” is part of the “Festival of Science + Arts” hosted by the Royal Society, the UK’s academy of science.

New Cyclotron

A new cyclotron financed by the European Union and the Free State of Saxony is installed at the Research Site Leipzig and prepared for its commissioning in the spring of 2011. The scientists will use the radioactive nuclides produced on the circular accelerator to develop and assess radioactive probes for the investigation of brain functions.

CALENDAR OF EVENTS

JULY

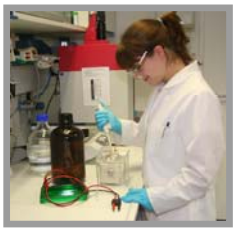
6,000 Visitors Discover the Research Site

Within the scope of the Entdecker-Tour 2010, a discovery tour event organized by the newspaper *Sächsische Zeitung*, more people than ever before flock to the research center Dresden-Rossendorf for an Open Lab Day on July 4, enjoying the pleasant cool air in the labs while the outside temperatures are scorching.

Agreement on Cooperation Concluded

The HZDR and Leipzig University conclude an agreement on cooperation aimed at intensifying the cooperation in research and instruction in the future. A particular objective is to strengthen and foster the ties that exist between the Research Site Leipzig and Leipzig University.

AUGUST



Welcome

The HZDR welcomes twelve new apprentices on August 3. At the start of the new vocational training year, it is now possible to learn the profession of a biology lab technician and to complete a practical education in the program of studies for radiation technology which ultimately leads to the "Bachelor of Science" degree.

New Accelerator

A new 6 megavolt ion accelerator goes into test operation at the Institute of Ion Beam Physics and Materials Research. The new system replaces the old accelerator and provides more stable ion beams as well as higher particle flows. An additional feature is its Accelerator Mass Spectrometry (AMS) which now permits the scientists to determine the age of material samples.

Youth in Research

In August and September, young physics talents work once again in the research center. They had won their internships as special prizes which had been granted in diverse state contests within the youth research program "Jugend forscht."

IEEE Magnetics Society Summer School

About 100 international participants attend the Summer School of the IEEE Magnetics Society, the USA's professional association of engineers and physicists, in Dresden. The program is jointly hosted by Dresden's Leibniz Institute for Solid State and Materials Research Dresden (IFW) and the HZDR.

DRESDEN-concept e. V.

The partners of the research alliance DRESDEN-concept, which also includes the HZDR, establish an association. It pursues the objective of promoting science and research, the general and continued education and training of young scientists and technicians, and the exchange of scientific knowledge at the science venue Dresden. DRESDEN-concept is a network of the TU Dresden [Dresden University of Technology] and Dresden-based non-university research facilities, museums, and libraries. The alliance represents an important component of the TU Dresden's application within the scope of the Federal Government's Excellence Initiative. It has received substantial support from the HZDR.

CALENDAR OF EVENTS

SEPTEMBER

Radiation to Combat Cancer

September 21 marked the founding of the “National Center for Radiation Research in Oncology Dresden/Heidelberg.” It unites two research clusters which cooperate closely in the radiation research sector: On the one hand, the Dresden-based OncoRay center which is supported by the TU Dresden [Dresden University of Technology], the University Hospital Dresden as well as the HZDR; and, on the other hand, the Heidelberg Institute for Radiation Oncology (HIRO). OncoRay is subsidized during the second phase by the Federal Ministry of Education and Research (BMBF) with 12 million euros.

Innovative Imaging System

Germany’s first combined PET/MRT system for full body screenings is installed at the research center. The device, which was built by the Philips corporation, is capable of delivering almost simultaneous functional and anatomical images of the body which are used in cancer research.

PhD Seminar

Approximately 90 doctoral and diploma students participate in the PhD Seminar, which is now the fifth of its kind at the research center. The best presentation and the best poster come from PhD students at the Institute of Radiation Physics. In order to better integrate these students into the research center, representatives from all institutes will join forces in a PhD students’ council in 2010. A total of about 120 doctoral candidates are employed at the HZDR.

New Guesthouse

On September 21, Saxony’s State Minister of Research, Prof. Sabine von Schorlemer, lays the cornerstone for the new guesthouse together with the Board of Directors. It is built right next to the research center.

Leipzig’s Long Night of Sciences

It is the second event of its kind, and Leipzig’s HZDR researchers at the scientific center Wissenschaftspark Permoserstrasse are happy to welcome numerous visitors. They can learn about the research site while participating in guided tours of the laboratories.

CALENDAR OF EVENTS

OCTOBER

Highlights of Physics

Staff members from the Institute of Safety Research represent the HZDR at the Science Festival in Augsburg which is held between October 9 and 14. The festival attracts about 23,000 visitors under the motto “Gigawatt” during the Year of Energy.

New TU Rector Introduces Himself

The new Rector of the TU Dresden [Dresden University of Technology], Prof. Hans Müller-Steinhagen, introduces himself at the HZDR with a presentation on the DESERTEC project revolving around power supplies from deserts. He is the Head of the International Advisory Board of the Desertec Industrial Initiative, a joint venture of private enterprises which was founded with the objective of creating the prerequisites for implementing the Desertec project.

NOVEMBER

German-French Laser Colloquium

On November 5 and 6, young scientists from Germany and France committed to the research und utilization of laser light meet with laser research pioneers at the French Embassy in Berlin and provide an account of what has been achieved in this research field during its 50 years of history. The colloquium is organized by the French Embassy in Berlin and the Helmholtz Association. Its co-organizers are Prof. Roland Sauerbrey, HZDR, and Prof. Ludger Wöste of the Freie Universität Berlin.

The Next Generation of Magnetic Researchers

The German Research Foundation (DFG) has awarded a post-graduate program which had been applied for by Dresden scientists and seeks to advance the development of high temperature superconductors. The HZDR’s High Magnetic Field Laboratory (HLD) also participates in this program.

Excellent Spin-Off Concept

The spin-off project SAXRAY wins Germany’s national Founders’ Contest “start2grow.” The project, which was jointly launched by the HZDR, the TU Dresden [Dresden University of Technology], and the TU Bergakademie Freiberg [Freiberg University of Mining and Technology], seeks to simplify X-ray analytics in materials science.

Researchers Working on Behalf of ESS

The HZDR is also very pleased about the official approval of a grant which was presented by Thomas Rachel, the Parliamentary State Secretary at the Federal Ministry of Education and Research (BMBF), to the Forschungszentrum Jülich: The grant permits the participation of German researchers, including scientists from Dresden, in the planned European Spallation Source (ESS). The German activities will be coordinated from Jülich.

Success for the Cancer Research Venue Dresden

Dresden is selected as the partner location of a German center for translational cancer research. The joint application consists of the University Hospital Dresden and the TU Dresden [Dresden University of Technology], the HZDR as well as the Max Planck Institute of Molecular Cell Biology and Genetics (MPI CBG). In the future, Germany will be home to six centers for health care research which are dedicated to the most important common diseases.

CALENDAR OF EVENTS

DECEMBER

New School Lab

The new School Lab “Delta X” starts into its pilot phase. Initially, upper level students of college preparatory *Gymnasiums* will have the opportunity of conducting experiments revolving around magnetism. www.hzdr.de/schuelerlabor

Rare Resources

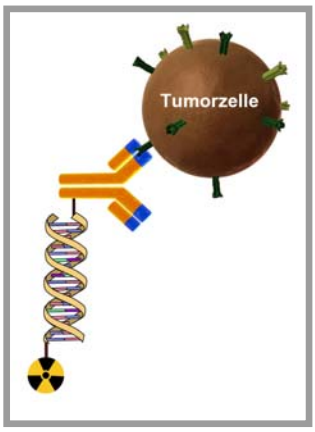
The HZDR and the TU Bergakademie Freiberg [Freiberg University of Mining and Technology] get the approval of the Federal Ministry of Education and Research (BMBF) for the joint establishment of a national resource technology center in the mining city of Freiberg. The goal is to establish a Helmholtz institute; the technologies researched at this institute are to make a vital contribution towards safeguarding the sustained supply of Germany’s economy with mineral and metalliferous raw materials.

USING NATURE AS A ROLE MODEL

Scientists break new ground in internal cancer radiation

Due to the aging population, the cancer-related mortality in developed industrial countries is constantly increasing. For the treatment of cancer, physicians primarily focus on three strategies: Surgery, chemotherapy, and external radiation. However, if cancer cells have already been detached from a tumor and deposited metastases elsewhere in the body, then the chances for recovery are significantly reduced. On their way towards finding a method which helps detect and efficiently treat metastases, the Rossendorf radio pharmacists have taken a big step forward. Their vision is that cancer could be irradiated not only in the classic way from the outside, but also from the inside with the help of radioactive substances. Thus, the rays could be targeted better at cancer cells, and healthy tissue would be protected.

A very effective possibility that radioactive substances are able to detect tumors and attach themselves to these tumors is based on the use of specific antibodies. But it takes several days before they accumulate in the cancer tissue. It is, thus, possible that radioactive antibodies unintentionally expose the organism to radiation. In order to circumvent this, the researchers are developing a subtle method: First, non-radioactive antibodies are injected. The radioactive component is only administered after these antibodies have accumulated at the cancer cells. This component then quickly finds its way into the tumor where it unites with the antibodies.



But how can the radioactive component find the antibodies? The researchers use nature as a role model with a system that mutually recognizes itself: Two complementary, single DNA strands “A” and “B.” The antibodies are equipped with “A” while “B” is labeled radioactively. Once the two single strands meet, a very stable bond is rapidly created just like a zipper. The scientists, though, do not use any naturally occurring DNA, but rather its mirror image. Thus, strand “B” can only connect to strand “A” and not to any other binding sites inside the body. Within the scope of his doctoral dissertation, Christian Förster improved the radioactively labeled DNA in such a way that this DNA can optimally distribute and bind itself inside the body. This is a big step forward on the way towards internal radiation.

Picture: Radioactively labelled antibodies are perfect probes which help detect cancer cells dispersed inside the body and destroy these cells from the inside.

PUBLICATION

C. Förster, R. Bergmann, et al.: Radiolabeled L-oligonucleotides with tunable pharmacokinetics – A suitable complementary system for pretargeting approaches; Nuclear Medicine and Biology 37(6), 706 (2010), DOI: 10.1016/j. nucmedbio.2010.04.100

CONTACT

Institute of Radiopharmacy
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FIGHTING CANCER TOGETHER

For the first time ever, a Dresden research group irradiates cancer cells with laser accelerated protons and analyzes the effects

Today, cutting edge research means teamwork. In order to gain new insights and create the foundation for progressive technologies, researchers also depend on close cooperations with colleagues who are active in other sectors. One such successful and promising example is the cooperation of the Rossendorf laser physicists with physicists, biologists, and physicians at Dresden's OncoRay center. The HZDR researchers are committed to the question of how charged particles can be accelerated with laser light to such high energies that they can be used in radiation therapy. It is their objective to develop compact devices for particle therapy in cancer patients.

Laser particle acceleration is still quite a new sector which has been researched at the HZDR since 2006. The project team which was founded back then has now grown into a department with more than 20 employees. They operate the high intensity laser DRACO with which they generate ultrashort, pulsed proton beams. Protons are positively charged particles and particularly suited for radiation therapy since they release their energy primarily inside the tumor. That is why they are used for inoperable tumors inside organs sensitive to radiation. The acceleration of protons with laser light requires significantly less space than with conventional, large-scale accelerator systems. A mature technology based on laser accelerated particles, so the vision and mission of the researchers, could be available in many hospitals with a radiation therapy unit in the future. At the moment, the particle therapy can only be used in a few centers around the globe.

Last year, the research center managed for the first time ever to irradiate cancer cells with laser accelerated protons and to examine their effect. This success only became possible in the joint OncoRay network: The team of scientists succeeded in generating a stable proton beam, measuring the precise dosage released to the cells, and determining the particles' biological impact from the extent of cell damages. The future challenge will be to optimize the properties of proton beams in such a way that they are clinically usable for cancer therapy. Currently, the laser physicists can generate proton energies of up to 20 mega electron volts. This is the minimum range for beams capable of penetrating tissue. Proton energies of up to 60 mega electron volts were already achieved by HZDR researchers on a larger laser system at the US American Los Alamos National Laboratory.

Picture: Dr. Doreen Naumburger prepares cancer cells for radiation with protons at the high intensity laser DRACO.

PUBLICATION

S. D. Kraft, et al.: Dose dependent biological damage of tumour cells by laser-accelerated proton beams; New Journal of Physics 12, 085003 (2010), DOI: 1088/13672630/12/8/085003

CONTACT

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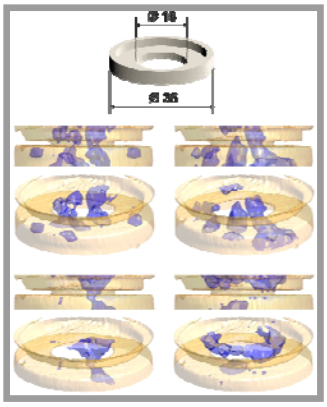
PURSUING WHIRLING GAS BUBBLES

The Helmholtz-Zentrum Dresden-Rossendorf creates ultrafast three-dimensional images of complex mixed flows



When mixtures of gas and liquids flow, there's turbulent confusion. For example, gas bubbles constantly change their shape, dissipate and consolidate, whirl around one another, or accumulate in front of obstacles. These processes can be observed exactly with the ultrafast three-dimensional X-ray tomography which was developed by Dr. Martina Bieberle and her colleagues. The procedure delivers images from the inside of a metal tube at millisecond intervals; thus, showing, for example, how a flowing mixture of air and water passes through a bottleneck. While some of the air bubbles essentially get stuck in front of the narrowing, other bubbles penetrate it at high speed and are severely deformed in the process.

Until now, the electron beam X-ray tomograph ROFEX has only been able to create cross-sectional images of a tube through which a fluid passes; in other words, two-dimensional images. Now, though, the researchers are able to deflect the beam in such a way that X-rays can penetrate the examined object at several levels until they are finally caught by a detector. Up to 500 volume images per second can be produced with 3D tomography. With this method it is possible to precisely ascertain how quickly the air bubbles flow through the water, what size they have, and how they change their shape. This method permits the analysis of various multiphase mixtures. The images are to deliver, for example, the database for simulations which help predict the behavior of complex flows.

Gas-liquid mixtures flow through pipelines in many technical facilities, whether it be in chemical process engineering, in power plants, or the extraction of mineral oil. Thus, the size and shape of the gas-liquid interface have a significant impact on how materials and heat are transmitted or how high the mechanical stress is on the receptacle walls which is why these factors must be taken into account when planning such facilities.

Picture: The flow experts at the HZDR know what happens behind in transparent tube walls: Thanks to ultrafast electron beam X-ray tomography, they are able to depict the shape and size of gas bubbles in an air-water flow.

PUBLICATION

M. Bieberle, et al.: Ultrafast three-dimensional X-ray computed tomography; Applied Physics Letters 98, 034101 (2011), DOI: 10.1063/1.3534806

CONTACT

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m.bieberle@hzdr.de

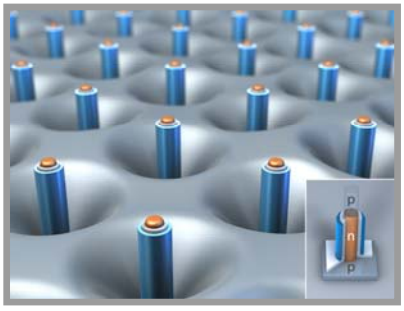
CURRENT FLOW AT THE NANO LEVEL

Silicon nanowires could become the memory chips of the future.
For the first time ever, their electronic properties have been described in three dimensions

Silicon is the most important material for the production of computer chips and other electronic components. The industry has actually already advanced to the era of nanoelectronics because every single transistor among the billions of transistors on a chip has now reached the size of only 50 nanometers (one nanometer equals one millionth of a millimeter). When it comes to the needs and requirements of industry and the possibilities of research, then such miniaturization has to be pursued further. That is why new concepts are currently in progress. In order to save space, transistors could, for example, be arranged differently. At present, they are either laid flat next to or stacked on top of one another. Yet it is conceivable that they are rotated 90 degrees so that they protrude from the chip surface like tiny nanowires. In the future, it would, thus, be possible to place many innovative structures onto the surface of just a single transistor.

Even though silicon nanowires are already produced today, their electronic properties are not yet sufficiently known to build reliable transistors for a new generation of microchips. Electric current will not flow horizontally, but instead vertically inside these transistors which will become smaller and save more energy than this is the case today. In joint investigations, researchers from the Max Planck Institute of Microstructure Physics in Halle and the Helmholtz-Zentrum Dresden-Rossendorf discovered that the ability of silicon nanowires to conduct electric current and subsequently process information as transistors is limited. Should they be used as transistors in the future, then developers would have to pay careful attention to these findings.

In order for an electric current to flow inside the semiconductor material silicon, it has to be enriched with ions, which means it is charged with such particles as boron or phosphor. The scientists discovered that these particles do not stay where they are; instead, they move towards the edge of the nanowire; in other words, towards the surface. There, they become partially inactive and no longer contribute towards conductivity. A special method permitted the scientists to longitudinally remove the nanowires layer by layer during the measurements which, in turn, allowed them to take three-dimensional measurements. That is how they got 3D images of the conductivity inside a nanowire which only has the thickness of one 25,000th of a human hair.



Picture: While transistors have been arranged on a flat plane so far memory chips based on nanowires protrude from the chip. This concept could revolutionize the architecture of chips.

PUBLICATION

X. Ou, P. Das Kanungo, R. Kögler, P. Werner, et al.: Three-dimensional carrier profiling of individual Si nanowires by Scanning Spreading Resistance Microscopy; Advanced Materials 22(36), 4020-4024 (2010), DOI: 10.1002/ adma.201001086

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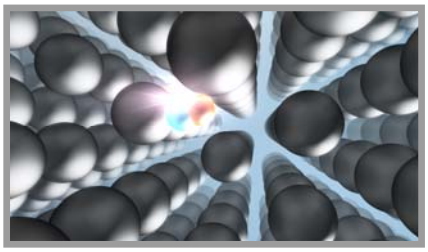
POSITRONS SNIFF OUT DEFECTS

A lab for the non-destructive testing of materials has been set up at the radiation source ELBE

A New measuring station has been set up at the radiation source ELBE which provides a globally unique concept for the non-destructive testing of materials. It permits tests of compact mechanical components like, for example, toothed wheels or ball bearings as well as pulverized, liquid, or even radioactive samples. The procedure is extremely sensitive and able to detect the smallest defects such as, for example, gaps or foreign atoms in a crystal lattice.

Positrons, the positively charged antiparticles of electrons, serve as probes. But they can penetrate the material only by a few micrometers which is why only very thin samples have been scanned with a positron beam so far. However, the HZDR researchers do not use any external source; instead, they have the positrons created right in the material sample by directing braking radiation from the ELBE source to the sample. Due to the radiation, the positively charged particles are formed in the entire sample volume – even if the dimensions of this sample cover a range of several centimeters.

For the detection of defects, the scientists apply the so-called positron annihilation spectroscopy. The braking radiation of the ELBE source causes the material to initially produce positrons. If these positrons encounter electrons with the appropriate spin, both particles annihilate each other (annihilation) while, at the same time, emitting two photons which fly away in opposite directions. Detector pairs arranged around the sample register these light flashes and record how quickly the positrons annihilate. Because even tiny defects and very low defect concentrations inside the material influence the life cycle of positrons, the researchers are, thus, able to gain valuable insights into the atomic structure of the sample; for example, to what extent a steel sample changes under mechanical stress. The new lab is used for interdisciplinary projects. For example, the HZDR safety researchers use the lab for analyzing the quality and characteristics of reactor steels.



Picture: If a positron meets an electron, then both elementary particles annihilate each other. This process lasts just a tiny bit longer if it occurs in the gap of a crystal lattice. The researchers at the HZDR use this effect to detect material defects.

PUBLICATION

M. Butterling, et al.: Positron Annihilation Spectroscopy using high-energy photons; Physica Status Solidi A 207, 334 (2010), DOI: 10.1002/pssa.200925340

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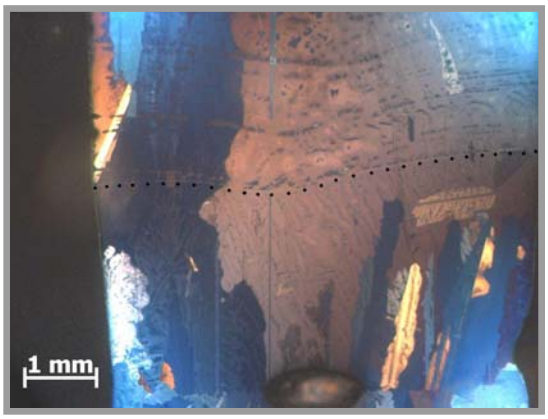
CUSTOMIZED MAGNETIC FIELDS

In cooperation with the Leibniz Institute for Solid State and Materials Research Dresden (IFW), magnetic fields are used for the production of titanium-aluminum monocrystals

Metallic alloys from titanium and aluminum are particularly popular materials in the aviation and automobile industries. Because even though they are lighter than the high temperature materials which are commonly used in these branches, they exhibit the same strength. In order to further optimize the specific properties of these materials, they have to be available as monocrystals; which means their components have to be arranged in a single, coherent, and uniform crystal lattice. Only such special structures allow the properties of a material to be measured in their pure form – which is also the basis for studying and improving the quality and characteristics of non-monocrystalline materials.



Monocrystalline compounds made from titanium and aluminum or other materials are, depending on their specific composition, not always easy to produce. Scientists at the Leibniz Institute for Solid State and Materials Research Dresden (IFW) and the Helmholtz-Zentrum Dresden-Rossendorf use customized magnetic fields to grow perfect monocrystals. Magnetic fields can have an impact on the direction into which liquid metals flow, for example, during crystal growth, and on the speed at which they move in the course of this process. The Helmholtz researchers have calculated what such a magnetic field actually has to “look” like in order to precisely control the interface between liquid and solid metals which is decisive for the formation of monocrystals. They, thus, created the prerequisites for a new, patented procedure with which crystals are grown at the IFW. It is based on a thin metal rod which is slowly melted and solidified repeatedly. The rod is surrounded by two magnetic coils which, on the one hand, produce the heat required for melting the metal and, on the other hand, generate a magnetic field which stirs the liquid metal in the melting zone. The researchers have become so successful with their method that they are now even able to grow complex metallic monocrystals and analyze their properties.

Picture: The shape of the solid-liquid interface can be designed with the help of a magnetic field so that the desired monocrystalline structures are created.

PUBLICATION

R. Hermann, G. Gerbeth, et al.: Convectional controlled crystal-melt interface using two-phase radio-frequency electromagnetic heating; Journal of Materials Science 45, 2228-2232 (2010), DOI: 10.1007/s10853-009-4117-0

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PROJECTS FOR THE FUTURE

RESEARCHING THE WORLD OF TOMORROW

As a member of the Helmholtz Association, the HZDR operates large-scale research facilities which are also available to guests from Germany and abroad wishing to conduct measurement studies. Part of the large-scale scientific equipment permits new insights into the behavior of matter under extreme conditions; that is, under extremely high temperatures, pressures, and electromagnetic fields as well as intense radiation. This core subject combines the HZDR's in-house materials science research with the focal points cancer research and nuclear safety research; thus, permitting comprehensive research results in an interdisciplinary approach which help solve scientifically and socially relevant problems.

In order to prepare the Helmholtz center in Dresden even better for the future when it comes to the analysis of materials in extreme states, the Free State of Saxony finances three large building projects in Rossendorf. This creates, in part, very rare and unique research opportunities for researchers from around the globe.

- With the expansion of the radiation source ELBE, a **center for high performance radiation sources** is being built between 2009 and 2014. The new constructions include a high performance laser system in the petawatt range, a narrow and a broadband terahertz source as well as experiments for coupling the high performance laser with the ELBE electron beam. While high performance lasers are used in cancer research, the other facilities supplement the research conducted in the sectors new materials and research with photons, neutrons, and ions.
- **The Dresden High Magnetic Field Laboratory (HLD)** is being expanded into an international user center. From 2011 to 2013, it will be equipped with a new capacitor bank and additional magnetic cells to meet the great demand for measurement times in ultrahigh pulsed magnetic fields. The Dresden researchers are already cooperating intensely with the European high magnetic field laboratories in Nijmegen, Grenoble, and Toulouse in the EU programs "EuroMagNET" and "European Magnetic Field Laboratory – EMFL."
- The objective of the **DRESDYN** project is the creation of a European platform for dynamo experiments and thermohydraulic studies with fluid sodium. Between 2013 and 2015, for example, the world's first precision dynamo is to be developed with which it will be possible to simulate more realistically, for example, the evolution of the earth's magnetic field, the magnetosphere, than has been possible with today's propeller-driven dynamo experiments like the one in Riga. By the way, the Riga dynamo was actually the first of its kind to verify the evolutionary mechanism of cosmic magnetic fields in a lab – with the participation of researchers from the HZDR.

Joining Forces for a Future with Safe Raw Materials

The German economy depends to a considerable degree on the safe and sustained supply of requisite raw materials. This is the only way it can produce goods and plants that are competitive internationally and as independent as possible of the global markets. So it is not surprising that the research topic "securing the supply of raw materials" was given top priority in the Federal Ministry of Education and Research (BMBF). In late 2010, the BMBF accepted the joint proposal of the TU Bergakademie Freiberg [Freiberg University of Mining and Technology] and the Helmholtz-Zentrum Dresden-Rossendorf to establish a new Institute for Resource Technologies which is now being built and operated together by both partners in Freiberg. The Helmholtz Institute Freiberg for Resource Technology focuses primarily on technologies for supplying the German business community with mineral and metalliferous raw materials.

NEXT GENERATION OF SCIENTISTS

FIRST HELMHOLTZ YOUNG INVESTIGATORS' GROUP

Last September, when the Helmholtz Association announced the names of the talented young scientists who would get support to set up their own junior research group, the joy was great for Dr. Shengqiang Zhou. Over the next five years, the HZDR researcher, who was born in China, will receive EUR 250,000 per year in order to continue his work. Since he earned his doctoral degree three years ago, he has been conducting research at the Institute of Ion Beam Physics and Materials Research where ions, i.e. charged particles, are used in materials science. These ions can change surfaces in such a way that innovative materials emerge with entirely new properties. Dr. Zhou is specifically interested in applications for the semiconductor and photovoltaics industries. He is researching functional semiconductor materials which might form the foundation for the computer chips of the future. Significantly higher process speeds and less energy consumption are expected when compared to today's chips.

Together with the Helmholtz Young Investigators' Group, the Helmholtz-Zentrum Dresden-Rossendorf has a total of nine junior research groups. The groups headed by Dr. Kilian Lenz and Dr. Michael Bussmann commenced with their work in 2010.

Junior Research Groups at the HZDR

- Ion Beam Processed Functional Materials for Spintronics and Photovoltaics
  Head: Dr. Shengqiang Zhou
- Transport Phenomena in Nanostructures
  Head: Dr. Artur Erbe
- Nano-Spintronics
  Head: Dr. Heidemarie Schmidt
- THz Quantum Dynamics
  Head: Dr. Dominik Stehr
- Magnetization Dynamics and Magnetostatic
  Head: Dr. Kilian Lenz
- Tumor-Specific PET Tracers
  Head: Dr. Reik Löser
- Computer-Assisted Radiation Physics
  Head: Dr. Michael Bussmann
- Nanoscale Biocomposite Materials / NanoBio
  Head: Dr. Katrin Pollmann
- CFD Development
  Head: Dr. Thomas Höhne

NEXT GENERATION OF SCIENTISTS

THE NEW SCHOOL LAB DeltaX – PILOT PHASE STARTED

Why does a graphite platelet float? What is the function of an oscillating circuit? How high is the resistance at low temperatures? Those who visit the new School Lab "DeltaX" at the Helmholtz-Zentrum Dresden-Rossendorf will find answers to these questions and can have a closer look at magnetism. Pupils have the opportunity of discovering the HZDR's current research topics on their own with the help of experiments. "Here, children and adolescents can get a real hands-on experience and test their abilities as researchers and scientists," notes the Head of the School Lab, Dr. Maria Hörhold.

The program of the School Lab initially addresses grades 10 through 12, but it will be expanded for lower grades in the upcoming years. Experiments revolving around optics and radioactivity are also on the agenda. The pilot phase started in December. Last year, Dr. Hörhold had submitted a successful application for start-up financing to the Helmholtz Initiative and Networking Fund. That is why the School Lab will now get 450,000 euros over the next three years. The money will be used, for example, to equip the facility with modern computers and instruments as well as finance the part-time position of a physics teacher and, as of 2012, also a chemist.

HIGHER, FASTER, FARTHER: APPRENTICES ON THE ROAD TO SUCCESS

For all new apprentices who start their vocational training at the Helmholtz-Zentrum Dresden-Rossendorf, it should become quickly apparent that people have great expectations for their future careers. The best apprentices to be honored every year by the Chamber of Industry and Commerce (IHK) always include career beginners from the research center. During the past few years, some of them even managed to complete their education with the best results in all of Saxony or Germany. In order to achieve such success, these adolescents can count on the full support and the active commitment of their instructors. They not only train and educate their protégés in a superb professional manner, but also foster their overall personal development as well as strengthen and encourage them; thus, allowing these young adults to excel both at work and beyond.

INTERVIEW: A TALENT FOR PHYSICS

With a school paper on the combustion behavior of fuels in nuclear reactors, Susanne Scholl from Dresden won one of the main prizes in the Saxon contest VON ARDENNE Physics Award 2010. The competition launched by the Helmholtz-Zentrum Dresden-Rossendorf in cooperation with the Saxon universities and supported by the VON ARDENNE Anlagentechnik GmbH corporation, the German Physical Society (DPG), and the Wilhelm and Else Heraeus Foundation was already held for the tenth time. Laureate Susanne Scholl, who is now studying technomathematics in Magdeburg, answered the following questions for us.

Ms. Scholl, how complex was your work?
The practical part was very simple because I worked with a computer program. It was far more complex to familiarize myself with the topic and the program language. It took me a long time, but it was very interesting. I always enjoyed immersing myself into the topic again.

Would you recommend such school papers to others?
I can highly recommend not only the scientific investigation of a physical topic but also specifically the work at the HZDR. Every day was exciting and insightful. I met a lot of very nice people, and I'm glad to have gotten the opportunity to carry out additional internships here.

Do you already know what you wish to do in your future career?
I don't have a concrete idea yet. At the moment, my plans only go as far as getting into a master's program which I'll probably pursue abroad. Let's see how things develop after that.

KNOWLEDGE AND TECHNOLOGY TRANSFER

DENSE NETWORKS, INNOVATIVE PRODUCTS, AND POPULAR SERVICES

Whether it be in energy technology, the chemical branch, or the oil and gas industry, in medicine or the food industry: If anyone wants to know whether processes are efficient and safe or whether the manufactured products actually meet high quality standards, then one has to observe the material flows inside a facility and their underlying processes with great precision. Not an easy task if one considers that thick and intransparent pipe walls shield these flows and currents or if one keeps in mind the extreme conditions, such as high pressures and temperatures, which prevail in industrial processes.

Here, the knowledge provided by the flow and measurement technology experts at the Helmholtz-Zentrum Dresden-Rossendorf can help: Starting with a sensor capable of measuring electroconductive fluids and liquids, a complete repertoire of patented measuring sensors and sensor concepts has been developed in the course of several years. In order to utilize these sensors, the HZDR concluded an additional license agreement with the GWT-TUD GmbH, a corporation committed to knowledge and technology transfer under the ownership of the TU Dresden [Dresden University of Technology] which has already generated royalties. At the same time, the sensor technology platform within the ForMaT program launched by the Federal Ministry of Education and Research (BMBF) is also supported with the objective of developing larger application fields for sensors.

In order to improve the transfer of results from fundamental research to the economy and society, the research center has intensified its network activities even further and expanded its contacts and cooperations with service providers specializing in technology transfer, such as the GWT, with enterprises and associations from the business community as well as with other research institutions during the previous year. As a new center within the Helmholtz Association, a particular focus was put on the establishment of networks with other Helmholtz institutes. In addition, a partnership was initiated with the Ascenion corporation which dedicates itself to the utilization of research results from the life sciences sector. “A comprehensive network as well as the creation of individual, technology-specific utilization structures form important pillars in our technology transfer,” notes Dr. Björn Wolf who heads the department. The HZDR also participated in an educational trip organized by the Karlsruhe Institute of Technology (KIT) with the objective of visiting best practice examples in Asia, and it also hosted a workshop focusing on participations in spin-offs.

At the local level, the HZDR continued its close cooperation with the spin-off initiative “Dresden exists” which is located at the TU Dresden [Dresden University of Technology] and has won already several awards. The research center provides equity capital for this purpose. Currently, several HZDR research teams receive substantial support from “Dresden exists” for the preparation of spin-off projects. For example, the SAXRAY staff members seek to simplify X-ray analytics in materials science; with their concept, they won Germany’s national founders’ contest “start2grow” in 2010. In addition to marketable products, the role of the Helmholtz-Zentrum Dresden-Rossendorf as an acknowledged service provider is also an important focal point of technology transfer. In particular, the Application Laboratory for Ion Technology with its specific competence and expertise in the modification and analysis of material surfaces through ion beams was able to acquire an increased number of industrial contracts in 2010.

CLOSE COOPERATION AND SHORT DISTANCES

The pharmaceutical manufacturer ROTOP Pharmaka AG, with which the Helmholtz-Zentrum Dresden-Rossendorf has been cooperating closely for many years now, relocated its corporate headquarters onto the research center’s premises in 2010 where it moved into a new office and production building. Both organizations are researching together innovative preparations for the diagnosis of cancer. The ROTOP corporation also distributes the radioactive pharmaceutical “GlucoRos” which is produced at the HZDR.

FACTS & FIGURES

AWARDS

HZDR AWARDS

Research Award
Dr. Viton Heera, Institute of Ion Beam Physics and Materials Research
Dr. Thomas Herrmannsdörfer, Institute Dresden High Magnetic Field Laboratory

Technology Award
Dr. Sergei Zherlitsyn, Institute Dresden High Magnetic Field Laboratory
Bernd Wustmann, Department of Research & Technology

Award for Doctoral Candidates
Dr. René Heller, Institute of Ion Beam Physics and Materials Research

Award for Science Communication
Heidemarie Heim, Institute of Radiochemistry

2nd Prize in the Siempelkamp Competence Workshop “Preservation of Competence in Nuclear Technology”
2010 Annual Meeting on Nuclear Technology in Berlin
Cornelia Heintze, Institute of Safety Research

Poster Award, presented at the Students’ Day during the Laser Optics Berlin 2010 convention
Franziska Kroll, Institute of Radiation Physics

Heinrich Barkhausen Award of the Carl Friedrich von Siemens Foundation for students and young scientists
Dr. Martina Bieberle, Institute of Safety Research

Award for the best presentation held during the “ICONE 18 Student Best Presentation Competition” at the “18th International Conference on Nuclear Engineering” (China)
Jurii Bilodid, Institute of Safety Research

Prof. Roland Sauerbrey, Scientific Director of the Helmholtz-Zentrum Dresden-Rossendorf, received an honorary doctoral degree from the University of Rostock.

PROFESSORIAL APPOINTMENTS

Prof. Peter Brust, Head of the Neuroradiopharmaceutical Division at the Institute of Radiopharmacy, was appointed as an adjunct professor at Leipzig University.

PD Dr. Harald Schneider, Head of the Semiconductor Spectroscopy Division at the Institute of Ion Beam Physics and Materials Research, was named “Visiting Chair Professor” at the Shanghai Jiao Tong University in Shanghai, China.

Dr. Peter Kaever, Head of the Department of Research & Technology, received appointments as Professor of Automation Engineering at the Cologne University of Applied Sciences (FH) and as Professor of Mechanical and Automation Engineering at the Beuth University of Applied Sciences Berlin.

FACTS & FIGURES

PERSONNEL MATTERS

Prof. Wolfgang Enghardt from the Institute of Radiation Physics was elected as Vice President of the German Society for Medical Physics (DGMP); his term of office began on January 1, 2011.

Prof. Joachim Wosnitza, Director of the Dresden High Magnetic Field Laboratory (HLD), was elected as Spokesperson of the German Physical Society's (DPG) Review Board 307 "Condensed Matter Physics."

Prof. Wolfhard Möller, Director at the Institute of Ion Beam Physics and Materials Research, went into retirement. His successor is Prof. Jürgen Fassbender.

Prof. Frank-Peter Weiß, the long serving Director of the Institute of Safety Research, assumed the technical-scientific general management of the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH corporation. The institute is provisionally headed by Dr. Gunter Gerbeth.

Dr. Arnd Junghans (Institute of Radiation Physics) and Dr. Matthias Posselt (Institute of Ion Beam Physics and Materials Research) were invited to participate in expert groups of the Nuclear Energy Agency (NEA) at the Organisation for Economic Co-operation and Development (OECD)

RESEARCH PROGRAMS 2010

HEALTH
Cancer Research

Radiopharmacy

- Translational tumor research
- Radionuclide therapeutics
- PET and multimodality imaging (PET Center)
- Neuroradiopharmaceuticals

Radiation Physics for Radiotherapy

- Radiation-induced cell damage
- Tomography-supported radiation therapy of tumors
- Laser particle acceleration

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STRUCTURE OF MATTER
Research with Photons, Neutrons, and Ions

Rare Hadronic Processes / FAIR

Photons

- Center for High Performance Radiation Sources
- User Center Dresden High Magnetic Field Laboratory (HLD)
- Rossendorf Beamline at the ESRF Grenoble (ROBL)

Neutrons

- Center for High Performance Radiation Sources

Ions

- Ion Beam Center

In-House Research

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FACTS & FIGURES

ENERGY
Nuclear Safety Research

Safety Research for Permanent Nuclear Waste Repositories

- Long-lived radionuclides in biosystems
- Long-lived radionuclides in permanent waste repository systems
- Transmutation

Safety Research for Nuclear Reactors

- Analysis of accidents in nuclear reactors
- Materials and components safety
- Thermal fluid dynamics of multiphase systems (TOPFLOW)
- Thermal fluid dynamics of liquid metals (DRESDYN)

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KEY TECHNOLOGIES
New Materials

Materials Processing and Nanostructurization

- Formation of nanostructures through non-equilibrium processes
- Materials processing by radiation
- Electromagnetic processing of materials

Complex and Correlated Materials

- Complex oxides
- Strongly correlated materials

Dynamics at the Nanoscale

- Terahertz spectroscopy and photonics
- Transport, magnetism, and spintronics

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FACTS & FIGURES

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(Updated: September 1, 2010)

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FACTS & FIGURES

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(Updated: December 31, 2010)

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Last year's scientific results are described in detail in the Progress Report of the research center.