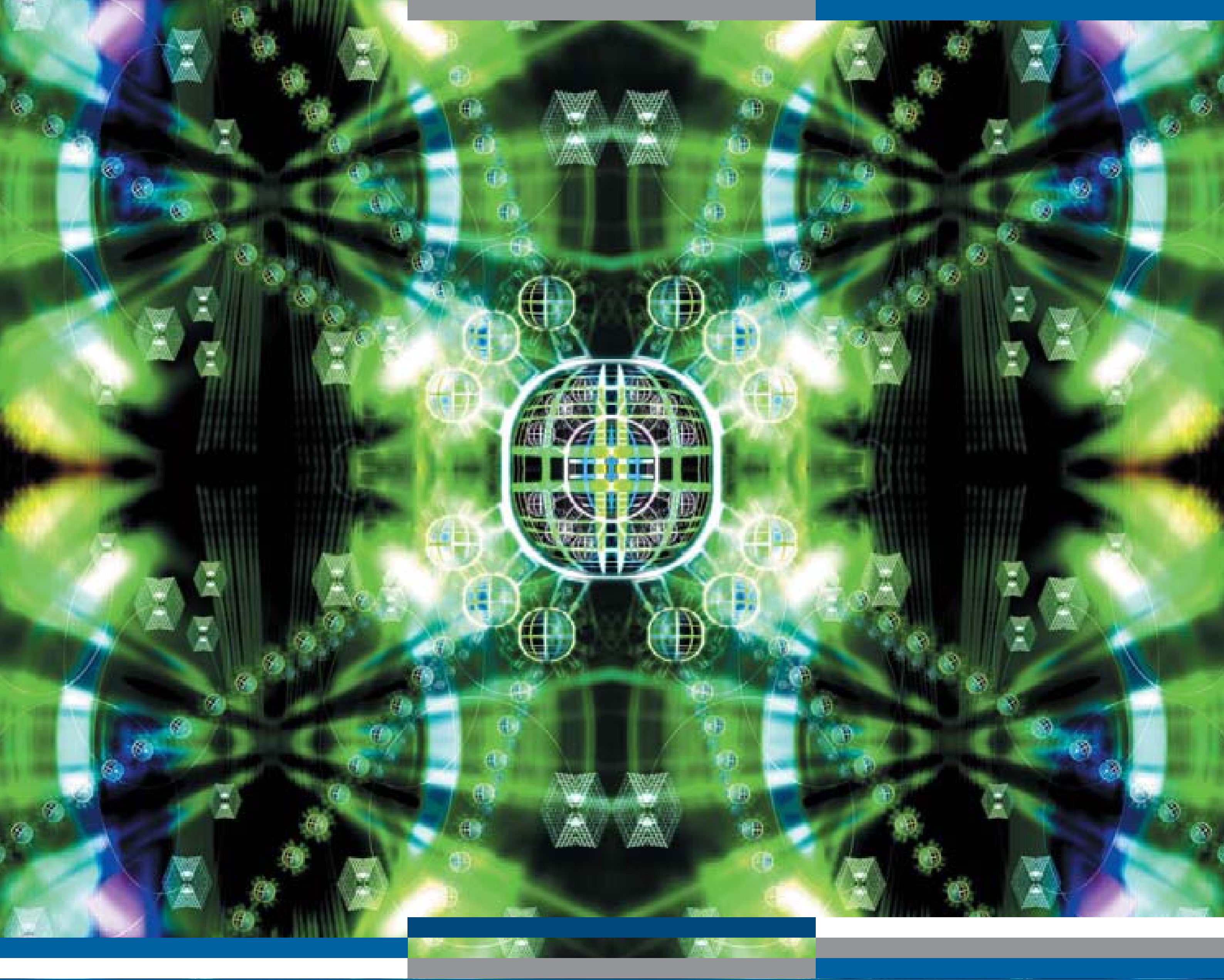


ENERGY
EARTH AND ENVIRONMENT
HEALTH
KEY TECHNOLOGIES
STRUCTURE OF MATTER
TRANSPORT AND SPACE

Annual Report 2006

HELMHOLTZ
ASSOCIATION

TABLE OF CONTENTS

We contribute to solving the grand challenges which face society, science and industry by performing top-rate research in strategic programmes in the fields of Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, Transport and Space.
We research systems of great complexity with our large-scale facilities and scientific infrastructure and in cooperation with national and international partners.
We contribute to shaping our future by combining research and technology development with perspectives for innovative applications and provisions for tomorrow's world.

That is our Mission.

HELMHOLTZ
ASSOCIATION

HELMHOLTZ AND INDUSTRY

PROFESSOR DR. JÜRGEN MLYNEK, President of the Helmholtz Association

Dear Readers,

Our choice of motto for the 2006 Annual General Assembly – "Helmholtz and Industry" – enabled us to focus attention this year on the process of transferring knowledge from research to industry. There are many sides to this, from cooperative projects with industry, patent registrations and licensing revenues through to spin-offs based on a successful product idea combined with a good business plan.

This is why the first part of our annual report presents select examples from all 15 Helmholtz Centres. These typical yet specific projects cover all six of our research fields and document our successful cooperation with industry. Let's think of it as a kind of snapshot that makes no claim to be exhaustive, because we are, after all, fortunate enough to have a wealth of good examples. Even those centres whose work is deeply rooted in basic research develop interesting cooperative models with industrial partners.

The second part provides an impression of the six research fields represented within the Helmholtz Association and of the topics they engage in. It also shows how our system of programme-oriented funding distributes the budgets for this research.

The third part is dedicated to our "People and Finances". This allows us to illustrate Helmholtz's role and dimension as an employer and lets us account for our use of financial resources. This section also presents the activities of the Initiative and Networking Fund plus our Performance Record in 2005, with facts and figures to document our work and achievements.

But let me return to the topic of our Annual General Assembly: Basic research and application are not contradictions; rather they form a pair. Our patron, Hermann von Helmholtz, was a passionate researcher and repeatedly emphasised: "Knowledge alone is not the purpose of human existence on earth. Rather, it is action and action alone that gives mankind a worthy existence." This is indeed how we understand our mandate and mission, namely to use our knowledge to contribute to solving complex and grand challenges in order to secure the sustainability and future viability of our society.

The Helmholtz Association is proceeding well along this path. My predecessor in this office, Professor Dr. Walter Kröll, led the way in setting the course towards this goal. On behalf of the Association, I would like to take this opportunity to thank him for this.

I hope the report makes interesting and enjoyable reading.

Your

THE PRESIDENT'S REPORT

We can look back on a busy and eventful year. On 23 June 2005, federal government and the federal states concluded a Pact for Research and Innovation with the German science and research organisations.

The political decision-makers aim to increase the level of research funding by 3% per year up to 2010 so as to meet the ambitious Lisbon Goal adopted by the European Union member states in 2000: as from 2010, 3% of the gross domestic product must flow into science, research and innovation, a pronounced increase over the present 2.5%.

In return, the Helmholtz Association committed itself to developing new future-viable research areas, to promoting young and early-stage researchers, to initiating concrete measures aimed at advancing equal opportunity, to expanding cooperation with other science and research organisations, with the universities and, in particular, with industry.

We take these responsibilities seriously and are already working on them. Because the Pact for Research and Innovation not only provides us with reliable planning, but also gives us the opportunity to accelerate the realisation of our strategic mission. Our mission begins with: **We contribute to solving grand challenges which face society, science and industry.** This is reflected in our six Research Fields: Energy, Health, Earth and Environment, Key Technologies, Transport and Space, and Structure of Matter. Helmholtz scientists perform around half of all publicly-funded energy research in Germany. Energy is one of the major topics for the future. Indeed, we must accelerate the development of climate-friendly technologies to meet the ever-growing demand for energy. We are partners in building the first experimental nuclear fusion reactor ITER, and we are also exploring the potential of renewable energy resources and are investigating how we can improve the efficiency of conventional techniques. The significance of the other research fields for society is there for all to see.

> "Real innovation can often develop unexpectedly from basic research as well. This is why we must work harder to ensure that we, in our capacity as scientists and researchers, maintain an open eye and an open mind for applications and ensure that our research findings are transferred into practice whenever and wherever the opportunity arises."
>
> JÜRGEN MLYNEK

Our mission continues with: **We research systems of great complexity with the our large-scale facilities and scientific infrastructure, cooperating closely with national and international partners.** The growth offered by the Pact also provides opportunities in this respect, because the greatest share of this funding will go to those research fields that use these resources to enhance and establish our large-scale facilities.

For example, scientists from around the world are working together at the Deutsches Elektronen-Synchrotron (DESY) to build the Free Electron X-Ray Laser (XFEL), while the Facility for Antiproton and Ion Research (FAIR) is to be built at the Gesellschaft für Schwerionenforschung (GSI).

Our mission ends with: **We contribute to shaping our future by combining research and technology development with perspectives for innovative applications and provisions for tomorrow's world.** We intend to give even greater weight to this aspect in the future, to benefit society by creating prosperity and jobs. Because we all know: only by innovating can we compete internationally and so maintain our good standard of living. And we must also remember that real innovation can often develop unexpectedly from basic research as well. This is why we must work harder to ensure that we, in our capacity as scientists and researchers, always maintain an open eye and an open mind for applications and ensure that our research findings are transferred into practice whenever and wherever the opportunity arises.

Only five years have passed since the Helmholtz Association was given a new structure. In this short space of time, we have already achieved much. The new financing instrument of cross-centre, programme-oriented funding, established under the presidency of my predecessor, Professor Dr. Walter Kröll, is working well and is already being optimised. The first round of strategic reviews has been completed. Networking with universities and the development of instruments to promote young and early-stage researchers have continued to move forward. Altogether, this makes the Helmholtz Association a very efficient and modern German research organisation. And at this point, I would like to thank Walter Kröll for mastering this difficult process.

Now, we have to consolidate this community of 15 German research centres. Not least, this includes resolutely implementing the system of programme-oriented funding and developing a united image under the "Helmholtz" brand to ensure that industry, politics and the public can better perceive and appreciate our work and our achievements.

Under the Initiative for Excellence and the Pact for Research and Innovation, we entered into commitments that now have to be met. So, we at Helmholtz joined forces to draw up a strategic master plan for the Association and its Centres. And now we are working together to evaluate the system of programme-oriented funding and to turn it into an even better strategic management instrument.

Shaping the Research Area: The Initiative and Networking Fund

The President of the Helmholtz Association is equipped with an Initiative and Networking Fund to be used for accelerating the reforms of the Helmholtz Association. At its meeting in December 2005, the Committee of Financial Sponsors decided to increase the budget for the Initiative and Networking Fund from 25m euros in 2006 to 57m euros in 2008. This equals one percentage point of the 3% total growth of the Helmholtz Association budget. This in turn opens up new freedoms and gives us scope to strengthen

"Working in the best interests of the whole nation and almost always on its behalf and at its expense, scientists seek to increase the knowledge and insights that can serve to enhance industry, wealth and the beauty of life, to improve the political organisation and moral development of each individual."

HERMANN VON HELMHOLTZ (1821–1894)

the fund in its capacity as a strategic instrument. We above all intend to use it to initiate new research topics within the Helmholtz Alliances, to network with universities through Virtual Institutes, to encourage international networking, and to promote young and early-stage researchers. To achieve this – and working in close cooperation with the universities – we are establishing Helmholtz-University Young Investigators Groups, Helmholtz Research Schools and Graduate Schools. A Helmholtz Academy for Science Management is currently being set up to train Helmholtz staff in the field of science and research management and administration. We also pay more than just lip service to the question of equal opportunity. We have a five-point programme aimed at initiating concrete measures that serve to raise the proportion of women working in senior positions and to keep women scientists and researchers in the Helmholtz Association or to recruit them from outside. Page 80 offers detailed information on the Initiative and Networking Fund.

Building new international large-scale facilities

The Helmholtz Association operates unique large-scale facilities and infrastructures and also places these at the disposal of the scientific community from both home and abroad. Particle accelerators, supercomputing systems, but also a mouse hospital and biomedical translational centres, the research aircraft HALO and the icebreaker POLARSTERN. All these facilities make research in Germany internationally attractive.

The Research Field Structure of Matter will see two new large-scale facilities established in international cooperation over the coming few years. Firstly, the Free Electron X-Ray Laser (XFEL) will be established at the Deutsches Elektronen-Synchrotron (DESY). As from 2013, XFEL will be able to deliver x-ray flashes of previously unachieved intensity. Not least, XFEL will make it possible to "see" the extremely fast processes that occur in complex systems, such as biological cells. Secondly, the Facility for Antiproton Ion Research (FAIR) is to be built at the Gesellschaft für Schwerionenforschung (GSI). This next-generation particle accelerator will deliver high-energy, concentrated ion beams capable of generating exotic atoms and antiprotons. Consequently, FAIR will be able to explore the nature of matter, in particular, quark-gluon-plasma. 60% of the financing for XFEL, whose total costs including staff amount to around 1,081m euros, will be contributed by federal government and the federal states. For the FAIR Project (with total costs including staff

amounting to 1,187m euros), federal government and the federal states have undertaken to provide 75% of the budget.
We are currently negotiating with our international partners on further financial contributions to both projects. These new international large-scale facilities are of outstanding significance for Germany's future as a centre of research, and for the Helmholtz Association as well. This is why the Research Field Structure of Matter has given the highest priority to realising these facilities. The scientific community is keeping a close eye on the new options that these offer. Completely new user groups are already forming, for example, an initiative on structural biology at XFEL in cooperation with the Max Planck Society, Hamburg University, and the State of Hamburg. Both large-scale facilities are of great strategic relevance to the Helmholtz Association and will contribute long term to further raising the Association's profile.
The building of a new research vessel to explore the Arctic has now been approved by the German Science Council. The "Aurora Borealis" is to be built as a European collaborative project and will not only be equipped with on-board labs, but also with a drilling rig. As an icebreaker, the ship could be used all year round in the Arctic to collect data on climate activity and geophysics.

Developing a "Helmholtz Brand"

In the past, the press and PR work done by members of the association focused mainly on the individual centres. This meant that the success achieved by one partner did not necessarily radiate across all the other Helmholtz members. This affected our ability to compete for financial resources and for outstanding young researchers. Because up-and-coming young scientists, in particular, seek specialisation in a subject area and a network in which they can advance their knowledge and their careers. The lack of a common image resulted in the Helmholtz Association not being appropriately recognised for its work or achievements, neither by the general public nor for that matter by industry, and especially in comparison and competition with other science and research organisations.
This is why the process of developing a "Helmholtz Brand" has become much more dynamic. Key importance attaches above all to integrating "Helmholtz" into the names of the centres. A new corporate design was also developed and has been placed at the disposal of all the centres. The Helmholtz Association Assembly of Members approved this policy at its meeting in April 2006. Nine Helmholtz Centres have meanwhile decided to change their names accordingly. In July, the German Research Centre for Biotechnology (GBF) in Braunschweig became the first centre to take on a new name. It is now called: Helmholtz Centre for Infection Research. Renaming also opens up opportunities for highlighting each centre's specific research field.

Creating a brand additionally serves to raise public awareness for the name of the Association's patron, the scientist and researcher Hermann von Helmholtz. He formulated his first main theorem of thermodynamics in 1847, his law "On the conservation of energy", and recognised the outstanding significance of thermodynamic theorems. Helmholtz was an enormously inquisitive, precise and versatile basic researcher. At the same time, however, he attached great importance to recognising applications whenever his research allowed. Speaking at a colloquium in Berlin in 1862, he said: "Working in the best interests of the whole nation and almost always on its behalf and at its expense, scientists seek to increase the knowledge and insights that can serve to enhance industry, wealth and the beauty of life, to improve the political organisation and moral development of each individual."
That is the mission of the Helmholtz Association. Working on behalf of society to contribute through scientific expertise to solving the grand challenges which face humankind, society and industry.

CURRENT PROJECTS FROM THE RESEARCH FIELDS

All six research fields are running numerous projects with partners from industry. This cooperation extends from knowledge transfer, contract research or jointly-developed products via patents and licences through to spin-offs.

SCIENTISTS ON BOARD THE RESEARCH SHIP PULL OUT A BUOY ATTACHED TO THE BREEDING BANKS. Photo: AWI/Bela Buck

OFFSHORE SEAWEED AND MUSSEL FARMS

Growing seaweed and mussels could become an interesting secondary use for the planned offshore wind farms in the German North Sea. Scientists from the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven are studying the potential of such cultures and have now harvested mussels and seaweed (in this case brown algae) of outstanding quality.

Wind energy is a growth market in Germany. The coming few years will see high-performance offshore wind farms built in the German Bight, North Sea. However, this will result in German fisheries losing many square kilometres of sea area. These areas will be placed off-limits and may only be navigated to carry out maintenance work. When marine biologist Bela Hieronymus Buck from the Alfred Wegener Institute heard of these plans around six years ago, he began to think about whether these areas had any potential for aquaculture and whether this might not be able to compensate the fisheries for their restrictions. Were, he thought, the solid concrete foundations of the windmills not ideally suited for fixing culture frames to breed and farm mussels and seaweed? And would such farming make economic sense? However, the rugged climate of the North Sea, the technical challenges as well as the conflicts of interest between the potential users turned the project into an adventure.

A first feasibility study by Bela Buck showed that the inshore breeding of mussels previously done along the coast could not be expanded – despite existing demand. On the one hand, the yields varied enormously, while on the other, serious conflicts of interest were seen between residents, fishermen and environmental protectionists about how the coastal area may be used. Alternative farming methods for mussels and other organisms had never before been considered on account of the rugged environmental conditions in the North Sea and would hardly have had a chance of being realised in the near-coastal waters and the competition with shipping, tourism or nature conservation. By contrast, the marine areas reserved for the wind farms offer opportunities for breeding various mussel and seaweed species in clean water away from the near-coastal crowding. Various organisms are already being cultivated in many countries today with various mooring systems – a method that would, however, have to be adapted to the rough conditions of the North Sea with its winter storms and strong tidal currents.

SCIENTISTS HAVE TO KEEP DIVING TO CHECK HOW THEIR SPECIMENS ARE DOING.

MUSSELS FROM THESE PILOT CULTURES HAVE A HIGH MEAT CONTENT AND ARE FREE OF PARASITES AND CONTAMINATIONS. Photos: AWI/Bela Buck

Environmentally-friendly aquacultures

Demand for seafood is high and increasing. Oysters and mussels are popular and healthy delicacies, while algae and algae products are needed above all in the food and cosmetics industries or in chemical and medical industries. In contrast to fish, mussels and seaweed can be cultivated without additional feedstuffs or drugs and with little labour, which means that the environment is neither burdened by increased food supplements nor by residues from vaccines. The all decisive factor, however, is the answer to the question of how quickly and of what quality the breeding candidates can grow on offshore sites. Because only if this is possible in economically-relevant, i.e. short, periods could the farming not only be scientifically interesting but also of interest to the fishing industry, for example as compensation for having their fishing grounds reduced to make way for the wind parks.

Good harvests from the pilot plants

To study this, the scientists established culture frames around the planned wind parks. On their monthly excursions there they took water samples and samples from the mussels. The settled mussels were then counted, their weight and growth rate recorded, and, finally, they were checked for parasites.

It was above all the common or blue mussels (*mytilus edulis*) that had settled on the test beds far from the coast that proved to grow between 1½ and 2 times faster than comparative mussels in near-coast banks and were, in addition, free from parasites. Sugar kelp (*laminaria saccharina*), a commercially-viable seaweed, was cultivated using a specially developed and patented breeding system, the so-called offshore algae ring. This brown algae that normally only grows naturally around Heligoland in the North Sea resisted the strong currents in the open sea and with good nutrient conditions proved to have very good growth rates in all test areas.

These results are encouraging and have initiated further projects that are now being put into practice in close cooperation with partners from business and industry, politics and administration, and science and research. For example, the culture techniques are now being further optimised for offshore use.

A quality analysis of the mussels bred locally aims to determine the water quality of a potential aquaculture region. Furthermore, precise measurements are needed on what forces act on the foundations of the windmills as a result of the combination of culture lines, currents and storms, because when fully developed, these several hundred metre long lines will often weigh several tonnes.

Set up offshore farms in good time

The Helmholtz scientists headed by Buck plan to inform potential operators of such offshore farms about the opportunities and risks involved and place offshore compatible technology, suitable breeding candidates and economic analysis methods at their disposal. Their work also enables them to identify in which areas of the North Sea the seafood products can best be farmed as a high-quality health food. The high quality of the seaweed and mussels produced to date might compensate for the higher production costs of offshore aquaculture. Even if the wind plants planned in Germany currently only exist on the drawing board, Buck is already working together with representatives of research and industry from Denmark, the Netherlands and Wales on turning the vision of top-quality seafood products farmed as a by-product of the wind parks into reality. “Of decisive importance is that we coordinate the multiple use of the marine areas now before the offshore wind plants are erected. Because only then will we be able to achieve synergies and will be able, for example, to develop foundation structures that are also capable of withstanding the additional loads caused by a culture line. That would not be possible with hindsight,” says Buck.

MATTHIAS BRENNER, Member of the Marine Aquaculture Research Group at the AWI

COMPARED WITH X-RAY BEAMS FROM A PARTICLE ACCELERATOR SUNLIGHT IS COLOURFUL AND DISORDERED. Photo: Getty Images

X-RAY FLASHES FOR MATERIALS RESEARCH

Accelerators are the giants of research – some versions are several kilometres long. They were above all developed for use in particle physics. But, researchers have also been using the storage rings as "super lights" for several years now to address applications-oriented questions, including those asked by industry.

When particles like electrons circle through an accelerator at almost the speed of light they become tiny headlights and emit an extremely bright x-ray beam called synchrotron radiation. This radiation is concentrated just like a laser beam, is much more intensive than the light emitted by conventional x-ray tubes and is very useful for "seeing through" materials, semiconductors or proteins.

Watching catalysts at work

Germany's largest synchrotron radiation laboratory is called HASYLAB and is located at the Deutsches Elektronen-Synchrotron in Hamburg (DESY). This "playground" is largely the preserve of basic researchers interested in the very smallest components of matter and in how these interact. However, industry, too, is gradually playing along as well. Three companies have meanwhile become long-term guests in Hamburg. Umicore from Hanau, Topsoe from Denmark, and the French Institute of Oil (Institut Français du Pétrole – IFP) pay an annual lump-sum to rent a specific quota of time for carrying out measurements on the storage ring. All three companies produce catalysts – substances that accelerate chemical reactions and so improve their economic usefulness.

A method called EXAFS has particularly attracted the companies' interest. EXAFS builds on the principle of experts firing x-ray flashes at a catalyst made of platinum, for example. The flashes dislodge one of the inner electrons from the atomic shell and ionise the metal. Decisive to this is that the process depends on what other atoms surround the platinum – a key basic insight for manufacturers. What is particularly interesting is that the catalyst can be studied under operating conditions as it were, for example, at temperatures of several hundred degrees Celsius and in a realistic chemical environment. This enables the industrial researchers to find out exactly why a certain catalyst works better in everyday operation than another.

DOCTORAL STUDENTS EXAMINING PROMISING FUTURE TOPICS AT HASYLAB. Photo: DESY

BETTER CATALYST TECHNOLOGY IMPROVES INNER-CITY AIR. Photo: Getty Images

The catalysts being studied at HASYLAB serve quite differing purposes. Topsoe is developing molecular aids for the chemical industry. The IFP provides the petrochemical industry with catalysts that desulphurise crude oil and natural gas. Last but not least, Umicore concentrates on the perhaps most well-known use of catalysts – namely the catalytic converters in the exhaust systems of every petrol or diesel driven vehicle (see below).
Other companies rent time on the superbeam in Hamburg to carry out special single measurements. They study materials to be used in aircraft engineering or in drill heads for the mineral oil industry to specifically identify so-called internal or residual stresses. These may occur during welding, for example, and may possibly form undesirable weak spots. Other companies capture crystallised protein molecules in the concentrated intensive x-ray beam in order to explore their structure down to atomic detail. Their goal is to collect measurement data as a basis for gaining a better understanding of diseases and for developing new and more effective drugs.
What is certainly clear is that industry has not yet fully exhausted the potential that synchrotron radiation holds. "Many industrial researchers don't know what fantastic opportunities this x-ray source provides," believes HASYLAB physicist Thomas Wroblewski. But that is to change. At present, it is above all the storage ring DORIS that is "alight" in Hamburg. But with a circumference of just under 300 metres, "she" is one of the smaller facilities. As from 2009, a much brighter x-ray lamp will shine. The converted PETRA ring – a good two kilometres in circumference – will not only light up the darkness for the basic researchers, but will also increasingly do so for scientists from industry as well.

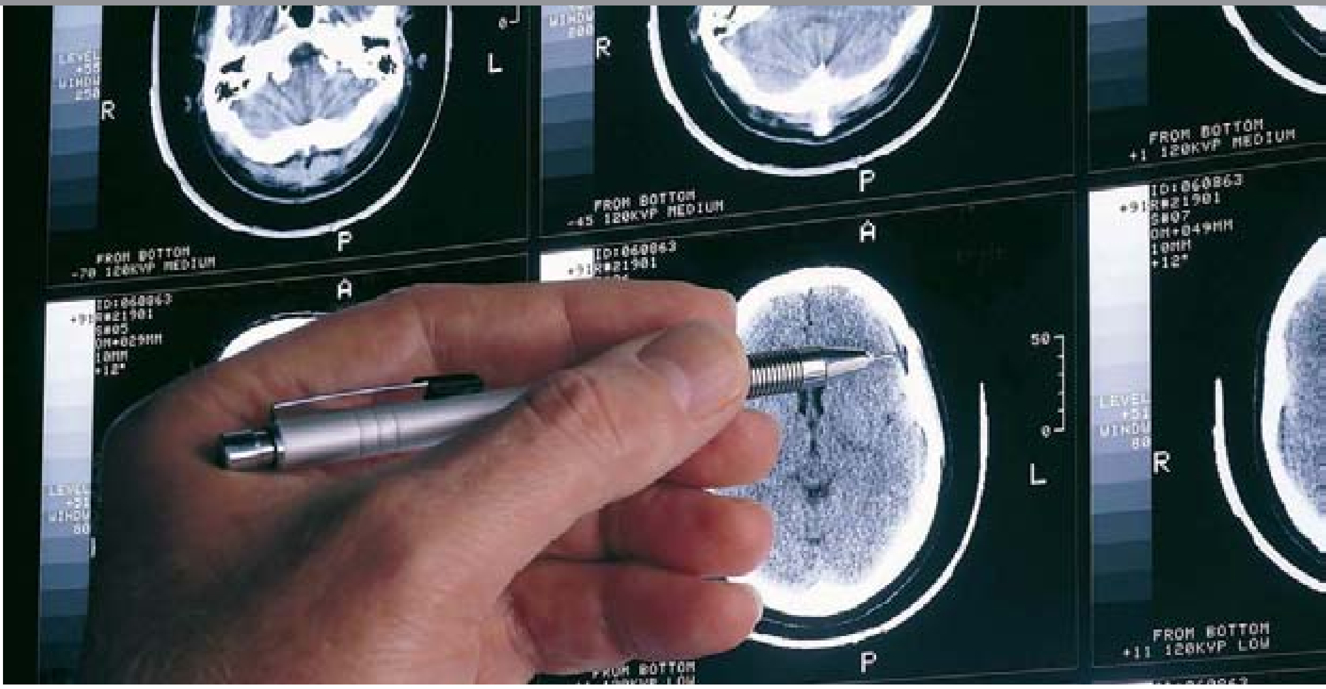
The next stage is XFEL

The planned free electron x-ray laser XFEL could also prove to be of interest for industry. The new large-scale facility for light-based research is being built together with European partners in the Pinneberg district, affiliated to DESY. With a length of 3.4 kilometres, XFEL will be the world's longest artificial light source. As from 2013, XFEL's x-ray flashes will be used to film chemical reactions, to unravel the atomic details of molecules, and to take three-dimensional images of objects in the nanocosm.

FRANK GROTELÜSCHEN, Science Journalist, Hamburg

X-rays set their sights on car catalysts

The catalytic converters used in car exhaust systems not least convert the highly toxic carbon monoxide into non-toxic carbon dioxide (CO_2). Synchrotron radiation will enable experts to find out what exactly happens in the process – and so create an important basis for improving the way these converters work. A diesel catalytic converter, for example, is made up of a honeycomb-like ceramic base interspersed with countless channels coated with platinum as the active component. The carbon monoxide attaches to the platinum. The precious metal accelerates its conversion into CO_2, but itself remains completely unaffected by the whole process. To study the ageing effects, scientists compared "used" cats with brand-new ones and identified clear differences in the atomic structures of new and old cats. EXAFS and the derived scientific methods open up insights into the ageing phenomena that cannot be achieved by conventional methods or, if so, only with great effort. This understanding makes it possible to make the cats more efficient and durable.



TUMOUR DIAGNOSTICS DEPEND ON IMAGING METHODS SUCH AS MAGNETIC RESONANCE IMAGING – EACH IMPROVEMENT BENEFITS PATIENTS. Photo: ImageSource

RESEARCH MEETS BUSINESS

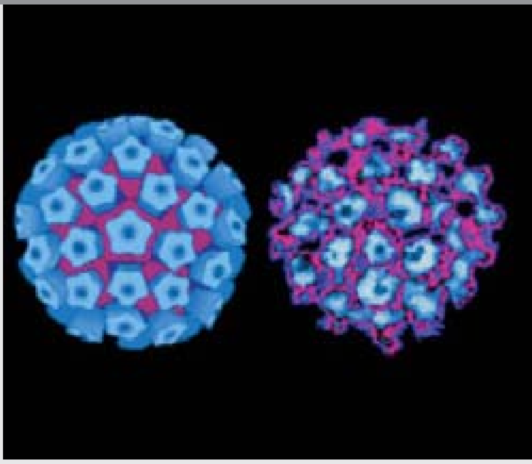
One of the world's exemplary partnerships was initiated in August 2006. The German Cancer Research Centre (DKFZ) in Heidelberg and Siemens AG plan to invest 20m euros over the next six years to expand their cooperation in the field of tumour diagnostics.

The two partners will also study possible applications of high field magnetic resonance imaging with field strengths of up to 7 teslas and so capable of producing even more precise information on tumours. "Despite major advances, we are still a long way from having exhausted all the potential that radiation physics offers oncology," says Professor Otmar D. Wiestler, Chairman of the Board at the DKFZ. The DKFZ and Siemens AG consequently joined forces in early 2006 to form a strategic alliance to drive progress forward to the benefit of the patients. The two partners are now working together to improve imaging methods such as Magnetic Resonance Imaging (MRI), Computer Tomography (CT) and Positron Emission Tomography (PET) so that the computed images provide even more precise information for diagnosis and radiotherapy planning.
DKFZ and Siemens will be investing more than 20m euros in the next six years. The insights and knowledge on the type and position of tumours acquired from the combined image data will be much more precise and will make it possible to treat each patient on an individual basis: maximum benefit with minimal side-effects. It will even be possible in the future to identify and treat the spread of individual cancer cells in the form of lymph nodes or distant metastases, making it easier to assess the biological aggressiveness, i.e. the growth and the likelihood of tumour metastasis.

Competencies in a "one-stop shop"

The Integrated Diagnostic and Therapeutic Centre (IDTC) which the DKFZ plans to establish together with Siemens will have a particular role to play. The competencies for all available radiological measures – from the tumour's initial diagnosis and biological characterisation via therapy planning through to monitoring the course of treatment – will be pooled in a one-stop shop.
"In this respect, the IDTC profits from the excellent synergy produced by combining DKFZ expertise in tumour diagnosis and

TO TAKE THE IMAGE, THE PATIENT IS FIXED AND MOVED INTO THE MRI UNIT. Photo: Siemens



COMPUTATIONAL MODELS OF HUMAN PAPILLOMA VIRUSES USING DATA FROM CRYO-ELECTRON MICROSCOPY. Photo: Linda M. Stannard

therapy with Siemens technological know-how as the market leader in medical imaging," says Professor Wolfhard Semmler, Coordinator of the Innovative Diagnostics and Therapy Research Centre and driving force on the DKFZ side of the alliance.

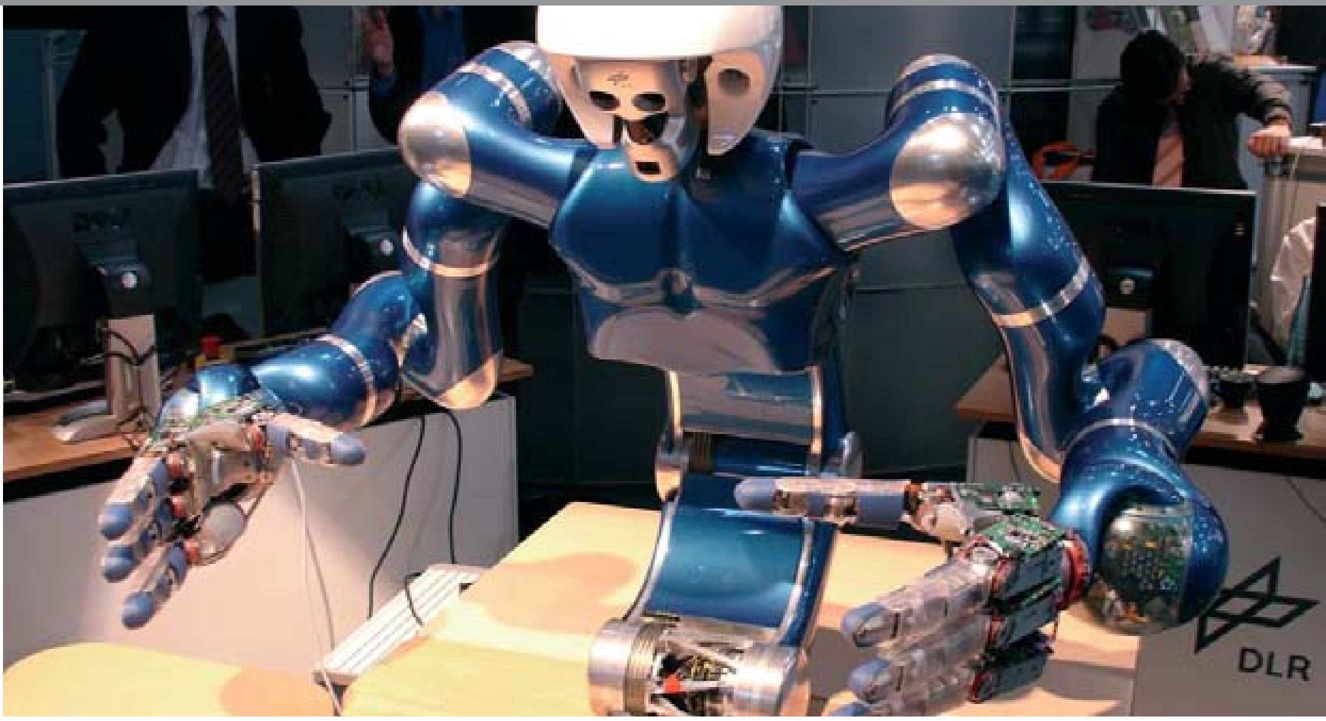
Using high field strengths to see more

One major step, however, that had also already proven itself in earlier collaborative developments is the alliance with Siemens AG in the field of high field MRI. This is special because Siemens not only introduces its latest prototypes into the alliance but also a seven tesla magnetic resonance imaging device. The partners plan to use this to explore the potential of very high field strengths in oncology. The position, area, structure, vascular supply and metabolism of a tumour can be seen in much greater detail than in the past. "This will make it possible in the future to optimise imaging down to molecular level and so make cancer diagnosis much more precise," says Otmar D. Wiestler. Nevertheless, magnetic resonance imaging at seven teslas also has a number of risks attached to it. "The higher absorption at this field strength is more likely to lead to overheating of the tissue and other side effects," explains Wolfhard Semmler. However, the benefits will outweigh the disadvantages for some types of tumours; scientists are already working on a corresponding risk-benefit assessment. For its part, the Cancer Research Centre is introducing its enormous wealth of research and scientific expertise into the alliance. In return, the DKFZ scientists get access to the very latest scanner generations together with opportunities to continuously improve and develop the hardware and software for these machines. The close ties with the National Tumour Disease Centre in Heidelberg mean that the latest clinical questions can be examined under ideal instrumental and staffing conditions, making it possible to transfer new findings and insights into clinical practice even more quickly.

DAGMAR ANDERS, DKFZ

A CANCER VACCINE

Sometimes, the process from basic research findings to major breakthrough can take decades. It has been known for over 40 years that certain high-risk viruses trigger cervical cancer, the world's second most common form of cancer among women. Soon, however, a vaccine against human papilloma virus (HPV) sub-types will be available for pre-puberty girls. These sub-types are transmitted through sexual intercourse and are widespread. Professor Dr. Dr. h.c. mult. Harald zur Hausen recognised and proved the connection between viral infection and cancer disease; his colleagues, Professor Dr. Lutz Gissmann and Professor Dr. Matthias Dürst from the German Cancer Research Centre in Heidelberg (today Jena) laid the foundation stone for developing the HPV vaccine which has now successfully passed the clinical trials and was approved in the United States in June 2006. Pharmaceuticals company Sanofi Pasteur MSD will soon introduce the vaccine in Germany as well.



ROBOT TORSO JUSTIN WAS THE UNDISPUTED STAR AT THE AUTOMATICA 2006 EXHIBITION. Photo: DLR

FROM SPACE TO EARTH: ROBOT HANDS WITH A SENSE OF FEELING

In the last five years, Germany's leading robot manufacturer KUKA has risen from 13th to 3rd in the world ranking. A success in which Helmholtz researchers played a decisive role.

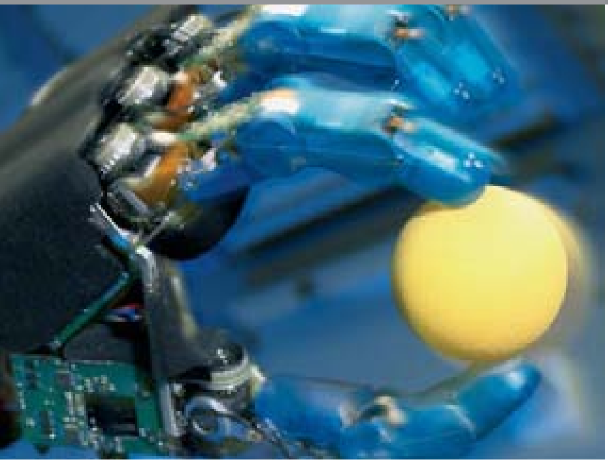
Gerhard Hirzinger and his team from the Institute of Robotics and Mechatronics at the German Aerospace Centre (DLR) in Oberpfaffenhofen developed the optimising methods that today make KUKA robots 30% faster than their competitors. While the robot gripping device (hand) is at work, a programme simultaneously computes the forces at work and so "knows" how quickly it is allowed to move along its path without overloading the joints. KUKA robots improve their own control parameters practically overnight by running through their movement options and optimising their paths. KUKA robots are used in industry today to perform a wide and diverse range of tasks.

The Helmholtz scientists headed by Professor Hirzinger are developing "soft robotics" for the future. The new robotic arm that KUKA is now manufacturing in a first small series production run differs fundamentally from conventional robot arms that perform their pre-programmed tasks "come what may" and so are only allowed to work where no humans are present. The arm avoids obstacles, responds appropriately with its torque control to counterforces and is easy for humans to control. This means that it is able to learn new movement patterns, whether tricky assembly jobs or simply wiping down a table. "Those are characteristics that create confidence, only arms like these can be used in rooms in which humans are present," says Hirzinger.

New internal workings for more power and sensitivity

The robotic arm is not only more sensitive and agile (seven degrees of freedom rather than six) but is also a lightweight. Although it only weighs 13 kilograms, it can lift loads of up to just under 20 kilograms, while consuming just 150 watts of energy. Predecessors weighed almost 40 kilograms and used twice as much energy.

All this has been made possible by novel internal workings. The specially-developed multipolar-internal drive motor ROBODRIVE



THE SENSITIVE HANDS EVEN HOLD SOFT OBJECTS. Photo: DLR

only weighs half as much as the motors otherwise used and converts its performance more efficiently. The complex control electronics are also built into the arm. The team headed by Professor Hirzinger has meanwhile won several prizes for the sophisticated engineering, a world leader, as well as for the futuristic design.
To go with the arm, the mechatronics scientists have now designed a 4-finger hand with 13 degrees of freedom that is even able to carefully pick up a raw egg or forcefully turn screws. “We thought long and hard about how many fingers are needed. You can hold an apple with three fingers but you can’t turn it. With four fingers all this is possible. The fifth finger is not absolutely essential,” explains Hirzinger.

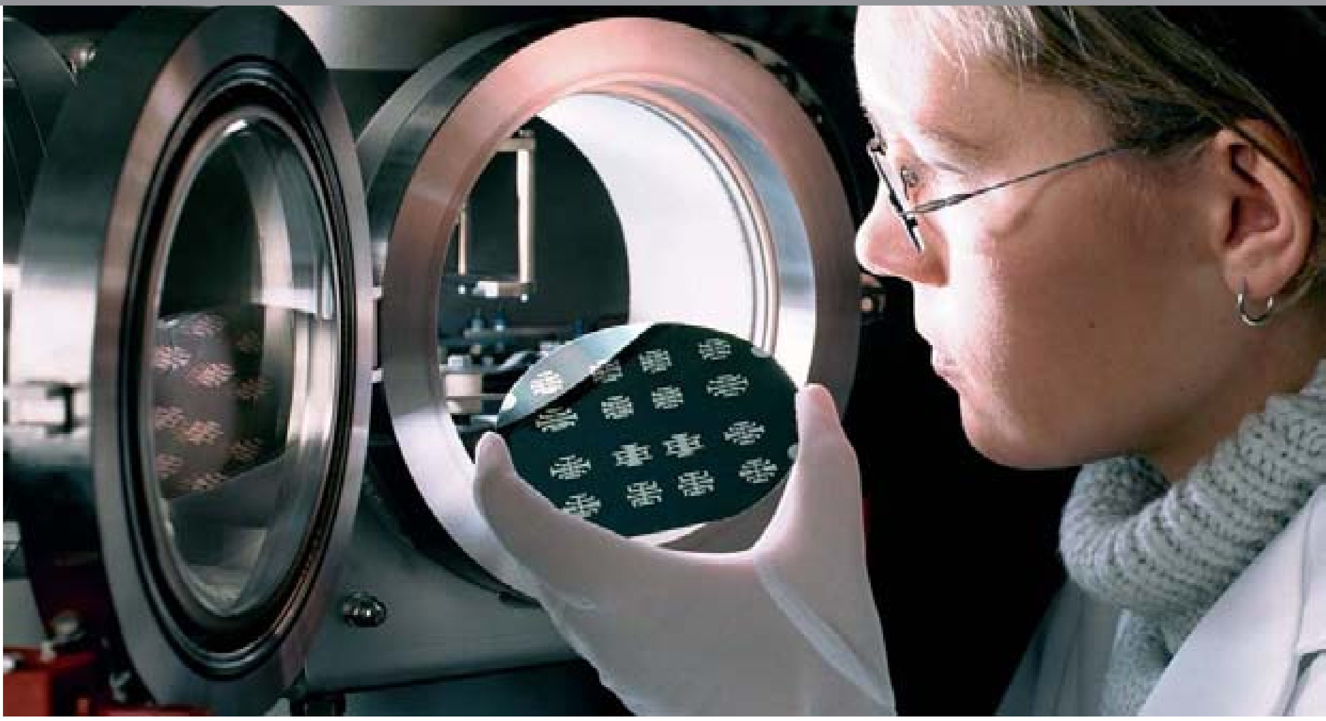
Justin’s a talented all-rounder

The scientists caused quite a stir at the latest robot exhibition AUTOMATICA in Munich. The two-arm robot torso Justin handled three balls simultaneously, poured out drinks, without spilling a drop, and also carried a crate of drinks. Such masterful performances succeed because Hirzinger’s team has acquired many years of experience.
Back in 1993, a ROTEX gripper attached to the outer shell of the Space Shuttle Colombia was already remote controlled by a “Spacemouse” also developed by Hirzinger and his staff. Basically, the Spacemouse makes it possible to intuitively control a three-dimensional object, whether a gripper or a computer graphic. “You act as if you were holding the object in your hand and were able to move it,” explains Hirzinger. Today, the Spacemouse is marketed by 3D Connexion under a DLR licence and is used by almost all automotive designers. The robot grippers (hands) produced by KUKA can also be controlled with a Spacemouse. What has proven itself in space is now being optimised so that, in a few years, it may even be useful for applications in normal domestic households.
ANTONIA RÖTGER, Helmholtz Association

IN THEIR FIELD CAMPAIGN, THE DLR RESEARCHERS USED A ZEPPELIN EQUIPPED WITH ATOMIC CLOCKS AND OTHER INSTRUMENTS. Photo: DLR

FIELD CAMPAIGN FOR GALILEO

Signal precision is what the European SatNav project GALILEO is all about. Even the slightest delay in signal arrival at the receiver due, for example, to reflections causes major errors: one microsecond equals 300 metres. The German Aerospace Centre (DLR) carried out a unique worldwide field campaign to guarantee the precision and reliability of the positioning and time services offered by GALILEO.
A Zeppelin airship simulated the satellite. Atomic clocks on board the Zeppelin and the measuring vehicle at ground level ensured, together with extensive sensors, such as laser-based gyroscopes, video cameras and synchronisation devices, that the signals were measured with great precision. 60 scenarios were run with different environments (city, suburbs, country), satellite positions (5 to 80 degrees) and respective user applications (vehicle, pedestrian, etc.). The knowledge gained from the measurements is now being fed into corresponding receiver algorithms that have been specially developed to make GALILEO a uniquely exact positioning system for civilian applications. Further measurement scenarios for applications in rail transport and inside buildings have already been planned.
CORDULA TEGEN, DLR



WORKING AT PETER GRÜNBERG'S LABORATORY, A RESEARCH ASSISTANT PUTS THE FINISHING TOUCHES TO THE SANDWICH STRUCTURES (ON THE WAFER). Photo: FZ Jülich

GIGABYTE HARD DISKS THANKS TO GIANT MAGNETO RESISTANCE

The European Patent Office and the European Commission honoured Professor Peter Grünberg from the Research Centre Jülich with the "European Inventor of the Year Award" in 2006 in recognition of his work in discovering giant magneto resistance, which led to the breakthrough in gigabyte hard disks.

Today, this effect is used in more than 90% of all hard disks manufactured. The European Inventor of the Year Award was presented for the first time in 2006. A committee made up of representatives of industry, research and politics selected patent registrations of recent years that had successfully managed the leap from research to application – and finally decided in favour of the Giant Magneto Resistance or GMR effect, discovered by solid state physicist Peter Grünberg as early as in 1988. Because a hard disk stores digital information in the form of small magnetic areas in the smallest space. Sensors which use the GMR effect are capable of reading even smaller magnetic patterns, because they are much more sensitive – and this resulted in the storage capacity of hard disks increasing enormously.

Triple-layer sandwich

The basis for the discovery of the GMR effect was provided by work done by Grünberg and his staff in the 1980s on microscopic structures built like triple-layered sandwiches: set between two magnetic iron layers just few atoms thick was a non-magnetic layer made of chrome. Depending on the thickness of the chrome layer, the magnetic moments of the two iron layers join with each other. They are either parallel or antiparallel. Even very weak magnetic fields, as occur in the magnetic patterns of the hard disk, affect this coupling. The clou is that when the magnetic moments in the microscopic sandwich switch, the electric resistance becomes almost twice as strong – hence the name Giant Magneto Resistance.

THE VARIOUS MAGNETIC DOMAINS OF THE MICROSANDWICH ARE CLEARLY RECOGNISABLE IN THE FALSE COLOUR IMAGE. Photo: FZ Jülich

Grünberg recognised that this effect can be used for highly-sensitive magnetic field sensors; tiniest fields already produce a clear signal.

From lab to industry

That also convinced industry. As early as in 1997, IBM brought a GMR reading head for computer hard disks to market – seldom has a basic research discovery moved so quickly into industrial production. More than ten international companies are meanwhile licensees of the patent and have produced revenues of double figure millions for the Research Centre. The GMR effect has long found its way into improved reading heads for hard disks, video tapes and MP3 players all around the world. In addition, GMR layer packages can also be used in the ABS systems of cars and in the future will be used to read biochips as well. Furthermore, the GMR effect opened the door to a completely new research area: spin(elec)tronics. Along with the charge, spin is the essential property of an electron. Its use could revolutionise the whole field of microelectronics.

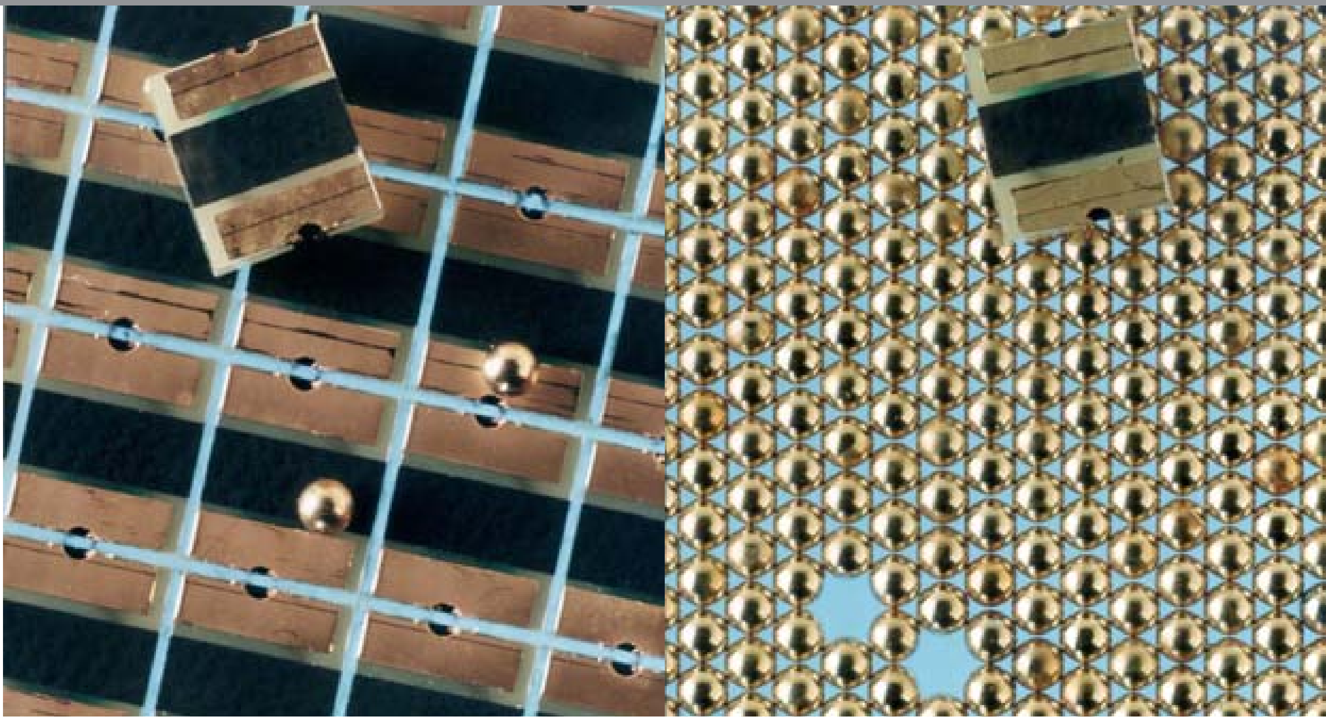
Although the award winner attained emeritus status in 2004, he remains true to the research centre. He can often be found at his office or on campus. Peter Grünberg sees retirement more as a fluid transition. Physical processes have always interested the physicist, who was born in Pilsen on 18 May 1939. His colleagues respect and like Peter Grünberg. Magnetic phenomena are really close to his heart and he always wants to get right to the bottom of them. “He almost compels you to really understand physics,” say his colleagues.

KOSTA SCHINARAKIS, FZ Jülich

THE NEW GLAZING LETS MORE LIGHT REACH THE PLANTS AND SAVES ENERGY. Photo: FZ Jülich

GREENHOUSES WITH INTELLIGENT GLASS ROOFS

Actually, the researchers headed by Professor Ulrich Schurr from the Institute for the Chemistry and Dynamics of the Geosphere at the Research Centre Jülich were interested in how plants adapt to changing environmental influences and how this can be used to encourage them to produce new constituents. To be able to do this, however, the scientists needed a new technology for greenhouses that they developed in several projects run together with partners from industry. Together with glass specialists Centrosolar Glas Fürth, a new highly-transparent glass was developed for greenhouses that allows up to 97% of the light through. This means that the plants receive up to 10% more light. The low-iron glass additionally allows up to 35% of UV-B into the greenhouse – radiation that is completely filtered out by conventional glass but is important for plant growth and plant constituents. Now, researchers – funded by the Federal Ministry of Education and Research (BMBF) – are studying what practical consequences this innovation holds. Energy saving was the goal of another development run together with three companies Centrosolar, Siedenburger Gewächshausbau and 3M. The project team made up of researchers and horticultural practitioners invented a switchable, transparent thermal insulator. This involves a highly-transparent film being stretched across the pane of glass and the interspace being inflated to form an insulating air cushion. The State of North-Rhine Westphalia recognised this development by awarding the Environment Prize for Horticulture 2006 to the researchers from Jülich and their industrial partners. This innovation is now being developed into an application within the scope of a BMBF collaborative project involving Jülich, a horticultural company and the University of Hannover.



STRUCTURED CIRCUIT BOARD, TIGHTLY APPOINTED WITH MICROSWITCHES. NEXT TO IT THE GOLD-PLATED STEEL BALLS. Photo: Sensolute

CLEVER LITTLE SWITCH SAVES ENERGY

Batteries could last up to ten times longer if devices were able to switch themselves off automatically as soon as they were no longer needed. Scientists at the Forschungszentrum Karlsruhe have developed an intelligent solution. They now plan to transfer their research into practice with a company called Sensolute.

Cycle lights, hearing aids, toys – the battery is generally quickly exhausted. Because who really always remembers to switch the device off? Professor Dr. Hartmut Gemmecke and Dr. Thomas Blank from the Institute of Data Processing and Electronics (IPE) at the Forschungszentrum Karlsruhe have developed an irresistibly simple solution: a microvibration switch that responds to the slightest movements. Inside the switch lies a cleverly–structured system with a cavity through which the gold-plated steel balls can roll. Like a tennis ball they travel back and forth between two gold-plated contacts, thereby closing an electric circuit. But when the switch is completely motionless, the electric circuit opens and so saves energy. “Batteries last ten times longer,” explains Hartmut Gemmecke. Although the switch is a high-tech product, it can nevertheless be produced at low cost. “We use exactly the same circuit boards and production methods as found in mass production electronics,” says Blank. The circuit boards are manufactured locally, while the gold-plated steel balls with a diameter of about 0.8 millimetres are outsourced. The IPE then cuts each of the circuit boards into 1024 individual switches, and automatically tests and sorts them. Compared with silicon-based accelerometers, these microvibration switches come at an unbeatable price.

Start-up with support

Because the idea translated so quickly into a concrete product, Gemmecke and Blank are now establishing a limited company called Sensolute GmbH. “We want to start up the company but still remain at the FZK,” says Gemmecke. For first time, the FZK, with a 20% share, is also a partner in a spin-off. The Helmholtz programme to facilitate spin-offs from research institutions (EEF-II) provides funding to pay for a staff member to do the marketing. “We now have inquiries for around 2 million units,” says Dr. Jens Fahrenberg from the Marketing, Patents and Licensing Unit at the FKZ, which supports the spin-offs.

The first mass market to emerge was rear cycle lights. Equipped with the micro switch and a photosensitive sensor, they light up as soon as the bike is used in the dark. If it is left somewhere,

INDIVIDUAL SWITCHES NEXT TO A FOUNTAIN PEN TIP. Photo: Sensolute

SUPERCONDUCTING HIGHEST FIELD MAGNETS EXAMINED THOROUGHLY ON THE HOMER 2 TEST BED AT THE INSTITUTE FOR TECHNICAL PHYSICS. Photo: Forschungszentrum Karlsruhe

the light automatically switches itself off after 30 seconds. Previously, battery powered rear lights mostly had a mercury switch that closed the circuit when the bike was ridden. As from 2007, switches like these will be prohibited in Europe for environmental reasons. Because when the bike is scrapped, the switches generally land on the rubbish dumps. “But as so often, the real devil was in the detail. For example, how to find the right adhesive and surface solutions to protect the sensitive electronics from moisture, even when the bike is left outside,” explains Gemmecke.

Lost of different applications

But rear bike lights are only one of the many products to which Sensolute can contribute the tiny vibration switches. Movement sensitive switches like these can also be used for tracking people, be it children or for professional purposes. Position signals are only transmitted whenever the carrier of a SatNav detector moves. If the person remains at one place, the position request intervals become longer, also saving battery power. Further potential applications include irons that automatically switch themselves off and toys. A microvibration switch for hearing devices would make the tiny on/off switch, which older people sometimes find difficult to use, completely redundant. Furthermore, people often forget to switch off their hearing aid when they put it down somewhere – resulting in the tiny coin cells being empty when the user needs the device again. Hearing aid users can even lie down on a couch, because the movement caused by breathing is enough to keep the circuit closed. Only when the device lies still on the bedside table will it switch itself off.

ANTONIA RÖTGER, Helmholtz Association

TOP-RATE MAGNETS FOR RESEARCH AND INDUSTRY

Theo Schneider and colleagues from the Institute for Technical Physics at the Forschungszentrum Karlsruhe are developing superconducting coils capable of generating highly homogenous and temporally stable magnetic fields of extremely high field strengths. Two Nobel Prizes have been awarded in recent years for work on nuclear spin spectroscopy, while a derived diagnosis method is in widespread use in medicine as well, nuclear spin resonance imaging, also known as magnetic resonance imaging (MRI). Scientists at Karlsruhe have also been working together with the company Bruker Biospin for more than 20 years now specifically on developing superconducting coils for nuclear spin spectrometers. This close cooperation has resulted in Bruker Biospin becoming a technology leader; they have repeatedly brought globally unique high-performance machines to market. The revenue generated through licences meanwhile amounts to around 5m euros for the Forschungszentrum Karlsruhe. “We’ve developed superconducting switches and superconducting contacts and so are able to generate a quasi-stationary field that would hardly change at all over 100,000 years,” explains Schneider. The researchers are currently working on superconducting coils made of a bismuth compound that generate magnetic fields of 23.5 teslas – a new record for highly-stable, spatially homogeneous fields. “The higher the field, the better the resolution,” explains Schneider.

PRACTICALLY THE WHOLE NORTH GERMAN PLAIN HAS A SUBTERRANEAN LAYER CAPABLE OF STORING CARBON DIOXIDE. SCIENTISTS ARE NOW TESTING THIS IN KETZIN. Photo: PLANETOBSERVER.COM

RESPITE FOR THE CLIMATE

Geoscientists want to store carbon dioxide from fossil fuel power stations in porous subterranean rock and are now testing the potential of this technology in Ketzin, Brandenburg.

The idea sounds simple enough. Could we slow down global warming if power stations were able to capture the greenhouse gas carbon dioxide produced when burning coal, oil or gas? Then they would only have to store the non-toxic gas so securely that it cannot escape into the atmosphere over the coming millennia, where it would aggravate the greenhouse effect. Such brilliant sounding ideas generally have more than one catch to them: firstly, it is neither easy nor cheap to separate the greenhouse gas from the post-combustion chimney exhausts. Secondly, although suitable reservoirs for storing carbon dioxide certainly exist, the question of how to get the gas into depots and whether it can be kept there safely and securely for many thousands of years has not yet been adequately studied.

It is precisely this deficit that the GeoForschungsZentrum (GFZ) in Potsdam is trying to address in the EU project CO_2SINK. Because time is pressing. The planning and construction work for two German coal-fired power stations designed to be able to capture the greenhouse gas before it flows into the air are already moving apace. As soon as they come online, the corresponding reservoirs and geological storage technology will have to be available to stockpile the carbon dioxide.

Nature itself actually has such subterranean gas reservoirs. “After all, natural gas has already been safely stored in such deposits for many thousands of years,” reports GFZ researcher Günter Borm, coordinator of the CO_2SINK project.

Sandstone layers as reservoirs

Good candidates for geological carbon dioxide storage include porous layers of rocks in which large volumes of gas can be stored in tiny cavities. However, these additionally have to be geologically sealed by a layer of clay. Practically the whole of the North German Plain between East Friesia and the Polish border has suitable rocks with potential for such reservoirs.

Would such a depot remain geologically sealed, even long term? This is exactly what the GFZ Potsdam is testing in the surroundings of the small town of Ketzin, west of Berlin. Back in East German days, town gas was already stored in the porous rock layers in the summer. In the winter months, it was brought back to the surface

CO_2 FROM COAL-FIRED POWER STATIONS TO BE CAPTURED AND STORED IN SUBTERRANEAN RESERVOIRS. Photo: laif

GEOSCIENTISTS RELY ON DRILL CORES TO STUDY THE EARTH'S CRUST. Photo: GFZ

as fuel. CO_2SINK, however, goes deeper: 700 metres below the surface lies the porous rock layer that is to be tested as a carbon dioxide reservoir.
In the future, several trucks each loaded with more than 20 tonnes of liquid carbon dioxide will arrive each day. The liquid gas will first be kept in intermediate tanks. Later, it will be heated to turn it back into gas and then pumped deep into the ground at a temperature of around 30°Celcius and a pressure some 75 times higher than the air pressure in Ketzin. At this high pressure, the carbon dioxide becomes a supercritical fluid. This is what physicists call a substance that has the density of a liquid but expands like a gas in the minute rock pores. The GFZ researchers subsequently take measurements in the reservoir itself, in the overlying rock, in the boreholes and on the earth's surface to see how the carbon dioxide acts underground. These measurement techniques are being developed as part of the CO_2SINK project.

An integral part of climate protection

Neatly separating carbon dioxide from the air and transporting it to the depot currently costs around 70 euros per tonne. However, the European Union hopes that this price can be reduced to below 20 euros in the future. It then costs around 7 euros to inject one tonne of carbon oxide into the subterranean ground. Climate researchers working on behalf of the United Nations estimate that 2,000 billion tonnes of carbon dioxide could be stored underground in various parts of the world with this method. That is 70 times more carbon dioxide than is currently emitted into the air every year around the world as a result of burning fossil fuels. The GFZ project is especially practical because the carbon dioxide can be retrieved under controlled conditions. In fact, CO_2 is actually a valuable resource. It is needed to conserve foods, to fill fire extinguishers, to make foamed cream from a can or to produce sparkling water. "We have to undertake many measures to slow down the climate change caused by greenhouse gases. For example, we should use energy more efficiently, expand the range of renewable energies, and store the carbon dioxide produced by burning," says Günter Borm.
ROLAND KNAUER, Science Journalist, Lehnin

THE MULTI-TALENTED INNOVARIG

Exploratory drilling is essential to modern geosciences. Like a "microscope inside the earth" it provides direct insights into fundamental processes taking place within System Earth. But such drilling also helps answer questions like the availability of resources (natural resources and deposits, geothermal energy, water) or the use of subterranean areas. The experience gained by the GeoForschungsZentrum (GFZ) through its research work all around the world has shown that no drilling rig on the market is capable of meeting the special requirements of geosciences and geotechnical projects.
This is why the GFZ experts headed by Professor Rolf Emmermann have now developed their own drilling rig "InnovaRig" that meets all the requirements of exploratory drilling. At the same time, InnovaRig is also capable of carrying out contract drilling for industry. The rig is easy to transport and offers cheap drilling up to depths of 5,000 metres.
The engineering designers attached particular importance to ensuring that the environment is affected as little as possible by the drilling work. The specialist German company Herrenknecht Vertical GmbH was commissioned by the GFZ Potsdam with building the rig, while another company, H. Angers Söhne Bohr- und Brunnenbaugesellschaft mbH, will operate it. Despite the highest technical requirements, InnovaRig is expected to be ready for operation as early as at the end of 2006 and will then "drill deep holes" to serve science and research for at least 15 years.

GKSS RESEARCHERS ABOARD THE "TOR MAGNOLIA" ARE TESTING NEW COMPUTATIONAL MODELS FOR WIND AND SWELL. Photo: DFDS

RESEARCH STEERS OCEAN-GOING GIANTS

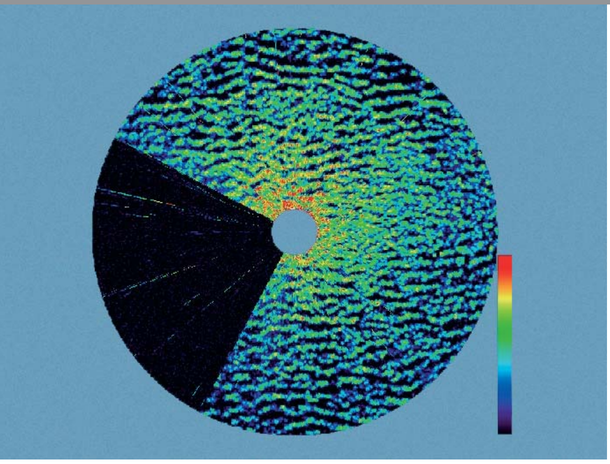
Newly-developed software and measuring devices help captains make navigation decisions. Helmholtz researchers are making shipping safer.

Modern cargo ships are enormous, some of them over 300 metres long. This asks a lot of both captain and first mate. Much as truck drivers, they too are under pressure to optimise costs. Wrong decisions can result in expensive delays or even damage to the ship or its load. This is why an EU project called ADOPT (Advanced Decision Support System for Ship Design, Operation and Training) has been running since April 2005. Working in an international team, researchers are developing a system that aims to help the captain run his ship and enhance the safety of ship and environment. The Forschungszentrum Geesthacht (GKSS) and OceanWaveS GmbH, a spin-off from the GKSS, are both "on board" in this project.

Many factors play a role in deciding which course is the best for a heavily-laden giant of the seas: swell, current and wind, and the ship itself, its cargo and how it reacts. The captain has to know and assess all these factors to guide his ship to its destination safely and quickly. " ADOPT aims to give navigators valuable decision-making aids," says Dr. Heinz Günther, who coordinates the GKSS contribution. The system of measuring instruments and software initially records the latest environmental data such as swell and wind directly from on board the ship. These are fed into computational models that compute the behaviour of the ship and the surrounding sea. The result is a real-time risk assessment. If necessary, the system will also suggest course or speed changes to reduce any risk. This enables the captain to decide quickly on the basis of the latest data, even under heavy weather and poor visibility.

Swell chart produced every two minutes

Measuring swell is an important part of the project. OceanWaveS GmbH provided the necessary measuring system WaMoS II. This is connected to a standard issue X-band radar device as already found on-board most ships. The radar beam scans the water surface and delivers real-time images of the waves within a radius of around 3 kilometres. The system does this by measuring swell features such as wave height and direction and displays them on a monitor once every 2 minutes. The data are currently measured



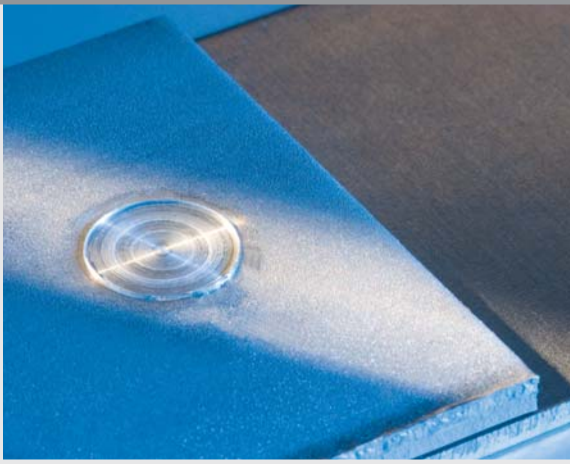
WAMOS II PRODUCES A SEQUENCE OF 32 RADAR IMAGES ONCE EVERY TWO MINUTES. WAVES ARE DEPICTED AS STRIPES OF HIGH (RED) AND LOW (BLACK) RADAR ECHOS. Photo: GKSS

onboard the "Tor Magnolia" and are fed into the system being developed under ADOPT. However, WaMoS II does not make any predictions. "WaMoS II is a real-time system," says Ina Tränkmann, engineer at OceanWaveS. It will be used on large ships and on oil platforms. The measuring system makes it possible to determine the exact height of the wave. On oil-drilling platforms, this means better protection for workers. OceanWaveS Gmbh is based in Lüneburg, has nine staff and is now marketing WaMoS II worldwide. A subsidiary has just been set up in New Zealand: OceanWaveS Pacific Ltd.

More safety at sea

Under the ADOPT programme, Helmholtz researchers from Geesthacht are cooperating closely with shipbuilders Flensburger Schiffbau GmbH, who, together with Danish shipping company DFDS, made the "Tor Magnolia" available as a research platform while the ship continued with its regular service. The Hamburg University of Technology (TUHH) produces the modelling computations for ship behaviour. Other partners come from Denmark, Norway, Greece and Britain. The 3m euro project is scheduled for completion in March 2008. The planned system promises greater safety at sea for passengers, crew and cargo. It will not only help everyday operations, but will also assist with training sailors and building future ships.

CLAUDIA RATERING, Science Journalist, Münster

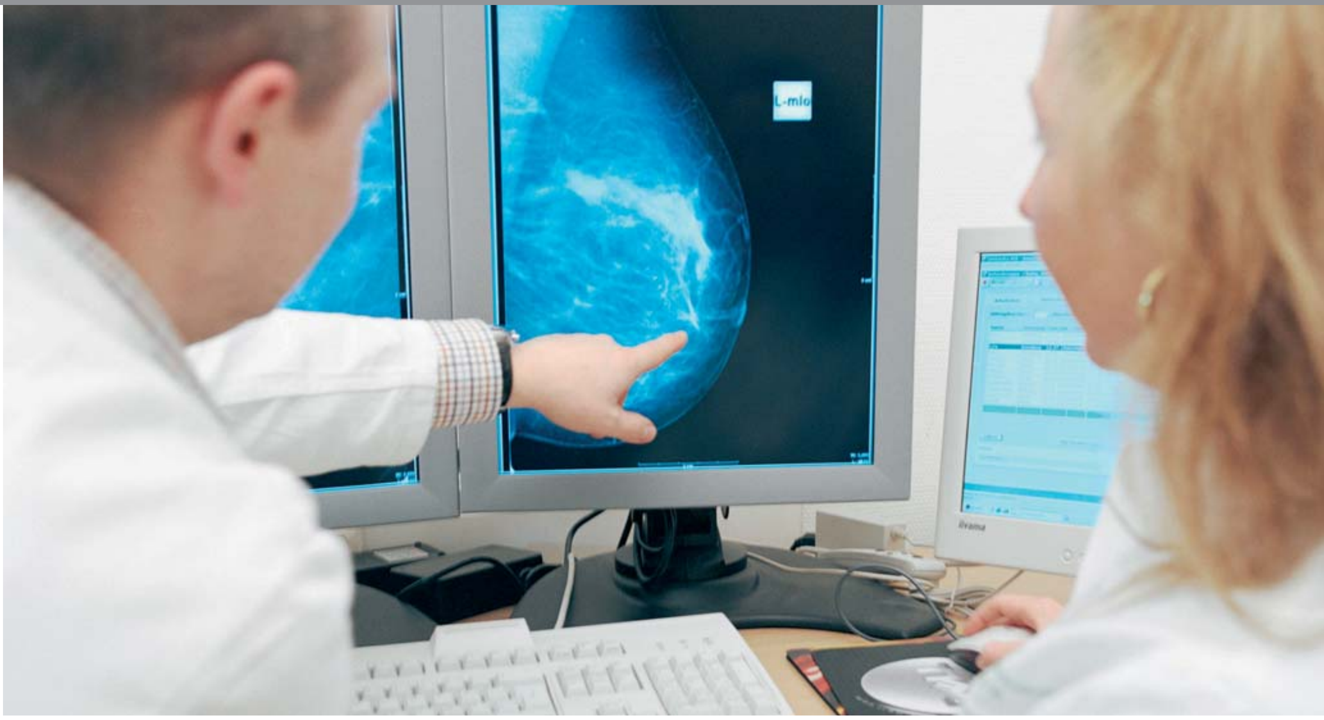


WELDING WITHOUT MELTING. FRICTION STIR METHOD MAKES SPOT WELDING POSSIBLE. Photo: riftec

COLD SPOT WELDING

Conventional welding has a decisive drawback. Heat generated during welding damages the metals. This is why scientists at the GKSS Forschungszentrum Geesthacht took friction stir welding and developed a joining method with which light metals, in particular, can be friction-spot welded without any major heat damage. "The method is a real alternative to the established methods used in the lightweight engineering sector, where fusion welding and mechanical joining methods such as punching or riveting have been used," says Matthias Beyer from the GKSS, where the friction spot welding system was developed and patented by the Joining Technology Group.

"Some like it hot - we cold weld!" is the slogan under which RIFTEC GmbH was formed in 2003 to promote the new technique as a spin-off from the Joining Technology Group at the GKSS. RIFTEC is the first licensee for this patent and is working on optimising the method of friction spot welding for industrial maturity. To accelerate this development, the company launched a collaborative project with the GKSS Forschungszentrum in mid 2005. Together with another company, Harms und Wende GMBH & Co KG from Hamburg, RIFTEC took on responsibility for developing and building an industrial welding system. Friction-welding specialists from the Joining Technology Group at the GKSS and engineers from RIFTEC are working closely together to examine welding process and tool design and to analyse the characteristics of the joints. "We already have plenty of interested inquiries for our technology from the fields of automotive and aerospace engineering," says Christoph Schilling, Managing Director of RIFTEC GmbH and main inventor of friction spot welding.



JUST UNDER 46,000 WOMEN PER YEAR IN GERMANY MUST RECKON WITH BEING DIAGNOSED WITH BREAST CANCER. Photo: laif

SLOWING DOWN ESTROGEN METABOLISM

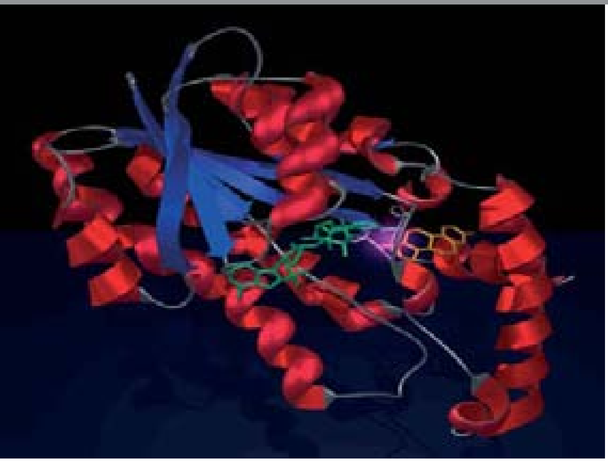
A specifically-targeted blocker for hormone metabolism could stop breast tumours growing in some patients. Scientists from the GSF-National Research Centre for Environment and Health near Munich are collaborating with industrial partners to find suitable agents.

Breast cancer is one of the most common causes of death among women in Germany. According to the German Cancer Research Centre in Heidelberg, up to 46,000 women in Germany contract breast cancer every year. Often, the tumour is influenced by female sex hormones, which means that the cancer cells grow quicker as the estrogen level rises. This presents an opportunity, albeit that it must be used with caution. “This possibly means that the disease may be checked by suppressing hormone production,” explains Professor Dr. Jerzy Adamski, Director of the Genome Analysis Centre (GAC) at the GSF-National Research Centre for Environment and Health.

Estrogens belong to the steroid hormone groups whose metabolism has been studied for many years by Adamski and his staff. Their expertise in this field makes the GAC scientists into much-sought-after partners of industry. Since 2000, the researchers have been working in cooperation with chemical and pharmaceuticals company Solvay GmbH on finding a specific agent to counteract estrogen-dependent diseases. The scientists focus primarily on breast cancer, but also consider other hormone-dependent diseases, such as endometriosis, a mostly benign but painful abdominal disease that can lead to infertility and that could be influenced by such an agent.

Specifically-targeted blocker

“Our challenge was to develop an agent that specifically targets one single enzyme of the hormone synthesis. By doing so, we hope to avoid side-effects like acne or circulatory disorders,” explains Adamski. The scientists decided to block the last and decisive step of hormone synthesis: the conversion of estron into estradiol by enzyme 17 beta-Hydroxysteroid-Dehydrogenase



SCIENTISTS USE COMPUTERS TO MODEL HOW CERTAIN MOLECULES DOCK WITH THE ENZYME INSTEAD OF ESTRON AND SO BLOCK HORMONE METABOLISM. Photo: J. Adamski

Type 1 (17 beta-HSD1). Because only with estradiol does an active hormone form that can act in the target cell – all previous intermediate products of the hormone synthesis remain inactive. This approach is particularly promising because 17 beta-HSD1 is only active in steroid-dependent tissue, such as in the breast gland or the uterus, which means it may be possible to put a tissue specific block on estradiol synthesis.

Reactions in the computer

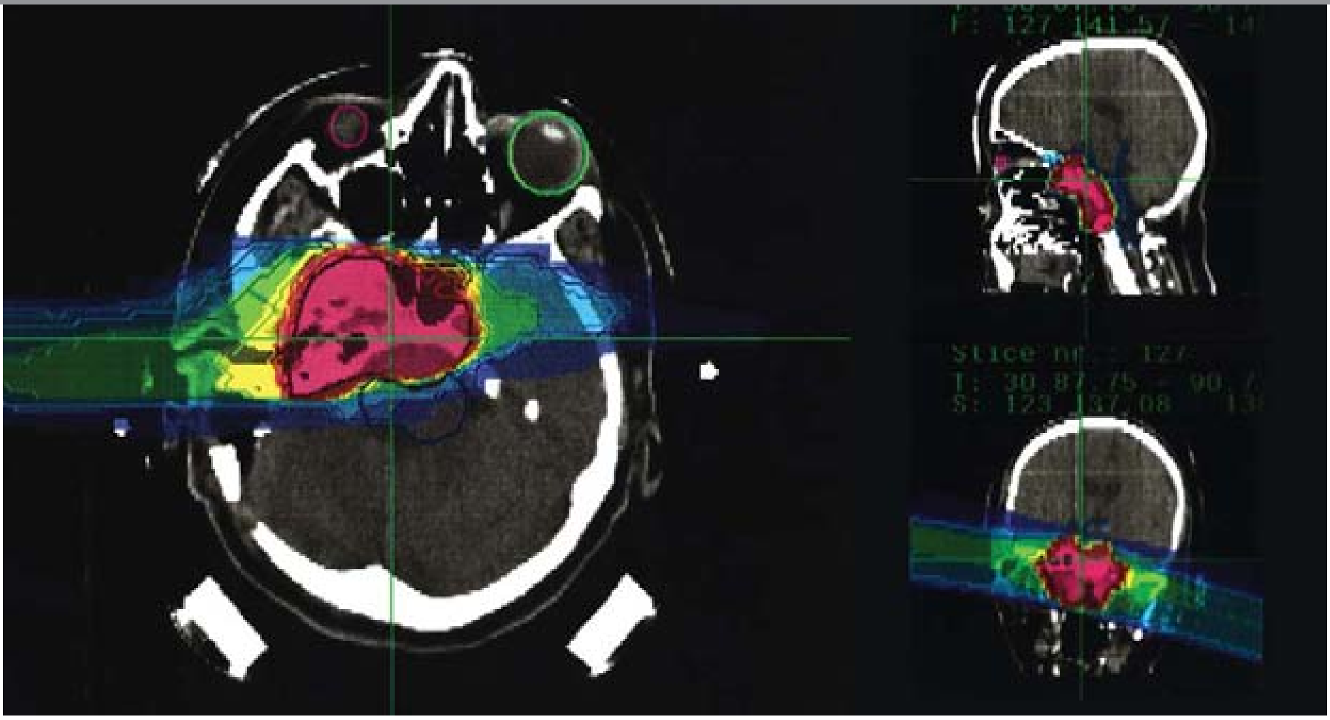
Since the three-dimensional structure of the enzyme is already known, the scientists were able to model certain molecules in the computer that can be considered as potential blockers. These are artificial ligands that dock onto the enzyme as antagonists rather than estron and so prevent the conversion from estron to estradiol. The researchers in Adamski's group and the industrial cooperation partners from Solvay have meanwhile identified ten key substances that are good candidates for chemical tests. Five of these proved to be particularly effective. Even in smallest concentrations of less than 100 nanomoles they blocked enzyme activity by half – better than all other known substances. In addition, the specificity tests showed that they affected the 17 beta-HSD1 enzyme only, while leaving other 17 beta-dehydrogenases unaffected.
These "test winners" are now moving into applied research. Although our cooperation with Solvay will come to an end in 2006, the GSF continues to have a stake in all the patents that developed from the cooperation. "All in all, our collaboration with Solvay succeeded surprisingly quickly. It only took five years from the first pilot experiments through to the development of products that have now entered the preclinical test phase – and that's a record in drug research," emphasises Adamski.

MONIKA GÖDDE, Science Journalist, Munich

ELISABETH KREMMER AND HER TEAM PRODUCE AROUND 300 ANTIBODIES PER YEAR FOR RESEARCH. Photo: GSF

MONOCLONAL ANTIBODIES MADE TO MEASURE

Monoclonal antibodies play an important role in diagnostics and research, since they are able to bind very specifically to a wide range of molecules. However, producing good antibodies is best left to the experts. The GSF has outstanding options available to it in this respect: "We are able to continually produce antibodies that precisely meet the requirements of the requesting scientists," explains Dr. Elisabeth Kremmer, Head of the Research Platform for Monoclonal Antibodies. Since 1995, the group that operates as a service facility has been producing around 300 tailor-made antibodies per year, with an upward trend. Kremmer and colleagues from the Max Delbrück Centre for Molecular Medicine and the Gene Centre of the University of Munich were awarded the Erwin Schrödinger Prize 2000 for the quality of their antibodies. Even in very difficult cases, they succeed in producing high-quality antibodies. This is why the GSF receives many national and international inquiries for cooperation in producing specific antibodies. In most cases, the commissioned antibodies are used as "tools", for example to detect the existence of herbicides in environmental samples. But the antibodies are also used to detect the presence of various proteins in diagnostic applications. And some are also considered as possible therapeutics. Antibodies developed at the GSF also regularly attract the interest of industry. Since 2004, more than 50 antibodies have succeeded in making the leap from research lab to factory floor.



THREE-DIMENSIONAL RADIOTHERAPY PLANNING WITH CARBON IONS MAKES IT POSSIBLE TO CONCENTRATE THE DOSE PRECISELY ON THE TUMOUR. HEALTHY TISSUE IS LEFT LARGELY UNAFFECTED. Photo: GSI/DKFZ

TUMOUR CELLS DRIVEN TO SUICIDE BY ION BEAMS

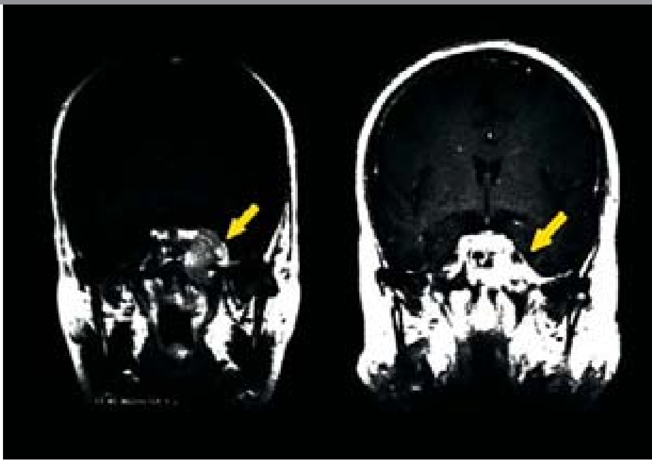
An effective therapy against particularly resistant tumours has been developed on the ion accelerator at the Gesellschaft für Schwerionenforschung in Darmstadt.

Working in cooperation with industry, scientists are now developing tailor-made ion accelerators for hospitals. Destroying individual cancer cells through radiation or cell poisons is a difficult biological process. However, ion beams such as those generated at the Gesellschaft für Schwerionenforschung (GSI) in Darmstadt are able to specifically damage tumour cells so badly that they self-destruct. "We can pass the ion beams very precisely across the tumour and so destroy it with pinpoint accuracy," explains Gerhard Kraft, Head of the Research Unit at the GSI. Ion therapy offers particularly great hope for patients, especially those with well-localised but inoperable tumours, because it is more conservative and effective than radiotherapy used to be. Prime indications for such treatment are deep-seated tumours in the skull that are located too close to life-critical regions to be able to remove them completely by surgery. Since 1997, the scientists in Darmstadt have been working together with doctors from the Radiological University Hospital and the DKFZ in Heidelberg to treat some 300 patients with radiotherapy using ions from the GSI accelerator; in all cases, the tumour went into remission. Around 80% of the patients reached the "five-year tumour check", meaning that no tumour growth had been seen over those five years and in favourable cases the tumour had actually disappeared.

Pinpoint precision

Gerhard Kraft and Wilma Kraft-Weyrather have been studying the effect of ions on living cells for almost 30 years now. Initially, using simple yeast cells that can be irradiated when dried in a vacuum, later with mammal and human cells that call for sterile radiotherapy conditions under normal atmospheres. In their work, they discovered that ion beams initially only cause minimal damage as they pass through the tissue, because the "heavy load" comes at the end of the beam, namely at a precisely-defined depth achieved by setting the speed of the beam. Only there do the ions suddenly begin to tear open so many connections in the major molecules of the DNA that the cells are no longer able to repair themselves and so generally destroy themselves.

THE PATIENT'S SKULL IS FIXED WITH A MASK DURING RADIATION TREATMENT. HOWEVER, SCIENTISTS ARE NOW WORKING ON METHODS THAT ALSO WORK WITH MOVING ORGANS. Photo: GSI



COMPUTER TOMOGRAPHY OF A PATIENT (LEFT) AND SIX WEEKS AFTER RADIOTHERAPY. IN THIS CASE, THE TUMOUR COMPLETELY DISSOLVED. Photo: Universitätsklinikum Heidelberg

This fundamental knowledge led to the idea of using ion beams to combat cancer cells. Ions are charged particles and so can be perfectly directed with electromagnetic fields. By using the speed of the ion beam to control its depth, it is possible to achieve pinpoint accuracy and so spare the surrounding tissue – in complete contrast to conventional radiotherapy with x-rays that already reach their maximum impact just a few centimetres below the skin. For deep-seated tumours, the x-ray dose in the healthy tissue can be higher than the dose that reaches the tumour. The serious side-effects of neutron therapy include the destruction of large parts of the tissue leading to the death of many patients and minor side-effects like dry mouths, nausea through to hair loss. These do not generally occur with ion therapy.

Carbon is the perfect ammunition

The question is, however, which ions are best suited for combating cancer? First clinical trials carried out with neon ions at Berkeley in the 1980s proved disappointing. Eventually, Gerhard Kraft and Wilma Kraft-Weyrather identified carbon as the perfect ammunition against malignant cells. Carbon atomic nuclei have six protons and six neutrons, and at high speed – when their electron shells are jettisoned – only interact slightly with the tissue so that the damage they cause along their path through the tissue is largely repairable. Then, as they approach their target point they become slower and the length of interaction is sufficient to irreparably damage the cells. The ion beam is precision-guided in tiny steps over the exactly-surveyed malignant cell accumulations – and only moves on when the pre-calculated dose has been achieved for each pinpoint. Furthermore, traces of radioactive carbon isotopes also occur in the tissue which then release gamma rays as they decay. This makes it possible to perfectly control the beam. Scientists at the Forschungszentrum Rossendorf (FZR) near Dresden have developed a camera that records this gamma radiation during ion beam treatment. If necessary, the radiotherapy treatment plan can be corrected.

Since 1997, the GSI has been performing carbon ion therapy at its accelerator facility, in cooperation with the Radiological University Hospital Heidelberg, the FZR Dresden and the DKFZ. Patients come for three weeks of radiotherapy of between three and five minutes per day. "In the future, we will certainly be able to substantially reduce the number of carbon ion irradiations for radiobiological reasons," says Kraft.

We are currently only irradiating those parts of the body that we can "immobilise", such as the scull area, along the spine and in the pelvic region. Kraft and his staff are now working with Siemens Medical Solutions to develop a method for carrying out radiotherapy on moving organs, such as the lung. This means that the beam has to be adjusted in synchrony with the breathing. The GSI scientists simulated the moving tumour with a ball that moves in a water bath like a tumour in tissue. The adjustment already works excellently in this model, reports Kraft.

Smaller accelerators than the plant in Darmstadt with its diameter of 70 metres that is capable of accelerating even very heavy ions such as uranium up to 90% of the light of speed are suitable for ion beam therapy. However, smaller accelerators than these with speeds of up to one third of the speed of light, equal to 100,000 kilometres per second, are fast enough to treat tumours in all body depths. Working in cooperation with Siemens Medical Solutions, the scientists have designed a much more compact, tailor-made machine for use in hospitals. This uses carbon ions in the cancer therapy. The first machine of its kind is to be built at the University Hospital of Gießen and Marburg. While the Heidelberg Ion Beam Therapy Centre HIT is currently being built in Heidelberg, for which the GSI has already developed an appropriate ion accelerator with a diameter of 20 metres. As from 2007, more than 1,000 patients with deep-seated tumours will be treated here every year. "Of course, ion radiation therapy is not a cure-all," emphasises Kraft, "but is does fill a gap in the treatment of tumours that are either wholly or partly inoperable."

ANTONIA RÖTGER, Helmholtz Association

SHINY BLACK SOLAR MODULES WILL SOON DELIVER TOP RATES OF 80 WATTS EACH. Photo: Sulfurcell

INEXPENSIVE ELECTRICITY FROM SUNLIGHT

The Hahn-Meitner Institute in Berlin (HMI) is developing and optimising novel solar cells. Scientists at Sulfurcell, a spin-off from the HMI, are now venturing into the market.

With crude oil prices at record levels and increasing global climate warming, interest in renewable, environmentally-friendly energy sources has grown strongly over recent years. A group of scientists headed by Professor Dr. Martha Lux-Steiner at the Hahn-Meitner Institute in Berlin have a lot of experience in developing and studying solar cells. At the end of 2003, some of the scientists formed a company called Sulfurcell, launched with start-up capital of around 16m euros. Meanwhile with almost 50 staff, the company has been producing so-called thin-layer solar cells on a pilot line since 2004 company. These cells are special, because they are the first in the world to use copper-indium-sulphide (CIS) as the absorber material on an industrial scale. This enables Sulfurcell to make reasonably-priced solar modules in the middle performance range, with energy yields that lie well above those of conventional silicon modules. Dr. Ilka Luck, co-founder of the company, worked on developing the technology at the HMI in the 1990s and also did her doctorate on the subject under the supervision of Martha Lux-Steiner, an internationally-renowned expert in this field. At the HMI lab, CIS cells just a few centimetres in dimension already achieved efficiency rates of 13%, meaning that more than one eighth of the incoming solar radiation was converted into electricity, reports Luck. The around 0.8m^2 CIS solar modules from the pilot production line currently achieve half the rate of the best experimental values.

80 watts per module

In two years at the latest, the scientists expect their solar modules to achieve top performance rates of 80 watts – which would equate to 10% efficiency. The challenge now lies in scaling up the technology from lab to commercial dimensions – in size and number. Nevertheless, the scientists plan to keep production costs low. This is why they are not interested in complex new production methods. “We use process steps that have already proven themselves in practice,” says Luck. For example, “sputtering” – an energy-saving way of applying an even coating to large glass surfaces, in this case with CIS absorber material. All in all it was possible to reduce the production method to just a few fundamental and robust processes. This largely occurs at moderate temperatures of up to

FACADES FITTED WITH BLACK CIS MODULES (LEFT, AS A MODEL) WOULD LOOK AS ELEGANT AS THIS. NEXT TO IT A FACADE WITH CONVENTIONAL SOLAR CELLS. Photo: Nikolaus Meyer

200°C only – clean rooms or complicated, cost-intensive manufacturing methods are not needed. Sulfurcell is currently able to produce around 20,000 modules per annum. Next year, it plans to raise capacity by up to four times. And sales are not a worry. Products marketed by Sulfurcell and its competitors worldwide are “sold out until 2007” says Luck.
Together with Sulfurcell Managing Director and co-founder, Dr. Nikolaus Meyer, who also did his doctorate at the HMI, Luck has brought a number of strategic partners on board. Besides mid-sized service-providers in the field of energy and high-tech production plants, several capital investment companies also have a stake in Sulfurcell, including a subsidiary of energy utility Vattenfall. Research and development are done “in-house” at Sulfurcell as well as in cooperation with the HMI, and especially with Martha Lux-Steiner. The institute also has a small shareholding in Sulfurcell, says Luck.

Expansion not ruled out

Originally, “Sulfurcell” was the name of a research project at the HMI. To realise the product on an industrial scale, “we initially offered our technology to various companies”, says Lux-Steiner, who headed the project at the HMI and supervised the doctorates of the Sulfurcell founders. Although the companies they contacted showed great interest, none made any binding commitments. Each company would have wanted to continue to pursue its own technology. “Then, in autumn 1999, we decided to try it ourselves,” says Lux-Steiner. “So we offered our wares throughout Europe in an attempt to find investors,” she says, describing the long and drawn-out process of securing start-up funding. With success – the company has established itself at the Berlin Adlershof Science Park and looks optimistically into the future. There’s plenty of surrounding land for further expansion, says Ilka Luck.

RANTY ISLAM, Science Journalist, Berlin

INNER TENSIONS MOSTLY CAUSE VEHICLE PARTS TO SPRING BACK A LITTLE. HMI SCIENTISTS CAN PREDICT THIS EXACTLY. Photo: Digital Vision

BENDING AND BREAKING

Materials researchers at the Hahn-Meitner Institute in Berlin are literally bending and breaking materials in any which way they can. Dr. Rainer Schneider and his colleagues use high-energy x-rays to produce a high-resolution image of the tensions occurring within the steel sheets when they are formed in the production process. Working in cooperation with “inpro”, a company in which several automobile manufacturers hold a stake, the HMI researchers are now examining how materials behave under such tensions. These tests aim to improve the quality of simulation modelling in car-body building.
Initially, this means carrying out many different experiments to adapt the tools required for forming the sheet metal parts, such as punches, dies and clamps. The strong “spring-back” effect is responsible for this, because the sheet does not simply take on the tool form, but rather springs back. This effect is particularly strong in new, highly-stable steels. Modelling these processes makes them “more predictable”. This could reduce the adjustment steps needed for developing the forming tools and so save hundreds of thousands of euros per developed body part.

POTENTIAL VACCINES MUST FIRST BE TESTED ON ANIMALS. THE VPM HELPS SCIENTISTS MEET THE APPROVAL AUTHORITIES' REQUIREMENTS. Photo: HZI/Hübner

BUILDING BRIDGES TO PRACTICE

The path from discovering fundamental principles in the lab through to producing a vaccine is a long one indeed. Industry often shies away from this for reasons of cost. That is why the Helmholtz Centre for Infection Research supported the launch of Vakzine Projekt Management GmbH, a limited company that will carry out the early clinical phases.

Whether SARS, bird (avian) flu, or the latest measles outbreak in spring 2006, we will increasingly find ourselves facing the eternal threat of new epidemics. Many infectious diseases are still difficult to combat, if at all. Antibiotics fail ever more often, because the bacterial germs have become resistant. And they don't help at all against viral diseases like AIDS.

But, protection against infection is still better than any treatment, and that means vaccination. Today's vaccines protect children and adults from classical infectious diseases such as measles, mumps, German measles (rubella), flu or polio. However, there is still no effective vaccine for many infections, especially in developing countries. This is why the worldwide demand for new vaccines is enormous. Nevertheless, companies working in this field have strongly reduced their involvement over recent decades. This also applies for Germany, although basic research here has uncovered highly-interesting starting points for new vaccination methods that now need to be systematically developed towards final application, a task that Vakzine Projekt Management GmbH, VPM, has now taken on.

This company was founded in 2002 with its registered office in Hannover and is the result of an initiative launched by the Federal Ministry of Education and Research (BMBF). In 2001, the ministry commissioned the Gesellschaft für Biotechnologische Forschung (GBF), today called the Helmholtz Centre for Infection Research, with the task of putting a so-called "vaccine initiative" into practice. This measure aimed to fill the gap between research and the clinical development of new vaccines. That, in turn, serves to make public research funding more efficient, by reactivating Germany as a centre of vaccine research and development.

The VPM first acquires the licences to highly-promising vaccine candidates from research institutes. Then, working together with partners, it carries out the process development and the preclini-

NOT EVERY INTERESTING AGENT FROM THE LAB IS ALSO A SUITABLE VACCINE – THE VPM PICKS OUT THE BEST CANDIDATES. Photo: HZI/Bierstedt

cal and early clinical development stages. Finally, it is able to re-sell the results to the vaccine industry as added-value licences. At the end of its grant, the VPM plans to become financially self-sufficient. In addition, the company offers support with the analysis and assessment of immunological research and development projects. It also advises on patenting and on planning development programmes as well as on the dossiers for clinical studies that have to be submitted to the relevant authorities and ethics commissions.

Just before the finishing line: New agents

The VPM compiled its product portfolio from a database called the "vaccine map". This covers practically all the projects running in Germany aimed at preventing or treating infectious diseases, cancer or chronic immune system diseases. The company is targeting a worldwide market worth more than 6 billion euros. Three vaccines and one immune therapeutic, Soluferon®, are currently passing through the preclinical development stage. Another immune therapeutic, agent VPM4001 to combat prostate cancer, successfully passed a clinical phase I/II study at the TU Munich in spring 2006. Some 73% of the patients – all with advanced prostate carcinoma in a hormone resistant stage – responded to treatment with VPM4001. An international committee of experts recommended further clinical development.

The advantage of the VPM business model for the scientists is that their ideas are transferred into practice. If the studies are a success, the economic proceeds benefit institutes and inventors through licensing contracts. To achieve this, the VPM takes on the work that cannot be performed by basic researchers. But, it still takes good ideas to achieve economic success.

HANNES SCHLENDER, Helmholtz Centre for Infection Research

Further information: www.vakzine-manager.de

NEW METHODS AIM TO MAKE ANTIBODY PRODUCTION MORE RELIABLE. Photo HZI/Hans

AN ANTIBODY PRODUCTION ALLIANCE

The Helmholtz Centre for Infection Research (formerly GBF), and Swiss pharmaceuticals company Hoffmann-La Roche have set themselves the goal of developing new and improved production methods for antibodies. Their scientists are working together to optimise the cultivation conditions for special production cells. These are needed to produce recombinant antibodies. The cooperation is initially planned for three years, but has been ambitiously designed to run over a longer term.

Recombinant antibodies are a class of protein molecules that have grown enormously in importance over recent years as a result of many substances turning out to be pharmaceutically effective. In the meantime, this group of molecules has produced the first blockbusters, i.e. drugs with a turnover of more than one billion dollars per year, for example in cancer therapy. Recombinant antibodies serve the human body as a "weapon" in the battle against pathogens that have invaded the body. Because their bonding behaviour is very specific, they can be used in medicine to expressly find and neutralise other molecules. Better production methods will instil new drive into this research.

PART OF THE PLASMA CHAMBER FOR THE FUSION EXPERIMENT WENDELSTEIN 7-X: TWENTY SUCH ELEMENTS ARE JOINED TOGETHER TO BUILD EACH RING. Photo: IPP/W. Filser

PLASMA VESSEL BOOSTS INNOVATION FOR INDUSTRY

Particularly complex production contracts commissioned by science are capable of initiating and advancing high-tech developments in industry. One such example involves the construction of the plasma vessel for the fusion experiment Wendelstein 7-X that is being built at the Greifswald branch of the Max-Planck-Institut für Plasmaphysik (IPP).

Much like the Sun, a fusion power station generates power by fusing atomic nuclei. The fuel needed for this is a hydrogen plasma that has to be enclosed in magnetic fields and heated to high temperatures of several millions of degrees. The Wendelstein 7-X experiment, the world's largest stellarator-type facility, is now being built in Greifswald in which the plasma will be contained in a magnetic cage. The scientists want to use this experiment to study whether this design is suitable for a power station.

The bizarrely-shaped vacuum chamber for the Wendelstein plasma is made up of several hundred individual components – an engineering masterpiece performed by plant engineers MAN DWE GmbH in Deggendorf, Lower Bavaria. After five years of construction work, Franz Kufner, Head of Plant Engineering at MAN DWE, emphasised the "enormous two-way technological inspiration that delivered decisive advantages both to the IPP in its capacity as customer and, particularly, to MAN DWE in its role as supplier. In performing this extremely demanding contract, science and industry demonstrated what Germany is capable of achieving in the high-tech sector."

1,600 metres of welding

Indeed, it was a particular challenge to manufacture the peculiarly-shaped vacuum vessel with the requisite precision to match the twisting plasma ring within the demanding tolerances of occasionally no more than 3 millimetres. To reproduce the bizarre curvature in steel, the 35-tonne plasma vessel was assembled in 20 sections made up of 200 individual rings. Each ring is itself made of several finger-thick and 18 centimetre-wide sheet steel strips which are

ITS SHAPE CLOSELY FOLLOWS THE INTRICATE CONTOURS OF THE PLASMA. PORTS PROVIDE ACCESS TO THE PLASMA FOR HEATING AND MEASUREMENT DEVICES. Photos: IPP/W. Filser

bent and bowed several times to follow the twisting contours. More than 1,600 metres of multi-layered, hand-welded seams join the 800 and more individual components together to form a vacuum-sealed vessel.
After carrying out seal tests on the vacuum components, a total of 299 ports were cut into the steel walls through which scientists will later be able to heat and observe the plasma. Each of the 20 sections was fitted with mountings on the inside that will later be used to hold the wall cladding, while 2,400 metres of cooling and heating pipes were welded to the outside. All vessel segments and pipes underwent a helium leak test to verify the ultra-high vacuum seal tightness. Three-dimensional measurements using a laser tracker accompanied the whole production process from individual component through to assembled section and so ensured that the prescribed form was indeed achieved.

Innovations now being transferred

The demanding task produced a lasting benefit for MAN DWE. For example, the system of three-dimensional computer-aided design engineering introduced for the Wendelstein contract is meanwhile being used on 15 technical design workstations: 3D-modelling of difficult assembly processes in the refining sector has meanwhile become the industry standard. Similarly, the vacuum engineering demanded by the IPP contract substantially increased the company's experience. Consequently, MAN DWE was able to win further contracts in the field of physical plant engineering, such as the production of a 200-tonne vacuum container for the tritium-neutrino experiment KATRIN in Karlsruhe. The robot initially used to precision place numerous fittings in the Wendelstein vessel is now being used as an innovative application in the field of instrument engineering – for welding preparation and for intricate three-dimensional curved cuts. And the specially purchased laser tracker for measuring and surveying the plasma vessel has now been used to calibrate machining centres, with opportunities for this device also emerging in the field of apparatus engineering.
“Besides the substantial increase in knowledge,” summarised Franz Leher from MAN DWE, “our company gained more references through the contracts for the Wendelstein experiment and so became even more well known in the national and international markets. So, we feel well-equipped for contributing to the building of the fusion test reactor ITER in Cadarache.”
ISABELLA MILCH, IPP

Research with plenty of staying power

The ITER (Latin for “Path”) project brings together scientists from Europe, Japan, the United States, the Russian Federation, China, South Korea and India to work on creating the first experimental reactor of this type. ITER is being built in Cadarache, France, with an estimated budget of around 4.6 billion euros. The researchers hope that after completing ITER they will be able, for the first time, to generate a burning plasma over a longer period of time that is capable of delivering power. A fusion power station will be able to feed the grid as from the middle of the century at the earliest, because the physical principles still have to be studied and the engineering components for a fusion power station developed. These include erosion-resistant materials, superconducting magnetic coils and components for dissipating the generated thermal energy.

HIGH BLOOD PRESSURE INITIALLY CAUSES NO DISCOMFORT, WHICH IS WHY THE DISEASE IS USUALLY IDENTIFIED QUITE LATE. Photo: Stockbyte

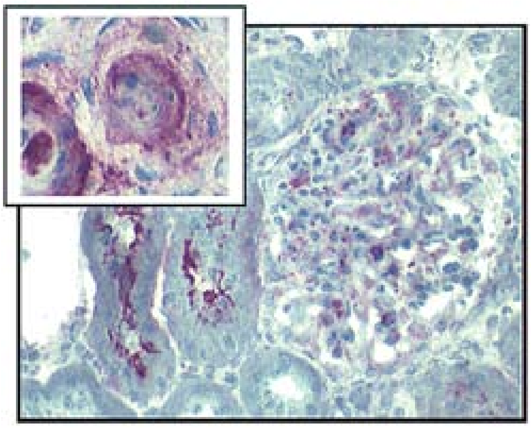
UNITED AGAINST HIGH BLOOD PRESSURE

High blood pressure is one of the most expensive common diseases. Because it often leads to damage of the cardiovascular system and other organs. However, the search for new drugs is extremely complicated and expensive.

Nowadays, pharmaceuticals companies lead the way that are able to gain access to useful information from basic research at an early stage. Researchers such as medical scientist and pharmacologist Friedrich Luft from the Max Delbrück Centre for Molecular Medicine in Berlin-Buch benefit from this trend.
Working with Novartis researchers from New Jersey (USA), Luft is studying the role played by the messenger substance angiotensin II in the processes that damage or repair organs like kidney or heart, for example. The kidney and high blood pressure expert is doing research on genetically-modified rats to find this out. Two human genes were transplanted into the animals' DNA: the angiotensinogen gene and the renin gene, whose protein product normally regulates the production of angiotensin II. As a result of their genetic modification, the rats produce too much renin and angiotensin II and so practically automatically develop high blood pressure. After around eight weeks, the animals die of kidney and heart failure. The researchers test whether the drug Aliskiren provided by Novartis supports the natural repair mechanisms in the organs and so can extend the animals' life and, if so, why. Luft's research work could eventually enable Novartis to use a renin inhibitor against cardiovascular diseases or organ failure instead of the conventional ACE inhibitors which stop angiotensin II production. Using rats from the same line, the researchers from Berlin are working with the pharmacology research group at Boehringer Ingelheim in Connecticut to study to what extent the blocking of the messenger substance p38 affects the drastically increased angiotensin II level in the rats and so is capable of reducing subsequent damage to heart and kidney.

Inhibiting harmful enzymes

In another project with Boehringer, Luft is examining the effect of so-called EET (epoxyeicosatrienoic acids) which seem to have a positive effect on the cardiovascular system and kidney function by reducing blood pressure. The researchers' idea is to inhibit the enzymes that transform the positive effect of EET and so enrich the EET and strengthen its positive effect. This is why Boehringer is



THE DRUG ALISKIREN INHIBITS THE MESSENGER SUBSTANCE RENIN AND SO COUNTERACTS KIDNEY DAMAGE CAUSED BY HIGH BLOOD PRESSURE (CROSS-SECTION SAMPLE). Photo: MDC

working with the researchers in Berlin to develop suitable inhibitors against one of these enzymes, Soluble Epoxide Hydrolase (SEH). Consequently, Boehringer provided Luft's research team with a genetically-modified mouse line that lacks the gene needed for producing the SEH enzyme. "A nice gift," says Luft, although 18 months were spent on crossbreeding before the mice could be used in the studies. For example, to study what long-term consequences optimal SEH inhibition has and what other genes could further improve the effect.

Two-way information flow

Friedrich Luft believes such cooperation to be very important. Companies not only provide the substances to be examined, but also all the necessary information on their pharmacology. "Although consumables, equipment and other forms of support do not reach the volume of funding provided by the German Research Foundation (DFG), it is nevertheless of interest and assistance to us," says Luft. His laboratory is also very interested in clinical studies, he says. And he has even set up a whole department for clinical pharmacology to this end (one stop shop). Phase I and Phase II studies are regularly carried out there. The molecules studied in the animal models are also checked on test persons and patients. An enormous advantage of the MDC concept lies in the availability of expertise in fundamental science and in clinical research. And there's no problem publishing findings either. "Novartis and Boehringer only request that they can view the data for one month before we submit the manuscript for publication."

SASCHA KARBECK, Science Journalist, Berlin

TWO DNA CHIPS FROM AFFYMETRIX WITH WHICH 500,000 GENE VARIANTS CAN BE ANALYSED IN A SINGLE EXPERIMENT. Photo: Affymetrix

USEFUL COOPERATION

"Without access to the latest technologies, it is not possible to answer the most topical biological questions," says Norbert Hübner from the Max Delbrück Centre for Molecular Medicine in Berlin-Buch.
This is why his research group is collaborating closely with biochip manufacturer Affymetrix, USA, in order to be able to search through all the DNA for gene variants that contribute to the development of asthma, allergic skin reactions or hay fever. "Many genes play a role in these kinds of illnesses, which is why it is so important to be able to catalogue as many variants as possible." Some 500,000 gene variants can be analysed with Affymetrix chips in a single experiment. And Hübner is able to conduct research with prototypes long before a new chip comes onto the market, "Of course, we provide technical feedback," says Hübner, who not only wins time, but also the opportunity to influence the development of the product. "We pass on what we consider to be useful so that the chip then better fits the questions that we want to have answered."

WELLS FOR DRINKING WATER IN A SUBURB OF HANOI. IN GLOBAL TERMS, ARSENIC IS THE MOST PROBLEMATICAL POLLUTANT IN DRINKING WATER TODAY. AND IN VIETNAM TOO. Photo: UFZ/Hauke Harms

ARSENIC LACED WITH FRONTIER RESEARCH

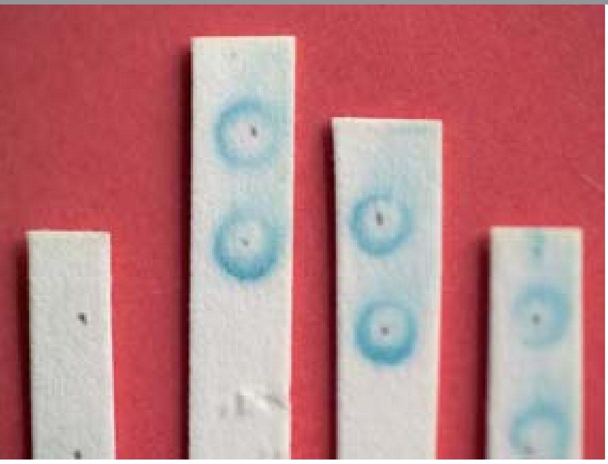
To combat dangerous diarrhoeas, international aid organisations supported the drilling of groundwater wells in Bangladesh in the 1970s.

Some five million hand pumps were installed to give families direct access to clean drinking water directly in their home or yard. And the project was successful. Infant mortality rates have fallen dramatically since the pumps came "online". However, an accumulation of excessive skin pigmentation, functional disorders of the liver and kidney and various forms of cancer was noticed in the same region in the mid-1990s. Everything pointed to arsenic poisoning. And indeed, analyses showed that the levels set by the World Health Organisation were being exceeded by more than five times the permitted maximum level in more than a million of these beneficial drinking water wells from which 30 million people drew their water. Similar problems to those in Bangladesh also appeared in Vietnam. But there is no need to travel so far. Arsenic contaminations of groundwater caused by ore mining can also be found in southern Saxony.

In global terms, arsenic is the most problematical harmful substance found in drinking water today. Poor countries, in particular, lack the analysis equipment needed to be able to test millions of water wells. However, only tests like these would enable the villagers to find out which wells they should move to or whether the water needed to be filtered. This is why we are desperately looking for simple, cheap and nevertheless reliable alternatives to the expensively-equipped professional lab.

Bacteria in the role of guinea-pigs

Staff from the Department of Environmental Microbiology at the Helmholtz Centre for Environmental Research - UFZ also took part in this search. Flora, fauna and bacteria have been on the frontline in the fight against the cell poison arsenic for millions of years. In the course of this battle, bacteria have developed microscopically tiny pumps through which they discharge the poisons that penetrate the cells before these can cause any damage. Yet, bacteria are too small to constantly keep suitable pumps at the ready for the eventuality of the respective poison appearing. They only react with their genetic switching mechanisms when there is real contact with the poison. These switches play a central role in



THE ARSENIC TEST IS AS EASY TO USE AS A NORMAL PREGNANCY TEST. Photo: UFZ/André Künzelmann

developing a biologically highly complex but very easy-to-use analysis method for arsenic detection.
The underlying principle of the test was developed in Switzerland. It builds on the method of genetically engineering bacteria to such extent that they change colour or light up when they come into contact with arsenic. Microbiologists from various research institutions are now working on parallel approaches to developing practicable tests. The UFZ focuses on the advantages of a strip that resembles and is as easy to use as a pregnancy test, be it in remote tropical villages or on a camp site in the Vogtland, southern Saxony. This is done by placing the bacteria onto paper in a dried state. Their blue colour after contact with arsenical water can be seen with the naked eye.
This patented test is being developed at the UFZ in collaboration with the University of Lausanne. Parallel to developing a marketable product, field tests, information events and user training courses are also being organised in the relevant regions.

How dutiful are bacteria?

Even if the prototype test strip already works, some unresolved questions still remain. How can the bacteria on the strip be kept inactive but nevertheless alive until they are needed and woken from their dry slumber? Or how comparable and informative are the colour changes if not all the microbes on the strip "do their duty"? And last but not least, a debate is still going on as to whether the use of genetically-engineered bacteria is acceptable.

MARLIS HEINZ, Science Journalist, Leipzig
PROFESSOR HAUKE HARMS, Head of the Department of Environmental Microbiology

THE RADIOWAVE-BASED SOIL REHABILITATION TECHNOLOGY WAS SUCCESSFULLY TRIED OUT AT LAB, PILOT PLANT AND FIELD SCALE. Photo: UFZ/André Künzelmann

LICENCE TO HEAT THE SOIL

Scientists from the UFZ have developed a new method for cleansing contaminated soils efficiently. It is suitable for demanding cases where its direct on-site use is called for or where ground remediation is needed in and around buildings.
The method uses radio waves to heat the ground and so accelerate pollutant discharge via the soil air or biological degradation. In principle, the method is like a microwave oven. However, the around 100 times larger wavelength means that the waves penetrate to such a depth that practically all dry and moist solids of all kinds can be treated on the cubic metre scale.
Following successful lab, pilot plant and field trials, the first licensing agreement has been signed on the use of the technology and its associated patents.

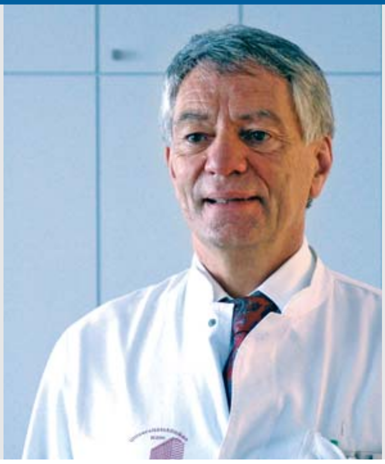
ULF ROLAND, Department of Environmental Technology

ERWIN SCHRÖDINGER PRIZE 2005

A THERAPY FOR PARKINSON'S USES A BRAIN PACEMAKER

In recognition of their work in developing a brain pacemaker to treat nervous disorders such as Parkinson's Disease, Professor Dr. Dr. Peter A. Tass from the Research Centre Jülich and Professor Dr. Volker Sturm from the University of Cologne were awarded the Erwin Schrödinger Prize 2005.

PROFESSOR DR. DR. PETER A. TASS, Research Centre Jülich



PROFESSOR DR. VOLKER STURM, University of Cologne

The Erwin Schrödinger Prize is worth 50,000 euros and is awarded annually by the Donor's Association for the Promotion of Sciences and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft) in recognition of outstanding interdisciplinary research performed at the Helmholtz Centres. The President of the Donor's Association, Dr. Arendt Oetker, presented the prize at the Helmholtz Association's Annual General Meeting held in Berlin on 17 November 2005. "The collaboration between the two scientists broke open disciplinary borders plus the institutional barriers between a university and a Helmholtz Centre," emphasised Dr. Klaus Rauscher, Chairman of the Berlin/Brandenburg Board of Trustees of the Donor's Association for the Promotion of Sciences and Humanities in Germany, in his address. "After all, the prizewinners also managed to cross the border between basic research and practical application by forming a company in 2005 to prepare and manufacture the new brain pacemaker for clinical application."

Medical scientist, mathematician and physicist Peter A. Tass is Head of the Research Group Magnetoencephalography and Brain Pacemakers at the Institute of Medicine, Research Centre Jülich, while medical researcher Volker Sturm is Director of the Clinic for Stereotaxis and Functional Neurosurgery at the University of Cologne. Together, they developed a new method that makes it possible to specifically desynchronise the hyperactivity of nerve cells that cause violent, uncontrollable shaking in Parkinson's patients. The new method is gentler and more patient-oriented than previous methods of electrical brain stimulation because it only sends signals when they are needed.

Parkinson's Disease is one of the most common nervous system disorders. Germany has some 150,000 Parkinson's patients. However, many cases are not identified, with estimates assuming that between 250,000 and 400,000 people are actually affected. Certain brain nerve cells in Parkinson's patients are faulty. While healthy nerve cells transmit their signals specifically and in sequence from cell to cell in a domino-like effect, the nerve cells in a specific region of a sufferer's brain fire their signals all at the same time. This results in patients having difficulties with their fine motor skills. Their hands shake violently, simple activities like tying shoelaces, buttoning up their clothes or writing become impossible, and walking also becomes increasingly difficult.

Parkinson's is triggered by the gradual death of cells in the substantia nigra, a structure in the midbrain in which the neurotransmitter dopamine (a chemical messenger) is produced. In healthy people, dopamine inhibits the nerve cells and ensures that they do not transmit their messages all at once. Drug-based treatment with dopamine helps many patients, but only for a limited amount of time after which it gradually loses its effect. The only treatment presently available to help such patients is deep brain stimulation. This method involves neurosurgeons implanting small electrodes into the patient's brain. These transmit high-frequency electrical impulses into the diseased brain region. That suppresses the nerve impulses. So far, this electrical stimulation has been delivered in the form of "continuous fire".

Professor Tass and his staff simulated the affected brain areas in mathematical models and used methods of non-linear dynamics and statistical physics to develop stimulation techniques that are particularly effective and gentle because they use the brain's self-organisational processes. Their newly-acquired insights enabled the scientists to develop a new method of brain stimulation that delivers individual electrical impulses to various groups of nerve cells as required. This method does not suppress the nerve impulses as in the case of conventional implants, but rather desynchronises them. As the successful first clinical trials carried out together with research partner Prof. Sturm at the University Hospital Cologne demonstrated, the tremors that patients with Parkinson's or Multiple Sclerosis experience are better suppressed with a much lower stimulation current. This is why the scientists expect this mild but very efficient modulation of nerve cell activity to cause fewer side effects in long-term application. FZ Jülich

NEW HEATING SYSTEM FOR THE FUSION TEST REACTOR ITER

Scientists from the Max-Planck-Institut für Plasmaphysik (IPP) and the University of Augsburg have developed an enhanced ion-heating system for the extreme requirements of the fusion test reactor ITER.

In recognition of this work, the Helmholtz Association awarded the Erwin Schrödinger Prize 2006 to Dr. Eckehart Speth, Dr. Hans-Dieter Falter, Dr. Peter Franzen, Dr. habil. Ursel Fantz, and Dr. Werner Kraus.
"The negative ion source developed by the prizewinners is essentially able to meet the high requirements and standards set by ITER. No other ion source in the world can compete with their development. So, the new concept has a good chance of being selected for use in ITER in 2007," explained Jury Member Professor Dr. Johanna Stachel, from the Physical Institute at the University of Heidelberg. Because it takes great effort on Earth to emulate what the Sun has been doing at just 6 million degrees Celsius for billions of years now. The hydrogen plasma must first be heated to over 100 million degrees to trigger the nuclear fusion. This can be done, for example, by firing fast hydrogen particles into the plasma.
The international test facility ITER (Latin for "Path") now being built in Cadarache aims to show for the first time that an energy-producing or generating fusion fire is possible. This calls for the fuel – a thin, ionised hydrogen gas – to be contained in a magnetic field cage and then heated until the fusion reactions ignite. Around half of the heating for the ITER plasma will be provided by "neutral particle heating". This involves firing fast hydrogen atoms

PRIZEWINNERS AND THEIR SUCCESSFUL DEVELOPMENT, A HIGH-FREQUENCY ION SOURCE TO HEAT PLASMA (FROM LEFT TO RIGHT): DR. URSEL FANTZ; DR. HANS-DIETER FALTER, DR. ECKEHART SPETH, DR. PETER FRANZEN, AND DR. WERNER KRAUS. Photo: IPP

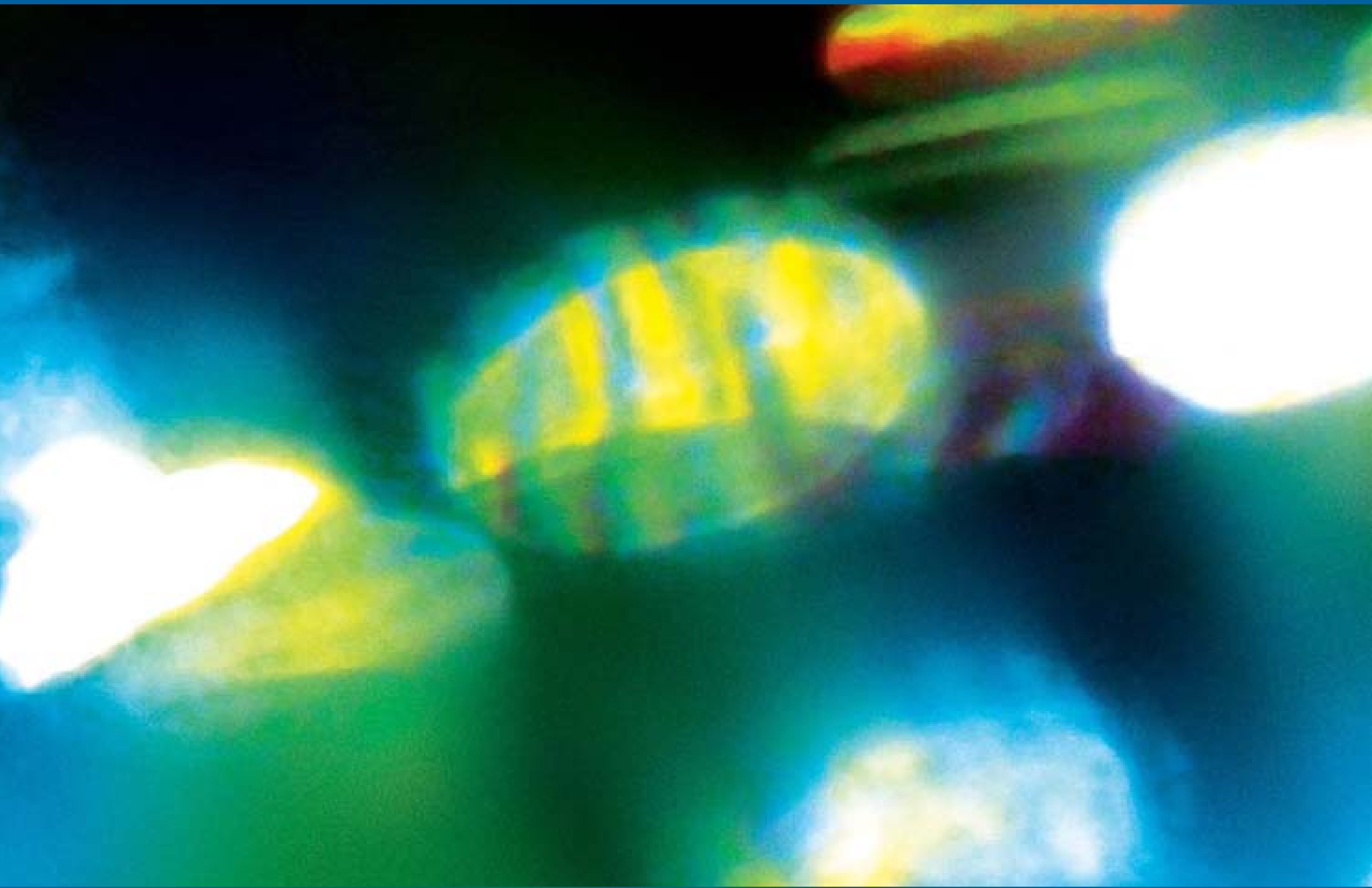
into the plasma to release their energy when they collide with the plasma particles. With this method, present-day plants are able to reach several times the temperature of the Sun at the press of a button. However, to be able to accelerate the hydrogen atoms in this heating system, they must first be made available to the electrical forces in the form of charged particles – that is as positive or negative ions. Previous heating systems only used positively-charged ions. However, before firing them into the fusion plasma, the ion beam needs to be neutralised again, because charged particles would be deflected by the magnetic field of the plasma cage. This is done by passing the ions through a gas curtain, where the ions pick up the missing electron again and fire into the plasma as fast neutrals.

This proven method now has to meet a number of new requirements for ITER. The particles actually have to fly up to three to four times faster than in the past so that they can penetrate far enough into the plasma. However, since positive ions become more difficult to neutralise the faster they are, it is no longer possible to work with positively charged ions, and so it becomes necessary to switch to negatively charged ions, since these are easy to neutralise, even at high speeds. However, they are much more difficult to handle than positive ions. The additional ion that causes the negative charge is only loosely bound and so relatively easy to lose.

So-called high-frequency plasma sources are particularly suitable for producing such fragile objects for ITER. Building on previous work done at the University of Gießen, such an ion source was developed at the IPP and has been in operation in the IPP experiment ASDEX Upgrade since 1995 – albeit for positive ions. Dr. Eckehart Speth and his staff at the IPP have been working on upgrading the beam source for negative ions since 2002.

This work was done in cooperation with the University of Augsburg, where Dr. Ursel Fantz and her staff have been doing research on sophisticated diagnostic and modelling methods for the collaborative project. This involves beaming a high-frequency wave into the hydrogen gas where it ionises some of the hydrogen atoms. This creates a cold plasma, a mixture of neutral atoms, negative electrons and positive ions, that flows into the actual beam source and comes into contact the internal walls and with a first lattice-shaped electrode. The surface is coated with caesium so that the plasma particles can take up the electrodes there – to form the desired negative hydrogen ions. Once the scientists had fathomed out the complicated dynamics of the caesium distribution on the wall surfaces, it became possible to use a small oven to continuously deposit an ultra-thin coating on the wall with a thickness of around one atomic layer.

The generated negative ions close to the lattice can now be removed from the beam source. They are then captured by the electric field of a second lattice, are concentrated into a beam and are further accelerated by a third lattice. The results achieved to date – in some cases world records – indicate that the high-frequency sources at the IPP already have a good chance of being chosen for ITER. Before a final assessment can be made, however, the technology's transferability to the ITER scale still needs to be proven. The decision on its use for ITER is expected in mid-2007. However, the new ion source could also find applications in other fields, such as in accelerators or in manufacturing large-area plasmas for use in industry. IPP



THE RESEARCH FIELDS

The Helmholtz Association has divided its activities into six Research Fields: Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, and Transport and Space. International experts regularly evaluate the 30 research programmes in total. The next round of strategic reviews will be held in 2007 and 2008.

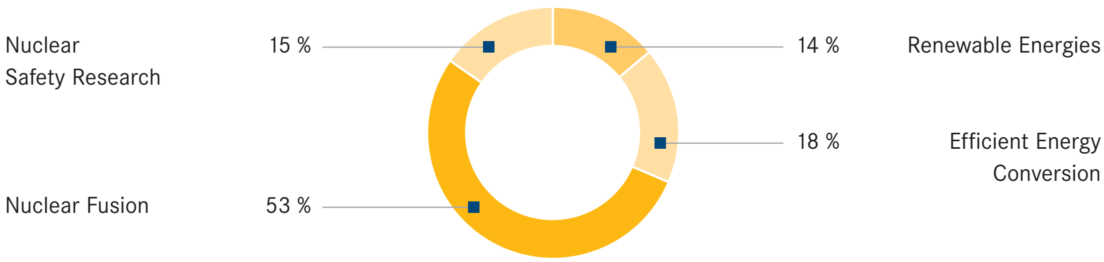
THE RESEARCH FIELD ENERGY

Goals and Roles

Energy consumption is increasing worldwide, and not only as a result of population growth. Rather, ever more people in emerging economies want to share in the affluence and prosperity. However, our fossil resources are limited and burning them produces environmentally harmful gases and releases large amounts of carbon dioxide into the atmosphere, thereby contributing decisively to anthropogenic climate change. This is why we need new and sustainable solutions for a secure energy supply. Our answer is research: to avert foreseeable global energy bottlenecks and to improve the disposal of wastes, residues and emissions. We begin by exploring the potentials offered by renewable resources, such as solar, biomass or geothermal energy, and go on to increase our efforts to make conventional power stations more efficient. Nuclear safety research, too, remains an important activity field. We are driving highly-complex fusion research forward together with our national and international partners. Energy research is long-term, forward-planning research aimed at satisfying the needs of present and future generations by developing new technologies. Consequently, our research field plays a key role in the national planning strategies and is the crucial driving force behind economically competitive innovation.

Structure of the Research Field Energy – Core-financed Costs 2005: 199m euros

The Research Field Energy additionally receives 105m euros for a total budget of 304m euros.



Programme structure

Six Helmholtz Research Centres work together in the Research Field Energy: The German Aerospace Centre (DLR), the Forschungszentrum Karlsruhe (FZK), the Research Centre Jülich (FZJ), the GeoForschungsZentrum Potsdam (GFZ), the Hahn-Meitner Institute (HMI) and the Max-Planck-Institut für Plasmaphysik (IPP). Scientists collaborate in four programmes:

- Renewable Energies
- Efficient Energy Conversion
- Nuclear Fusion
- Nuclear Safety Research

These programmes are led by interdisciplinary research teams equipped with large-scale facilities, test-beds for major components, high-performance analysis systems and supercomputing capacities. The choice of research topics also takes account of the assignment of roles and responsibilities as agreed between partners in science and industry.
The dialogue initiated by the leading organisations of industry and science produced a consensus view: no sensible energy option should be abandoned at this stage. Since only then will the power industry be able to address its two central challenges: ever dwindling resources and risks associated with waste disposal.

The Programmes

Renewable Energies

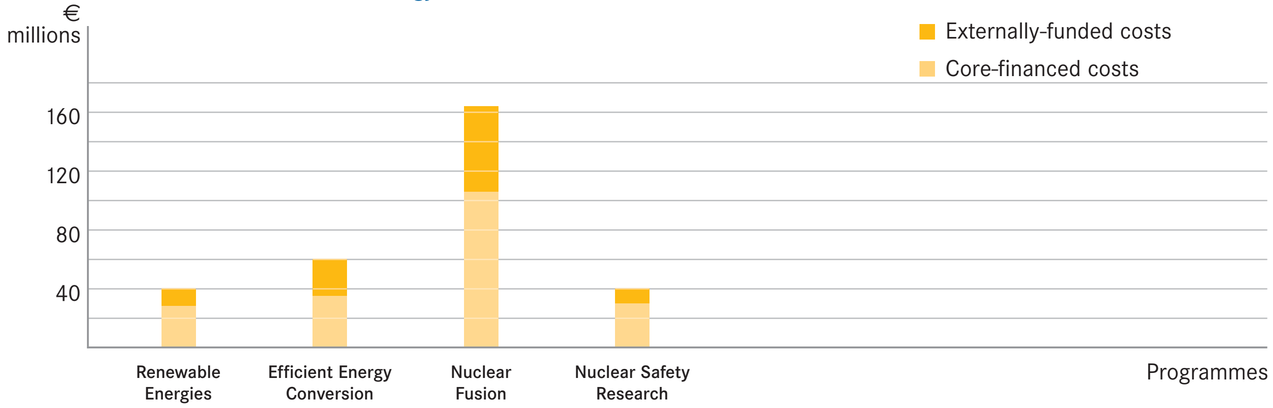
Renewables based on solar, geothermal and biomass energies are thought to epitomise sustainability, since they are not only inexhaustible but are additionally CO_2 neutral, which means they will not worsen the greenhouse effect. This is why we attach particular importance to studying renewable energy sources and developing economical technologies. Future research must, in particular, aim to lower costs. Wind power converters and solar collectors are already technically mature and are being marketed by companies – supported by national launch programmes. By contrast, the costs of photovoltaics continue to be too high, even under large-scale series production. New approaches, especially in the field of thin layer technologies, promise real improvements, but still need further examination.

The power generated by geothermal energy from low temperature resources continues to be unsatisfactory. This is why the programme includes a systems analysis to assess both the potential that renewables offer and the strategies for bringing them into more widespread use.

Efficient Energy Conversion

Carbon-based, fossil fuels such as crude oil, natural gas or coal will continue to dominate energy supplies for decades to come. However, there is great potential in making energy conversion technologies more efficient. This is where the Efficient Energy Conversion programme sets in. It explores new technologies for power stations and fuel cells and studies the use of superconductors in the electricity industry. Key topics include new components and solutions for high-performance gas turbines. Fuel cell research sees further developments in solid oxide fuel cells equipped with ceramic electrolytes and in low-temperature fuel cells, particularly the direct methanol cell. Research on new superconducting components for the power grid delivers highly promising solutions with which power can be transmitted in the future with practically no energy losses.

Total Costs: Research Field Energy



Nuclear Fusion

Nuclear fusion is a prime example of long-term forward-planning precautionary research. Only from the second half of our century and beyond could a fusion reactor actually generate power and so permanently resolve some of humankind's energy problems. The immense cost of research and development means that this goal can only be achieved in national and international cooperation. Consequently, Helmholtz fusion research forms an integral part of the EURATOM Fusion Programme. The Helmholtz research priorities agreed with our international partners focus on contributing to setting up ITER, a tokamak experiment, and on setting up the European-supported large-scale German stellarator experiment WENDELSTEIN 7-X. Tokamak and stellarator are two different concepts for confining hot fusion plasma in a magnetic field. ITER aims to demonstrate that fusion-based power generation is technically feasible. The experiment additionally aspires to provide the data needed for building a demonstrator power plant. The WENDELSTEIN 7-X stellarator experiment aims to show that the stellarator concept is also suitable for a fusion power plant. The Helmholtz Association supports this strategic master plan by conducting additional, smaller experiments and developing technologies and new materials to prepare components for a demonstrator power plant.

Nuclear Safety Research

In 2005, nuclear power stations in Germany generated around 163 terawatt hours of electric power and so covered 27% of the country's power demand. 17 nuclear power stations are still in operation. Consequently, research on the safety of nuclear reactors and on the safe disposal of nuclear waste is absolutely indispensable. Both topics are integrated into the European Union's EURATOM Framework Programme. Helmholtz research focuses primarily on aspects of safety in the event of conceivable major malfunction scenarios plus studies and work on the final disposal of radioactive wastes, especially long-term safety. Through their work, Helmholtz scientists also ensure that Germany's teaching and research competence in nuclear technology is secured, because this know-how is at risk of being lost as a result of the diminishing role of nuclear power generation in Germany.

THE RESEARCH FIELD EARTH AND ENVIRONMENT

Goals and Roles

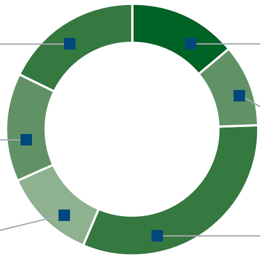
The 20th century saw the relationship between humankind and nature change fundamentally. Non-natural factors have since impacted life on earth with a previously unknown intensity. The main triggers are population growth and the development and application of new technologies. Both increase the demand for resources. In particular, the rapidly-growing consumption of fossil resources contributes to the Earth's climatic equilibrium being in danger of losing its balance, which would put the Earth's global ecological stability at risk.

The development of sustainable solutions first needs a better and closer understanding of the fundamental functions of System Earth and of how human society and nature interact. This is a key goal of the earth and environment research done within the Helmholtz Association. Researchers are also working on describing the consequences of the complex changes to earth and the environment as precisely as possible so that objective decision-making aids can be made available to decision-makers in politics and society.

Research projects that not only span the programmes but also integrate the centres and other institutions are playing an ever more important role in the Helmholtz Association. For example, six centres are working together in the Integrated Earth Observation System Helmholtz-EOS in order to study and address complex questions of polar ice and marine research, water cycle, disaster management, and land surface processes. At the same time, four of the six cooperating centres are also partners in the project to develop a Tsunami early warning system for the Indian Ocean, an international collaborative project that is scheduled for completion in mid 2008. A Helmholtz network of five centres has been formed to address the cross-research-field topic of systems analysis and technology impact assessment. A further example of research cooperation across institutional borders involves the German Marine Research Consortium (Konsortium Deutsche Meeresforschung – KDM) in which 11 research institutes from the Helmholtz Association, the Leibniz Association and the universities have joined forces.

Structure of the Research Field Earth and Environment – Core-financed Costs 2005: 272m euros

The Research Field Earth and Environment additionally receives 67m euros, for a total budget of 339m euros.



Programme structure

Nine Helmholtz Centres are actively involved in the Research Field Earth and Environment: The Alfred Wegener Institute for Polar and Marine Research (AWI), the GeoForschungsZentrum Potsdam (GFZ), the Research Centre Jülich (FZJ), the Forschungszentrum Karlsruhe (FZK), the Helmholtz Centre for Infection Research (HZI, formerly GBF), the GKSS-Forschungszentrum Geesthacht, the GSF-National Research Centre for Environment and Health, the Helmholtz Centre for Environmental Research - UFZ, plus the German Aerospace Centre (DLR) as an associated research institute. Research on the environment and System Earth focuses on addressing the grand challenges that national and international bodies have identified. Natural disasters, climate fluctuation and climate change, the availability and dynamics of clean water, sustainable use of resources, biodiversity and ecological stability plus the socio-political dimension of global change. The research field addresses these central tasks of earth and environment research in six programmes:

- Geosystem: The Changing Earth
- Atmosphere and Climate
- Marine, Coastal and Polar Systems
- Biogeosystems: Dynamics, Adaptation and Adjustment
- Sustainable Use of Landscapes
- Sustainable Development and Technology

None of these research tasks can be viewed in isolation from each other, since all the elements and processes are connected with each other in System Earth. To meet these dynamics, scientists working within the Research Field Earth and Environment not only collaborate with each other but also with colleagues from other research fields, for example, when the environmental impact on human health is studied or satellite data are used for modelling environmental processes. Beyond this, particular importance attaches to cooperation with partners outside the Helmholtz Association, at national and international level.

The Programmes

Geosystem: The Changing Earth

This programme focuses on analysing the physical and chemical processes taking place within System Earth and how geosphere, atmosphere, hydrosphere and biosphere interact. Scientists study and model the relevant geoprocesses so as to assess the state of System Earth and identify changing regional and global trends. They do this by building a global observation infrastructure and by exploring the inner Earth. Near Earth satellites, airborne recording systems, a global network of geophysical and geodetic stations, mobile instrument arrays plus the analytical and experimental infrastructure at the participating research centres join together to form an observation system which is itself integrated into national and international collaborative structures. Besides studying earth's magnetic and gravity fields, the key research topics are natural resources and material cycles, climate variability and the human environment, plus prevention of and forward-planning strategies for managing natural disasters, and the use of subterranean space, for example, to store carbon dioxide.

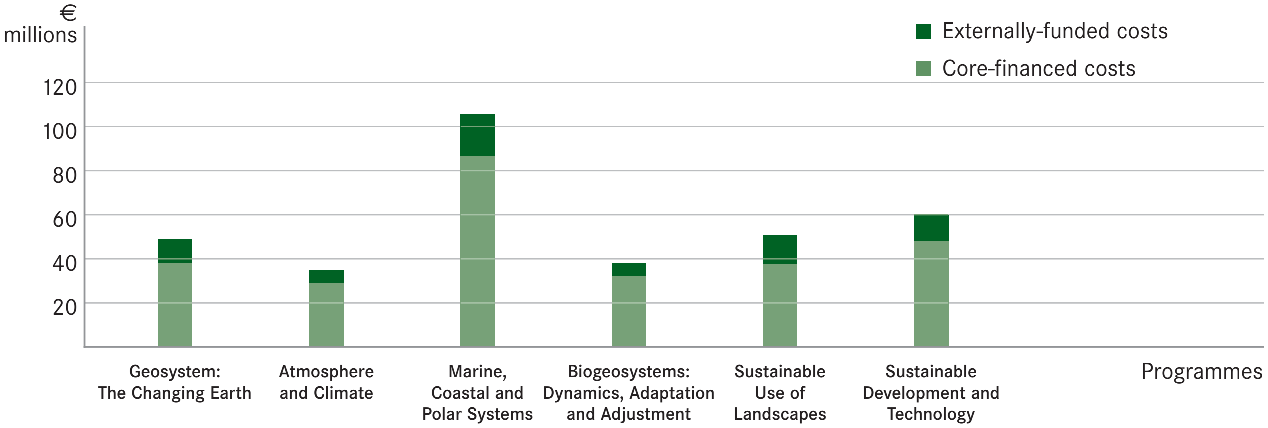
Atmosphere and Climate

The atmosphere is the key determinant of environmental conditions on Earth. Research in this programme analyses the atmosphere's state and changes, as well as the complex interactions taking place within the atmosphere and with adjacent spheres. The scientists also study how human activities impact the chemical composition of the atmosphere and, consequently, the climate. To enable them to predict global and regional climate changes, the participating scientists not only analyse chemical and microphysical processes but also the feedback mechanisms. Major experiments, such as an international field campaign on atmosphere research, are currently being run. Earth observation satellites, such as ENVISAT, deliver informative data. Through this work, the Atmosphere and Climate programme contributes substantially to the topics of "Climate variability and climate change" and "Water – cycle and availability".

Marine, Coastal and Polar Systems

The biological and geological nature of global marine systems and coastal regions is the object of research conducted in this programme. Special emphasis attaches to studying polar regions. The processes and interactions taking place within these systems are particularly decisive for the global climate. The research activities concentrate on acute changes in key regions, such as permafrost areas, and on global changes that can be deduced from studying natural archives, such as the ocean floor or polar ice. The programme's main objective is to create a model system to help predict developments. This model aims to depict, simultaneously, firstly how the cryosphere, the oceans and the marine biological and geological chemospheres influence the climate and biodiversity and, secondly, how energy and materials flow in the various space and time scales. Taking this model system as a starting point, scenarios can be developed for the management and sustainable use of the marine environment, and especially of coastal regions.

Total Costs: Research Field Earth and Environment



Biogeosystems: Dynamics, Adaptation and Adjustment

This programme investigates how biogeosystems (for example, agricultural regions or managed forests) respond to human intervention and environmental change. The researchers do this by studying elementary components like soils, microorganisms, flora and groundwater and how these interact. In their work, the scientists identify the critical factors and analyse reaction mechanisms and patterns. This makes early recognition of negative developments in biogeosystems possible and so provides the chance to develop methods to counteract them. This research programme is responsible for contributing to the protection and sustainable use of biogeosystems.

Sustainable Use of Landscapes

Many landscapes have been affected by human use. This research programme is commissioned to study the effects and consequences. This use takes on many different forms, from urban, densely settled and intensively used areas via contaminated former opencast mining areas through to semi-natural areas that are only suitable for extensive, i.e. non-intensive cultivation, such as deserts and semi-arid landscapes. This produces a broad range of research topics extending from basic research on biodiversity and ecological stability through to questions of resource management, particularly, in this respect, water cycles and water treatment. In addition, the scientists examine how climate change will affect land usage. These studies also take socio-economic and legal questions into consideration.

Sustainable Development and Technology

The grand challenges of environmental research, for example, the "sustainable use of resources", "water – availability and dynamics", and the "socio-political dimension of global change" can only be mastered with new technologies. This research programme develops technologies that are able to make anthropogenic material flows, such as water, carbon, wastes, and building materials, manageable, are able to conserve resources, to reduce emissions, and to facilitate the regeneration of natural resources. By combining socio-economic systems research with technology impact assessment and cooperating with other research fields and programmes it becomes possible to offer integrated strategies for sustainable development. The Sustainable Development and Technology programme concentrates the conceptional and systems-analytical activities of the Helmholtz Association so that the mission of sustainable development can provide a practicable basis for all stakeholders.

THE RESEARCH FIELD HEALTH

Goals and Roles

Despite enormous progress in science and research, only one third of all human diseases can be cured by treating the cause. In addition, the range of diseases is shifting as a result of changing lifestyles and habits, and an aging population. These developments present health research with major challenges.

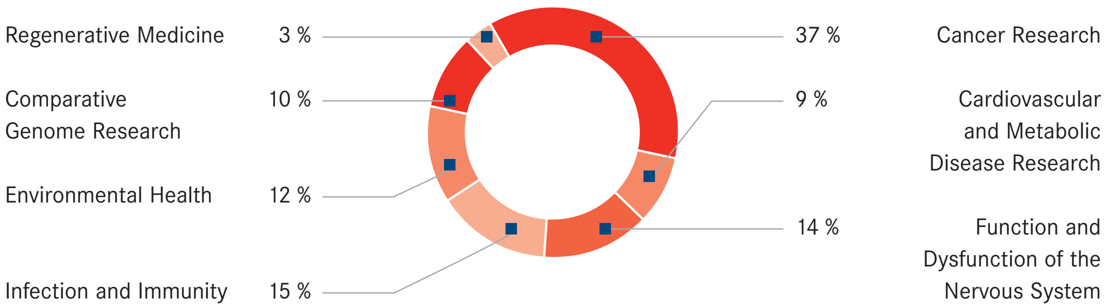
Work in the Research Field Heath focuses particularly on frequently seen, severe illnesses, such as cardiovascular disease or cancer. The research aims to gain a better understanding of the causal processes that lead to these diseases so that new prevention, diagnosis and treatment strategies can be developed and subsequently used in practice, in cooperation with clinics.

The effective transfer of basic research findings into applications and practice, particularly by interlinking research and clinic more closely, remains a key health research objective within the Helmholtz Association that spans all programmes. The National Centre for Tumour Diseases in Heidelberg is one of the key projects in realising this goal. The German Cancer Research Centre, the University Hospital and the Thorax Clinic, all in Heidelberg, are working together with the charity German Cancer Aid (Deutsche Krebshilfe) to establish a treatment centre for tumour patients. Basic researchers will work hand-in-hand with clinical scientists at this centre. This centre will be unique in Germany, offering a combination of state-of-the-art therapy and cancer research. Tumour patients will be able to use this out-patient centre as a central contact point where interdisciplinary teams of experts work together on drawing up diagnosis and therapy plans.

Besides this centre in Heidelberg, other translational centres are also being established at other locations. Working together with the Ludwig Maximilian University Munich and a private clinic operator, the GSF-National Research Centre for Environment and Health in Munich plans to establish a facility that will concentrate particularly on pneumological diseases. On the one hand, the GSF's unique combination of environmental and health research predestines it for research on respiratory diseases, while, on the other, this project enables it to address and redress the serious lack of pneumological research in Germany. A facility dedicated to combining basic research with clinical application is planned at the Helmholtz Centre for Infection Research, in cooperation with the Hannover Medical School (MHH). Basic research on infection biology at the Helmholtz Centre will join up with the MHH's expertise in clinical infection research to develop new vaccines, a key task in view of the growing role that infectious diseases play in public health. And the Max Delbrück Centre for Molecular Medicine in Berlin-Buch is also currently setting up a translational centre.

Structure of the Research Field Health – Core-financed Costs 2005: 258m euros

The Research Field Health additionally receives 85m euros, for a total budget of 343m euros.



Programme structure

Ten Helmholtz Centres cooperate in the Research Field Health. These include the Helmholtz Centre for Infection Research (HZI), formerly known as the German Research Centre for Biotechnology (GBF), the German Cancer Research Centre (DKFZ) in Heidelberg, the Research Centre Jülich (FZJ), the Forschungszentrum Karlsruhe (FZK), the GKSS-Forschungszentrum Geesthacht, the GSF-National Research Centre for Environment and Health, the Gesellschaft für Schwerionenforschung (GSI), the Hahn-Meitner Institute (HMI), the Max Delbrück Centre for Molecular Medicine (MDC), and the Helmholtz Centre for Environmental Research - UFZ. The scientists and researchers are working on six programmes, plus one still under establishment:

- Cancer Research
- Cardiovascular and Metabolic Disease Research
- Function and Dysfunction of the Nervous System
- Infection and Immunity
- Environmental Health
- Comparative Genome Research
- Still under establishment: Regenerative Medicine

The Programmes

Cancer Research

Cancer is a particularly severe and complex disease, often associated with a long-drawn-out course and with serious psycho-social consequences for patients and relatives. In Germany, around 400,000 people are diagnosed with cancer each year, of which more than half die. Cancer treatment is also very expensive. The research aims to significantly improve cancer prevention, early recognition, diagnosis and treatment. Researchers analyse the signalling pathways leading to the development of cancer, explore the genetic roots of the disease and identify risk factors that lead to cancer. A programme focus involves the development and application of innovative diagnostic and therapeutic methods based on molecular, cell biological, histological and radiophysical techniques. Other key research areas aim to understand the role of the immune system in cancer and to study cancer-relevant viruses.

Cardiovascular and Metabolic Disease Research

Cardiovascular diseases are the most frequent cause of death in western industrialised nations. Major risk factors are high blood pressure, diabetes and obesity. These are among the most common and widespread diseases and are responsible for massive expenditure within the public health system. To stem the incidence of these diseases in the long-term, scientists study the causes of vascular diseases and high blood pressure, of heart and kidney disease, and of metabolic diseases, such as diabetes and adiposity. In addition, they develop new ways of preventing, diagnosing and treating such illnesses. To achieve their goals, researchers use various methodological approaches based on genetics, genomics and bioinformatics, cell biology, and epidemiology.

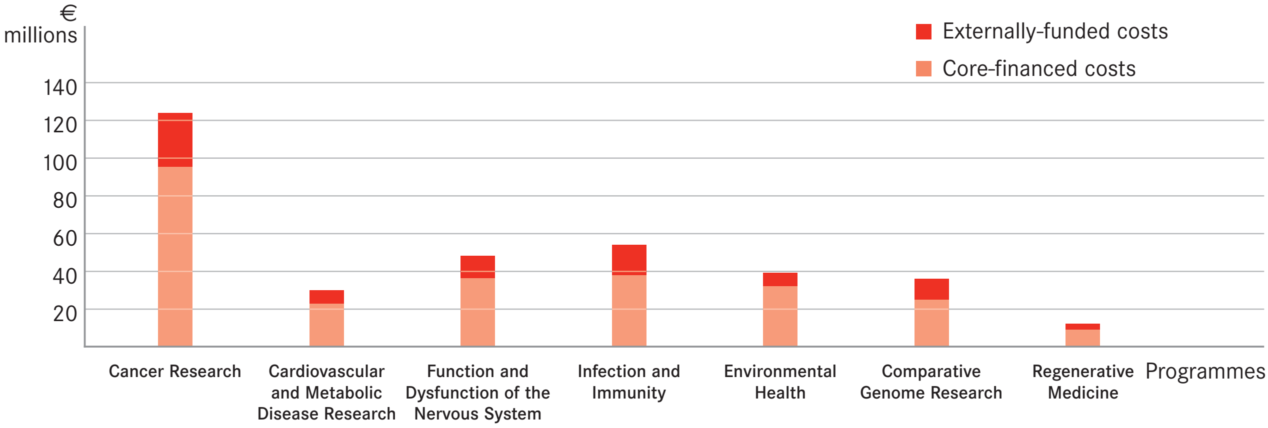
Function and Dysfunction of the Nervous System

As human life expectancy increases, neurological and psychiatric illnesses start to play an ever more important role. Scientists at the Helmholtz Association contribute to extending our knowledge of the causes of these diseases by carrying out basic neuroscience research. Central topics include the study of degenerative diseases of the motor neuron system, such as Parkinson's, of the retina, and diseases of the brain in general, such as Alzheimer's, epilepsy or cognitive function disorders resulting from strokes or brain tumours. To analyse the relevant mechanisms, scientists have to look closely and specifically at the individual signal-transmitting molecules and cells and, sometimes have to examine the whole neural system. The scientists use large-scale facilities to analyse normal and pathologically changed mechanisms in the living human brain and apply cutting edge techniques from genomic research and cell biology.

Infection and Immunity

More than 17 million people die of infectious diseases every year – that is one third of all deaths worldwide. In view of the growing threat posed by such diseases, the research seeks to understand the fundamental mechanisms of infection and immunity. Researchers study what causes pathogenic organisms and

Total Costs: Research Field Health



analyse the development of immunity in order to gain more knowledge about the molecular and cellular processes occurring in the course of an infection. Parallel to this, they analyse the fundamental mechanisms used by hosts to prevent or control infections. Based on these findings, they are able to draw up new strategies for fighting infections and also develop immune-therapy based strategies for treating other chronic diseases, such as autoimmune disorders and cancer.

Environmental Health

Human health depends on complex states of equilibrium which, on the one hand, can be genetically determined and, on the other, can be influenced by the environment. How strongly do environmental factors affect human health? What molecular and cellular mechanisms underlie these disorders? What new preventative and therapeutic strategies can we derive from this? Answering these questions is the key goal of the research done in this programme. The work focuses on common diseases, such as inflammations of the respiratory tract, allergies and cancer, whose origins are significantly influenced by toxic environmental agents, such as particle-like air pollutants (aerosols), chemicals and ionising radiation. The scientists take two approaches. Firstly, they look at the toxic agent to identify it and to understand its disease-triggering mechanism so that they can develop risk assessment and risk reduction strategies. Secondly, they consider the diseases themselves and study their developmental mechanisms to find out what kind of role environmental factors play in all this.

Comparative Genome Research

Understanding health and illness at cellular level is the key task performed by comparative genome research. To explain the molecular causes of diseases, scientists initially sequence the genomes of model systems, such as the mouse, and transfer their findings to analogous mechanisms in the human genome. The results are collected and analysed in databases. Proteome research complements the knowledge acquired on the genetic components of diseases through information on gene products, the proteins, and on their intercellular, disease-relevant interactions. Scientists from this programme contribute significantly to the National Human Genome Research Network.

Under establishment: Regenerative Medicine

Growing life expectancy in industrialised countries results in the incidence of age-typical diseases associated with functional disorders or failure of cells, tissues or organs increasing. This is why the therapeutic methods developed by the field of regenerative medicine are becoming ever more important. Helmholtz scientists are developing materials, methods and systems for the field of regenerative medicine that can be used in tissue engineering and organ replacement systems. The goal is to get as close as possible to the role played by the natural models and to support or even replace diseased organs. Furthermore, researchers are attempting to improve the interface between technology and organism, for instance, through neural coupling.

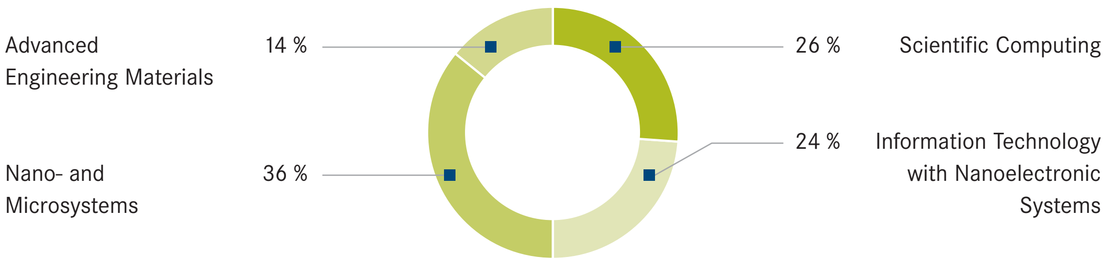
THE RESEARCH FIELD KEY TECHNOLOGIES

Goals and Roles

Key technologies, like nanotechnology, microsystems technology, advanced engineering materials and scientific computing, make it possible to open up new fields of technology and offer great innovative potential for science, industry and society. Consequently, research on key technologies contributes decisively to raising the international competitiveness of German industry. Scientists working in this research field concentrate on those technologies that are particularly complex, that promise new methods and solutions for other research fields or that are of particular interest for industrial application. Technologies that offer good prospects initially undergo fundamental and multidisciplinary examination. Where major potentials arise for applications, the research is continuously deepened until the technology's suitability for concrete fields of application is known. The exploration of key technologies builds on a broad scientific basis that is deliberately fostered and cultivated. This is done to prevent attention focusing too early on just a few potential applications, with the result that other opportunities are overlooked. The work performed by the research field also includes assessing new technologies on behalf of society to identify their inherent opportunities and risks.

Structure of the Research Field Key Technologies – Core-financed Costs 2005: 113m euros

The Research Field Key Technologies additionally receives 27m euros, for a total budget of 140m euros.



Programme structure

Three Helmholtz Centres work together in the Research Field Key Technologies: The Research Centre Jülich (FZJ), the Forschungszentrum Karlsruhe (FZK) and the GKSS-Forschungszentrum Geesthacht. The research field has a cross-disciplinary role to play by placing high-performance computing capacities at the disposal of internal and external users. Lead responsibility for the Helmholtz Association materials research conducted in various research fields with a problem-oriented approach lies with the Research Field Key Technologies. The scientists conduct research in four programmes:

- Scientific Computing
- Information Technology with Nanoelectronic Systems
- Nano and Microsystems
- Advanced Engineering Materials

Characteristic features of the work done include close cooperation with industry and coordinated networks to link up research institutes with companies. The research field brings together the shared interests of science and industry so that they can take concerted action in the European Union and on the international stage. The research field is the first point of contact for companies and professional, scientific or business associations, and advises political decision-makers on the opportunities and risks associated with new technologies. Each programme has a clear profile. Wherever existing competencies mutually complement each other, these are used for cross-programme cooperation. Molecular electronics is a typical example, located at the interface between information technology and nanotechnology. Other Helmholtz research fields, such as energy, transport, health and environment, also benefit from the work done on key technologies.

The Programmes

Scientific Computing

Processing large volumes of data and modelling complex systems are important research tools pooled under the heading of scientific computing. Focusing on high-performance and GRID computing, the programme provides indispensable infrastructures for German science and research. Experts at the John von Neumann Institute for Computing in Jülich (NIC) and at the Grid Computing Centre in Karlsruhe work on improving the development of methods, tools and applications, and support numerous users from other research fields and institutions. The researchers develop parallel algorithms plus new programming and visualisation techniques. A particular challenge lies in meaningfully managing and processing the ever-growing flows of data produced by accelerators and satellites. The modern concept of grid computing, in which computers are linked up to form functional arrays, makes it possible to analyse even greater volumes of data. The computer network GridKA is also being established at the Forschungszentrum Karlsruhe. As from 2007, it plans to process some of the data delivered by the Large Hadron Collider (LHC) located at the European Research Centre CERN, for which it will also be networked with computer centres in other countries.

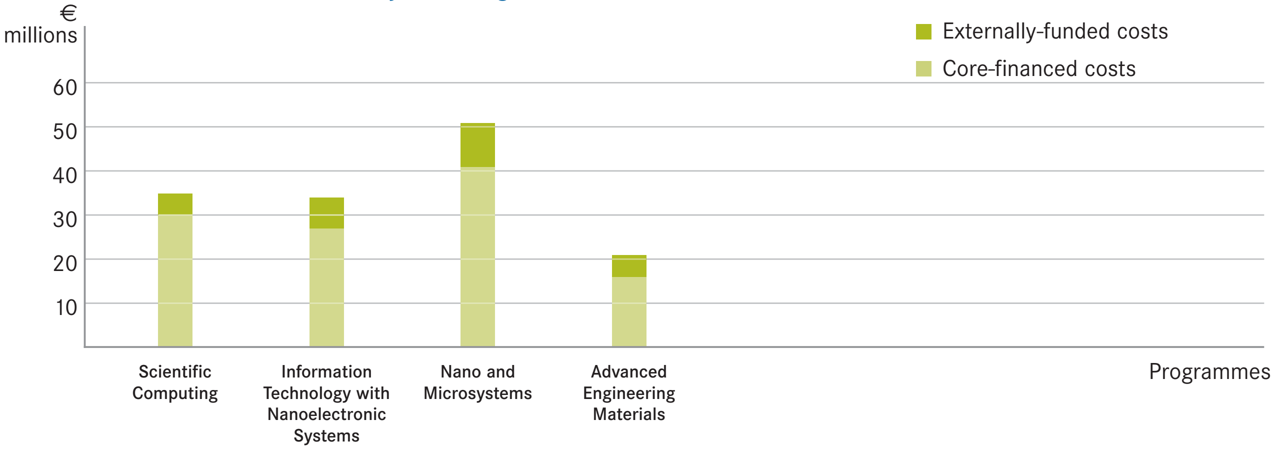
Information Technology with Nanoelectronic Systems

Semiconductor devices are becoming ever smaller, but the limits of miniaturisation have not been reached yet. The research performed in this programme anticipates industrial developments and studies quantum-electronic, magneto-electronic, ferroelectric and molecular nanostructures. Highest-frequency electronics and bioelectrical signal processing also belong to this programme area. The scientists do basic research on materials and the processes taking place, study information processing in logic devices, information storage in Random Access Memories (RAM) and mass storage media, plus the transmission of information to chip and system level, and also develop new sensors.

Nano and Microsystems

While microsystems technology already comes very close to application, nanotechnology still needs a great deal of basic research. Both these fields join together in this programme. For example, scientists work on developing new microsystems made of polymers, metals or ceramics that are capable of carrying out functions that silicon-based microsystems cannot perform. Such novel materials and technologies are capable of initiating innovations.

Total Costs: Research Field Key Technologies



Scientists also design microtechnical components and systems for selected fields of application, mostly in cooperation with industry, such as for microoptics, micro-process engineering, gas analysis, microfluidics and the life sciences. Nanotechnology is considered one of the key technologies of this century. The potential applications for inorganic, organic and bioorganic nanostructured systems are highly promising and have only just begun to be studied. On the one hand, this involves understanding the essential processes so that the next step can develop materials with completely new properties and characteristics, some of which will certainly interest industry. The researchers also intend to use technical materials to develop biological functional units under controlled conditions. They plan to position nano-production-plants at the interface between microtechnology and nanotechnology in which nanostructured systems can be industrially manufactured with tailor-made properties. The idea is to transfer research findings from lab to application and so facilitate the development of new products.

Advanced Engineering Materials

New materials and material systems, such as composite materials for sustainable and efficient resource and energy use and for applications in medical engineering, are the topics for research work conducted in this programme. In this respect, activities focus on two fields offering major potential for applications. On the one hand, these are metallic materials needed for lightweight engineering applications in fields of transport and energy engineering and, on the other, advanced engineering polymer systems for applications in lightweight engineering, chemical process engineering and energy engineering, plus medical engineering and technology. In the long term, they plan to enable these materials to complement or replace traditional materials and so open the way to new solutions. Working in close cooperation with industry, Helmholtz scientists are studying fundamental questions of alloy and polymer development, processing and finishing, and component and process trialling and testing. Computer simulation and material properties modelling also play key roles in developing new materials systems.

THE RESEARCH FIELD STRUCTURE OF MATTER

Goals and Roles

This research is indeed about what holds universe together at its innermost folds. What are the elementary building blocks of matter? What forces act between them? And how do the major structures of the universe develop from these? On the other hand, scientists also focus on the complex phenomena caused by the interaction of myriads of atoms in liquids and solids. For this is indeed where basic research produces insights that facilitate the design of novel materials with tailor-made electronic, mechanical or thermal characteristics.

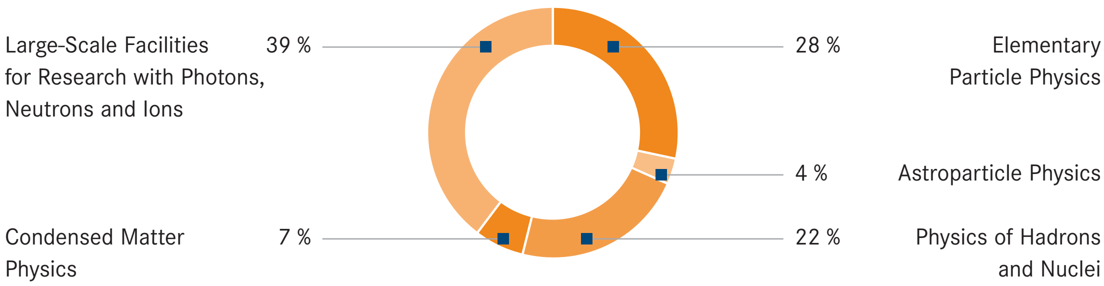
A particular strength of Helmholtz research lies in its large-scale facilities. Whether particle accelerators, synchrotron radiation or neutron sources, these major and in some cases unique scientific infrastructures are used by numerous researchers from both home and abroad.

With the planned x-ray laser XFEL, which is now being built at the Deutsches Elektronen-Synchrotron (DESY) in cooperation with European partners, an x-ray source will be created whose top-rate performance is 10 billion times higher than was previously possible. For example, XFEL will open up completely new insights into chemical and biological processes.

Another large-scale instrument is to be created at the Gesellschaft für Schwerionenforschung (GSI) in Darmstadt. The Facility for Antiproton and Ion Research (FAIR) is an accelerator of the next generation that will deliver ion beams of a previously unparalleled intensity and very high energies. This will make it possible to generate exotic nuclei or antiprotons that can then be studied in other experiments.

Structure of the Research Field Structure of Matter – Core-financed Costs 2005: 433m euros

The Research Field Structure of Matter additionally receives 40m euros, for a total budget of 473m euros.



Programme structure

Six Helmholtz Centres collaborate in the Research Field Structure of Matter: the Deutsches Elektronen-Synchrotron (DESY), the Research Centre Jülich (FZJ), the Forschungszentrum Karlsruhe (FZK), the GKSS-Forschungszentrum Geesthacht, the Gesellschaft für Schwerionenforschung (GSI) and the Hahn-Meitner Institute (HMI). Scientists work in five programmes:

- Elementary Particle Physics
- Astroparticle Physics
- Physics of Hadrons and Nuclei
- Condensed Matter Physics
- Large-Scale Facilities for Research with Photons, Neutrons and Ions

All programmes rely on the close interaction between theory and experiment. Some of the programmes are scientifically and technologically interlinked, while the strategies mostly build on the existing and planned scientific infrastructures and large-scale facilities. This is why the general goal aims to use these large-scale facilities efficiently and to give users the best possible support in order to maintain the leading role played in this field by Helmholtz and its international partners.

The Programmes

Elementary Particle Physics

This programme studies the basic building blocks of matter and the forces acting between them, including an understanding of the evolution of the early universe. The origin of mass, the unification of all fundamental forces at extremely high energies, and unifying quantum physics with the general theory of relativity are all among the truly grand challenges of physics. The researchers use the electron-proton collider HERA at DESY to study the inner structure of protons and the properties of strong, electromagnetic and weak forces. They also search for traces of new particles and for the supersymmetry partners of all presently known particles. Besides the accelerator capacities, scientists also have high-performance computers at their disposal for data analysis and for modelling questions of theoretical physics. The Grid Computing Centre Karlsruhe (GridKA) being built at the Forschungszentrum Karlsruhe will provide a high-performance computer centre that is internationally networked and capable of analysing data produced by the Large Hadron Collider (LHC) at the European Research Centre CERN in Geneva.

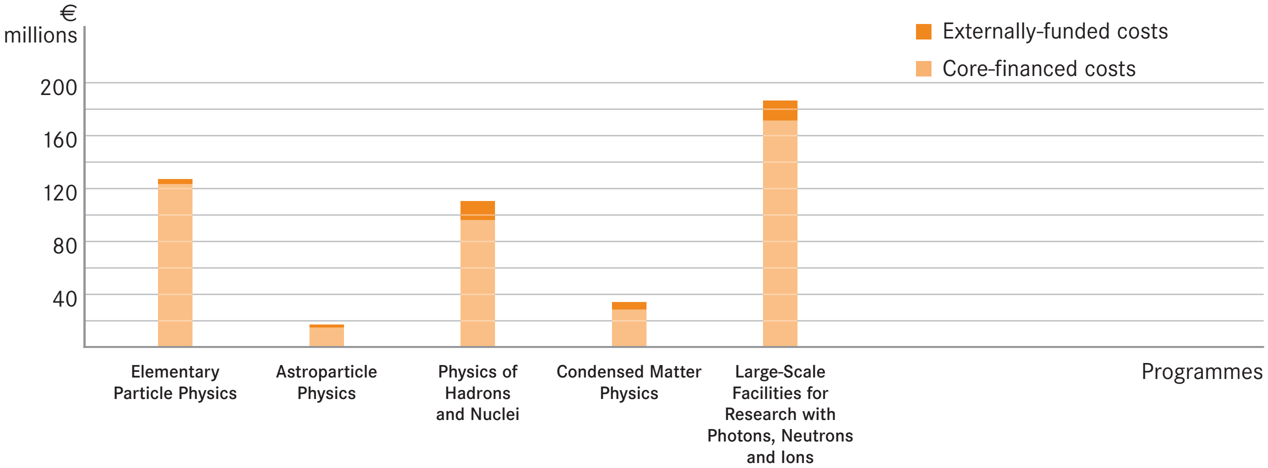
Astroparticle Physics

Astroparticle physics is a new interdisciplinary research area that combines our knowledge of the smallest building blocks with our understanding of the largest structures of the universe. This synthesis of knowledge and methodology has already produced numerous surprising results. Astroparticle physicists explore the sources of cosmic rays and the mechanisms of cosmic accelerators. They use gamma rays, neutrinos and cosmic rays to discover the universe beyond the range of classical wave-length observation. They explore the so-called dark matter, previously expressed only through its gravitational effect. The programme has three core focuses: studying cosmic rays at high energies (Pierre Auger Observatory, Argentina), using neutrino telescopes to search for high-energy neutrinos from astrophysical sources (AMANDA II and Icecube, Antarctic), and determining the neutrino mass to a cosmologically relevant degree of precision (KATRIN, Karlsruhe). These goals call for the development, construction and operation of major detectors backed up by an efficient infrastructure, sometimes located far away from existing labs.

Physics of Hadrons and Nuclei

Hadrons, nuclei and protons are made up of quarks that bind together through strong interaction. Scientists in the Physics of Hadrons and Nuclei programme concentrate mainly on the following topics: quark confinement in hadrons, the spontaneous breaking of chiral symmetry, the origin of hadron mass, properties of the nuclear many-particle systems, exotic nuclei at the limits of stability, generation of super-heavy elements (GSI), behaviour of extended nuclear matter in astrophysical objects such as neutron stars and supernovae. The search for previously unknown forms of matter is also a research topic. In addressing these questions, the programme uses experiments carried out on the large-scale facilities operated by the Gesellschaft für Schwerionenforschung (GSI) and the Research Centre Jülich (FZJ). The planned Facility

Total Costs: Research Field Structure of Matter



for Antiproton Ion Research (FAIR) to be built at the GSI in cooperation with international partners will provide a next-generation particle accelerator. The present GSI accelerators will serve as injectors for the new facility. The double-ring will deliver ion beams of a previously unachieved intensity and at very high energies. This will make it possible to generate exotic atomic nuclei or antiprotons for further experiments, for instance on the nature of quark-gluon-plasmas or forms of matter at the beginning of the universe. Helmholtz research in this programme also contributes significantly to present-day and future research activities at CERN (SPS and LHC).

Condensed Matter Physics

This programme studies the characteristics of solids and liquids in detail. Scientists investigate the interactions between electrons and atoms that determine mechanical, thermal, electronic, magnetic and optical properties. Many-particle systems are a complex research area. The physics of condensed matter operates in subatomic through to macroscopic dimensions, observes electronic reaction times ranging from the very smallest fractions of a second through to geological periods of millions of years. The programme's main goal is to explore new and unusual states of solids, soft matter, thin films and boundary layers. The programme benefits from large-scale facilities with neutron and synchrotron radiation. Scientists also use spectroscopic methods, thermodynamic and transport measurements, high-resolution electron microscopy, and supercomputers that enable them to carry out theoretical modelling and computer simulations.

Large-Scale Facilities for Research with Photons, Neutrons and Ions

This programme brings together large-scale facilities that are particularly important for nuclear and molecular physics, for plasma physics and for the physics of condensed matter, for structural molecular biology, for chemistry and materials sciences, for earth and environment research, and for engineering. The programme research concentrates on using existing photon, neutron and ion sources efficiently and on continually adapting these to the changing needs of the user community. In addition, a new large-scale facility recently came on line. The x-ray laser Flash at the Deutsches Elektronen-Synchrotron (DESY) generates radiation in the soft x-ray range. This will be joined in 2013 by the European x-ray laser XFEL that is also being built there and that will deliver x-ray flashes with an around 10 billion times higher intensity than has been possible so far. This would make it possible, for example, to film the very fast reactions taking place in chemical and biological systems, to unravel the atomic details of molecules, and to shoot 3D images of objects in the nanocosmos. Moreover, the Helmholtz Association is participating with its own beam lines in the research reactor FRM II in Munich and in the megawatt Spallation Neutron Source (SNS) at Oak Ridge in the United States.

THE RESEARCH FIELD TRANSPORT AND SPACE

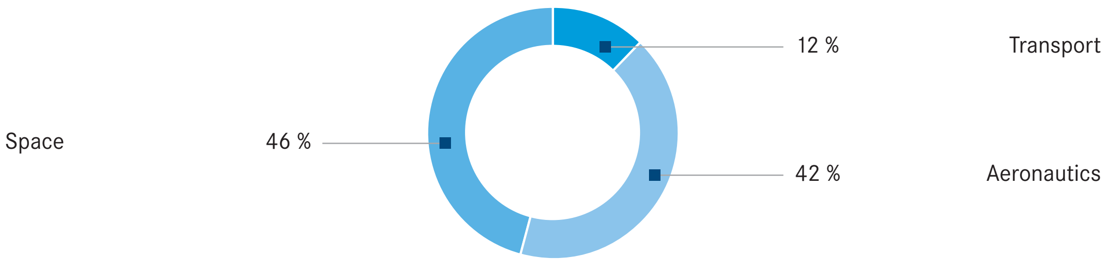
Goals and Roles

Ever increasing traffic and transport and growing volumes of data are dominant features of modern societies, albeit at the cost of security risks, environmental pollution and high levels of energy consumption. Scientists at the Helmholtz Association are looking for new concepts and technical solutions to meet the need for mobility, communication and information, to define future-viable and sustainable research topics, and to advise political decision-makers accordingly. The research also develops space-borne applications in transport, such as those that build on the future European satellite navigation system GALILEO.

Helmholtz transport and space research is performed exclusively at the German Aerospace Centre (DLR). Since 1 December 2005, the Federal Ministry of Economics and Technology (BMWi) has been ministerially responsible for the DLR, which will nevertheless remain a full member of the Helmholtz Association. From now on, the Helmholtz Association will agree its activities with the BMBF and the BMWi and so continue the successful programme development. The DLR collaborates closely with other Helmholtz research fields – especially Energy, Earth and Environment, Health, and Key Technologies. The eight DLR branches are located in various federal states and are closely networked with neighbouring universities and non-university research institutions. In its capacity as the German Space Agency, the DLR is the lead organisation for research conducted within the scope of the German Space Programme and coordinates Germany's participation in the programmes run by the European Space Agency (ESA).

Structure of the Research Field Transport and Space – Core-financed Costs 2005: 155m euros

The Research Field Transport and Space additionally receives 181m euros, for a total budget of 336m euros.



Programme structure

The researchers collaborate in three programmes:

- **Transport**
- **Aeronautics**
- **Space**

The work done in these programmes is characterised by their organisational and thematic integration into a single Helmholtz Centre: the DLR. This means that researchers working in all three programmes can draw directly on the shared core competences that they need, for example, in aerodynamics, propulsion technology, atmospheric technology, structural and design engineering, in robotics and mechatronics, in sensor technology and data processing as well as in the field of telemedicine. Synergies also unfold when research combines questions of aeronautics and terrestrial transport with those of space engineering. This covers areas like positioning, navigation, telecommunications and remote sensing systems. In addition, the research field incorporates topics from industry and society that share their roots with those addressed in its programmes. A typical example involves monitoring ecological contexts, where scientists working on topics like climate, pollutants or noise pool the data they gain from orbital, airborne and terrestrial Earth observation to enhance their research.

The Programmes

Transport

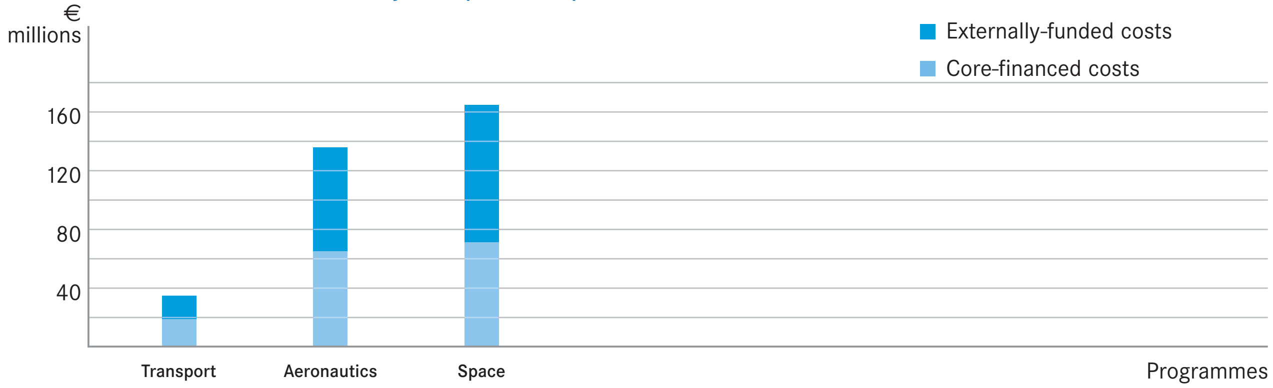
The transport system often struggles to cope with the volumes of traffic that pass through it today and is practically unable to take up any more. This jeopardises the competitiveness of Europe's economy. Massive traffic flows also affect the environment, are detrimental to the quality of life in towns and cities, and bear substantial accident risks. Research in the Transport programme consequently targets three strategic goals: developing new services and concepts to secure mobility, designing innovative solutions to preserve the environment and conserve resources, and improving traffic safety. To achieve the first goal, scientists study how traffic growth can be managed and develop mobility concepts for the future. They view road, rail and air transport as a single integrated system. Traffic data fed into traffic management models are key to this work. The field of environmental and resource conservation concentrates on new methods and technologies for using energy more efficiently and producing fewer exhaust and noise emissions. Scientists also develop new concepts for more efficient, environmentally-friendly transport systems, including the tools needed for technical design and simulation modelling.

The safety question focuses clearly on active accident prevention, including the safety of technical systems and aspects of human behaviour in traffic environments. The research areas Airport Design and Management and Space-borne Applications for Transport have established themselves as two major new topics in this programme and are located at the interface with the other two programmes in the research field. This enables them to optimise their use of the ensuing synergies.

Aeronautics

European integration is clearly reflected in the aviation industry today. So, the Aeronautics programme is driving forward its networking with European partners, and especially with its French and the Dutch partner organisations in aeronautics research: ONERA and NLR. The programme currently focuses on advancing and optimising cargo planes in cooperation with ONERA, on developing flight guidance technology in cooperation with the NLR, and on expanding the DLR-NLR wind tunnel network by integrating the wind tunnels operated by ONERA. This research has set its sights on the following strategic goals: better safety, less aircraft noise, fewer emissions, enhanced economics and more efficiency of the air transport system.

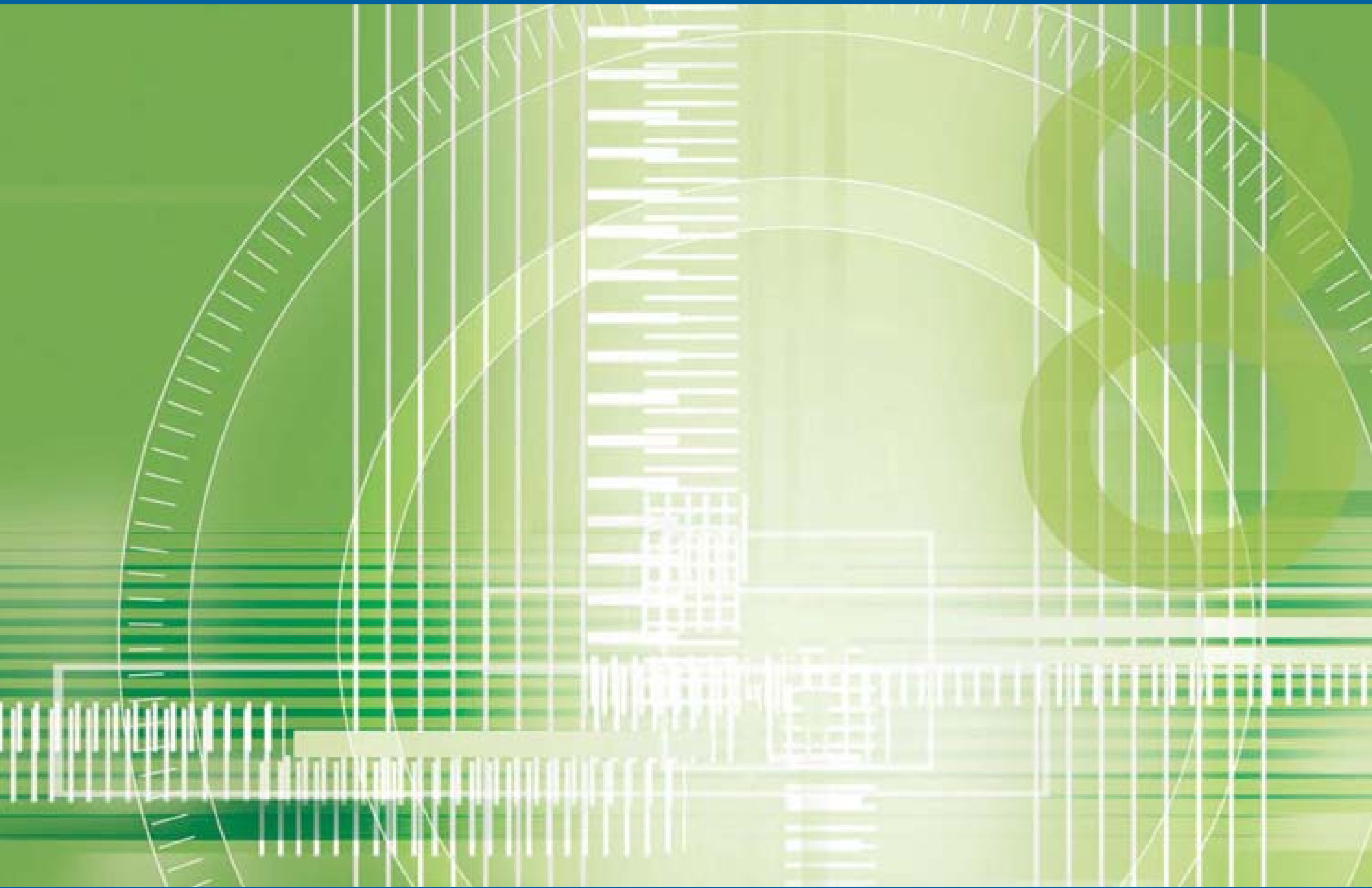
Total Costs: Research Field Key Transport and Space



The work on fixed-wing aircraft is concentrated under the umbrella of DLR/ONERA Aircraft Research. While the helicopter research done under the auspices of DLR/ONERA Rotorcraft Research focuses particularly on expanding the flight envelope by ensuring safe flying conditions, even under difficult weather conditions, and, at the same time, aims to improve the environmental compatibility of the air transport system. Another topic addresses efficient and environmentally-friendly propulsion systems. Research on safe and efficient air traffic management above all addresses the question of airports and airport vicinities. Aviation and environment research form an interdisciplinary topic. Scientists concentrate on air traffic with low pollutant and noise emissions as well as questions of wake vortices.

Space

The space research programme contributes, not least, to creating the foundation for designing and operating new satellites whose data are indispensable today for meteorology, environmental monitoring, disaster prevention and management, resource management, mobility and peacekeeping. The six programme topics are integrated into the German Space Programme. In the field of Earth observation, the DLR is the only European institution working “end to end” on satellite remote sensing, from sensor definition via realisation and through to data reception and processing. Research on communication and navigation includes the optimisation of mobile, satellite-based broadband communication and the creation of GALILEO, the European satellite navigation system. Space transport represents another research topic that aims to secure Europe’s access to space. Sharing the work with European partners, the researchers concentrate on rocket propulsion systems, especially thrust chamber technologies, high-temperature fibre ceramics and aerothermodynamics. The rocket propulsion tests performed at the DLR are a key part of the Ariane programme. Space exploration, especially into how the planetary system developed, and the search for water deposits and traces of life on other planets provide another space science topic. Research under space conditions essentially addresses questions relating to the efficient operation of the International Space Station (ISS). Technology for space flight systems rounds off the sixth and final topic. This involves developing remote-controlled, partly self-sufficient robots that can be used in space and also have applications in industry.



PEOPLE AND FINANCES

The following pages document how we invest our resources. Our staff are our most important resource. It is their ideas, creativity, dedication and commitment that drive science and research forward.

PERFORMANCE RECORD 2005

In addition to the institutional funding provided by federal government and the federal states (totalling 1.6 billion euros), the Helmholtz Centres additionally raised external funds worth 644m euros in total in 2005. The external funds raised in the applications-oriented research fields largely originate from cooperation with business and industry, while the external funding generated by the more basic research-oriented fields comes mostly from research grants won in competition with other organisations, for example in funding programmes run by the European Union or the German Research Foundation (DFG). The relatively high amount of external funding confirms the great appeal that Helmholtz research has for science and industry.

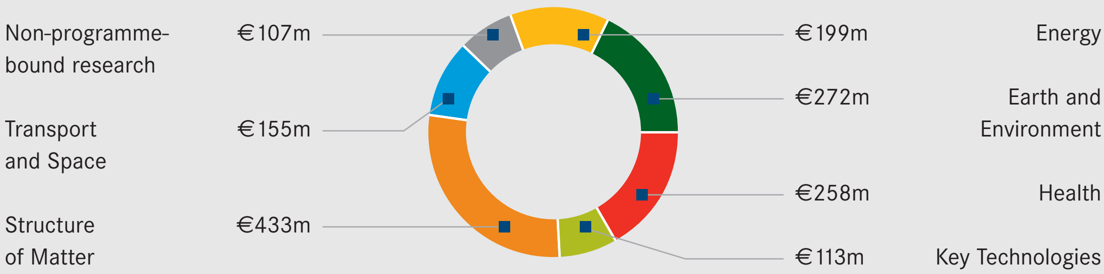
With the introduction of programme-oriented funding, the Helmholtz Centres began to systematically catalogue programme progress not only on the basis of activity reports, but also on that of quantitative success indicators. This involves each programme being reviewed by external experts. Depending on the programme's respective roles and goals, the criteria and benchmarks that indicate how successful the work of a specific programme has been will differ from case to case.

Nevertheless, the following serves to highlight some of the aspects found in such a performance record. They above all include scientific excellence, as well as promoting young academics and engaging in cooperation with industry.

Some of our achievements, for example, in developing and delivering concrete solutions to problems faced by society, cannot, however, be adequately represented in rigid and inflexible schemata. Contributions of these kinds are best illustrated by concrete examples, such as those presented in the first part of this annual report.

Costs of the Helmholtz Association

Core costs of the Helmholtz Association in 2006, financed within the scope of the programme-oriented funding



Scientific Excellence

- 12,000 scientific publications – two thirds of which appearing in ISI-cited specialist journals (2005)
- A good 5,000 collaborative research projects; participation in 211 DFG Priority Programmes and Collaborative Research Centres (SFBs)
- Between 40 and 50 habilitations and 50 to 60 Helmholtz researchers appointed to professorships (C3/C4 or W2/W3 grades) every year

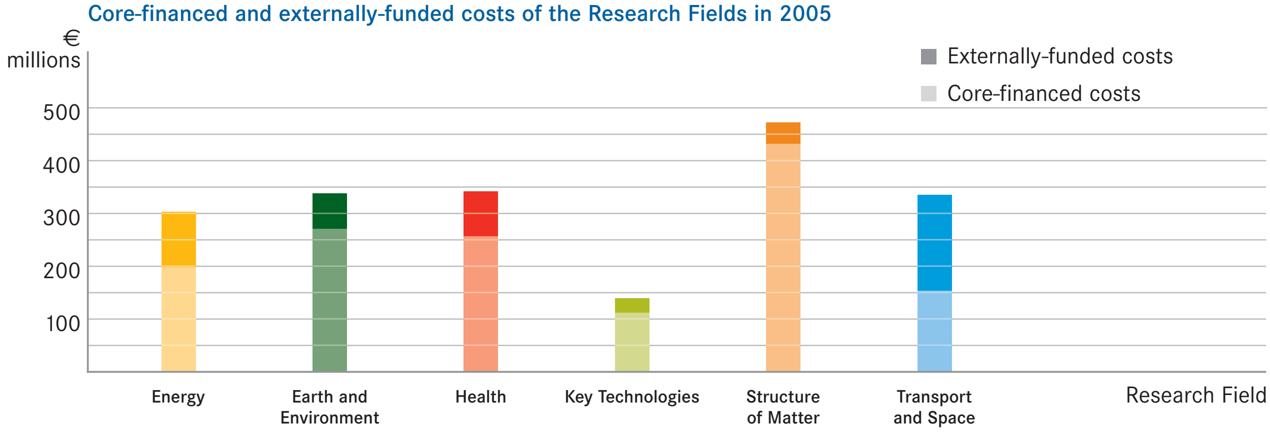
Partner of Industry

- The Helmholtz Association cooperates with industry in more than 2,000 collaborative projects
- Helmholtz scientists annually register 400 patents and sign more than 500 licence agreements
- 2005 saw 12 companies established as spin-offs by Helmholtz researchers

Promoting Young Academics

- Some 3,400 doctoral students supervised in 2005
- A total of 22 graduate schools established
- Helmholtz Centres involved in 51 DFG Research Training Groups and in 48 Marie Curie measures
- Around 1,000 Helmholtz scientists delivered 2,850 semester credit hours of teaching at universities (2005)
- A total of 89 young investigators groups, 59 of which with funding from the Helmholtz Association's Initiative and Networking Fund
- Encouraging continuous, uninterrupted research by supporting young scientists through family-friendly measures (childcare services, career re-entry programmes)
- The Helmholtz Association operates 19 School Labs and the "Kids 4 Science" initiative to ensure that we develop young researchers for the future

Core-financed and externally-funded costs of the Research Fields in 2005



COSTS OF THE HELMHOLTZ ASSOCIATION IN 2005

Core costs of the Helmholtz Association, financed from 2003 within the scope of the programme-oriented funding, and arranged by Research Fields and Helmholtz Centres.

in million euros	Sum	AWI	DESY	DKFZ	DLR*	FZJ**	FZK	GFZ
Costs for research and development	**1,593**	**78**	**179**	**103**	**210**	**267**	**210**	**40**
Special tasks	73	0.2	2.3	3.5	5.9	8.7	26.7	0.5
Sum: costs (programme-oriented funding)	**1,666**	**79**	**181**	**107**	**216**	**276**	**236**	**41**
Energy	**201**				**12**	**49**	**53**	**2**
Renewable energies	28				4	6		2
Energy efficient conversion	37				8	24	6	
Nuclear fusion	109					15	24	
Nuclear safety research	27					4	22	
Earth and Environment	**271**	**78**				**33**	**55**	**33**
Geosystem: The changing Earth	35					3		32
Atmosphere and climate	27					10	17	
Marine, coastal and polar systems	95	78						
Biogeosystems: Dynamics, adaptation and adjustment	31					17		
Sustainable use of landscapes	37							
Sustainable development and technology	46					4	38	
Health**	**277**			**83**		**30**	**18**	
Cancer research	104			80				
Cardiovascular and metabolic disease research	25			3				
Function and dysfunction of the nervous system	38					30		
Infection and immunity	40							
Environmental health	31						8	
Comparative genomics	27						4	
Regenerative medicine	11						7	
Key Technologies	**115**					**56**	**42**	
Scientific computing	30					28	3	
Information technology with nanoelectronic systems	28					28		
Nano and microsystems	40						40	
Advanced engineering materials	18							
Structure of Matter	**434**		**179**			**98**	**35**	
Elementary particle physics	107		103				4	
Astroparticle physics	18		5				13	
Physics of hadrons and nuclei	89					33	1	
Condensed matter physics	32					26	6	
Large-scale facilities (photons, neutrons and ions)	189		71			39	12	
Transport and Space	**157**				**157**			
Transport	19				19			
Aeronautics	64				64			
Space	74				74			
Non-programme-bound research	**138**			**21**	**42**	**1**	**6**	**6**

* In addition to the programme-oriented funding of the Helmholtz Association, the DLR additionally receives institutional funding from other sources each year (e.g. BMVg, BMBF Basic Grant Space Research (final grant 2005), special grants) that has not been considered here: approx. 40m euros.

GKSS	GSF	GSI	HMI	HZI***	IPP	MDC	UFZ	in million euros
56	**90**	**75**	**60**	**37**	**86**	**51**	**50**	**Costs for research and development**
9.3	1.6	0.4	2.4	1.3	7.9	1.2	0.9	Special tasks
65	**91**	**76**	**62**	**39**	**94**	**53**	**51**	**Sum: costs (programme-oriented funding)**
			17		**69**			**Energy**
			17					Renewable energies
								Energy efficient conversion
					69			Nuclear fusion
								Nuclear safety research
17	**14**			**3**			**38**	**Earth and Environment**
							1	Geosystem: The changing Earth
								Atmosphere and climate
17								Marine, coastal and polar systems
	14							Biogeosystems: Dynamics, adaptation and adjustment
				3			34	Sustainable use of landscapes
							3	Sustainable development and technology
5	**58**	**3**	**2**	**28**		**49**	**3**	**Health****
	2	3				20		Cancer research
	3					20		Cardiovascular and metabolic disease research
						9		Function and dysfunction of the nervous system
	14			26				Infection and immunity
	19		1				3	Environmental health
	21			2				Comparative genomics
5								Regenerative medicine
18								**Key Technologies**
								Scientific computing
								Information technology with nanoelectronic systems
								Nano and microsystems
18								Advanced engineering materials
13		**68**	**41**					**Structure of Matter**
								Elementary particle physics
								Astroparticle physics
		55						Physics of hadrons and nuclei
								Condensed matter physics
13		13	41					Large-scale facilities (photons, neutrons and ions)
								Transport and Space
								Transport
								Aeronautics
								Space
4	**18**	**5**		**6**	**17**	**2**	**9**	**Non-programme-bound research**

** In addition, the FZJ received 6.5m euros for the "Biotechnology" programme, which is exclusively funded by the state of North Rhine-Westphalia.

*** Helmholtz Centre for Infection Research, formerly German Research Centre for Biotechnology (GBF)

HELMHOLTZ ASSOCIATION STAFF 2005

The Helmholtz Association employs around 25,000 staff. The capacity (person years) of the core-financed staff is shown arranged by Research Fields and Helmholtz Centres.

Person years	Sum	AWI	DESY	DKFZ	DLR*	FZJ	FZK	GFZ
Staff for research and development	**11,840**	**392**	**1,149**	**823**	**1,652**	**1,823**	**1,630**	**313**
Centre management and management support	1,626	54	142	108	218	257	216	46
Basic infrastructure	1,976	28	130	77	160	631	514	12
Special tasks	1,702	21	108	119	220	350	488	33
Total staff	**17,144**	**495**	**1,529**	**1,126**	**2,250**	**3,061**	**2,847**	**405**
Energy	**1,520**				**83**	**325**	**345**	**9**
Renewable energies	209				28	37		9
Energy efficient conversion	263				55	173	34	
Nuclear fusion	866					82	160	
Nuclear safety research	182					32	150	
Earth and Environment	**1,830**	**349**				**240**	**382**	**252**
Geosystem: The changing Earth	272					19		248
Atmosphere and climate	195					64	127	4
Marine, coastal and polar systems	467	349						
Biogeosystems: Dynamics, adaptation and adjustment	217					120		
Sustainable use of landscapes	357							
Sustainable development and technology	322					37	255	
Health	**2,047**			**729**		**199**	**136**	
Cancer research	905			715				
Cardiovascular and metabolic disease research	164			14				
Function and dysfunction of the nervous system	255					199		
Infection and immunity	242							
Environmental health	222						51	
Comparative genomics	156						35	
Regenerative medicine	104						50	
Key Technologies	**715**					**231**	**349**	
Scientific computing	97					74	23	
Information technology with nanoelectronic systems	156					156		
Nano and microsystems	326						326	
Advanced engineering materials	136							
Structure of Matter	**2,375**		**856**			**476**	**261**	
Elementary particle physics	444		422				21	
Astroparticle physics	129		18				110	
Physics of hadrons and nuclei	566					138	9	
Condensed matter physics	205					164	41	
Large-scale facilities (photons, neutrons and ions)	1,032		416			174	79	
Transport and Space	**1,171**				**1,171**			
Transport	148				148			
Aeronautics	460				460			
Space	563				563			
Scientific infrastructure	**1,680**	**43**	**292**	**93**	**90**	**346**	**116**	**52**
Non-programme-bound research	**501**				**308**	**7**	**41**	

* In addition to the programme-oriented funding of the Helmholtz Association, the DLR additionally receives institutional funding from other sources each year (e.g. BMVg, BMBF Basic Grant Space Research (final grant 2005), special grants) that has not been considered here: 373 person years.

GKSS	GSF	GSI	HMI	HZI**	IPP	MDC	UFZ	Person years
499	**681**	**696**	**447**	**200**	**650**	**410**	**476**	**Staff for research and development**
80	128	62	48	51	100	49	68	Centre management and management support
17	80	9	31	34	205	25	24	Basic infrastructure
59	51	41	57	32	41	33	49	Special tasks
655	**940**	**808**	**583**	**317**	**996**	**517**	**617**	**Total staff**
			135		**624**			**Energy**
			135					Renewable energies
								Energy efficient conversion
					624			Nuclear fusion
								Nuclear safety research
118	**96**			**12**			**380**	**Earth and Environment**
							5	Geosystem: The changing Earth
								Atmosphere and climate
118								Marine, coastal and polar systems
	96							Biogeosystems: Dynamics, adaptation and adjustment
				12			345	Sustainable use of landscapes
							30	Sustainable development and technology
54	**367**	**28**	**12**	**158**		**337**	**27**	**Health**
	10	28	2			149		Cancer research
	22					128		Cardiovascular and metabolic disease research
						56		Function and dysfunction of the nervous system
	93			149				Infection and immunity
	134		10				27	Environmental health
	108			9		3		Comparative genomics
54								Regenerative medicine
136								**Key Technologies**
								Scientific computing
								Information technology with nanoelectronic systems
								Nano and microsystems
136								Advanced engineering materials
78		**498**	**205**					**Structure of Matter**
								Elementary particle physics
								Astroparticle physics
		419						Physics of hadrons and nuclei
								Condensed matter physics
78		79	205					Large-scale facilities (photons, neutrons and ions)
								Transport and Space
								Transport
								Aeronautics
								Space
99	**95**	**170**	**95**	**23**	**26**	**72**	**68**	**Scientific infrastructure**
14	**123**			**8**		**1**		**Non-programme-bound research**

** Helmholtz Centre for Infection Research, formerly German Research Centre for Biotechnology (GBF)

THE INITIATIVE AND NETWORKING FUND

Objectives and Purpose

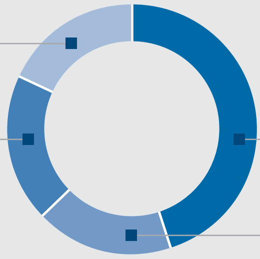
The President's Initiative and Networking Fund has developed into a central instrument for the Helmholtz Association. Under the Pact for Research and Innovation, the Helmholtz Association committed itself, not least, to expanding its networking with universities and to opening up new areas of research, including, in particular, high-risk and unconventional approaches. The Initiative and Networking Fund will be strengthened to enable Helmholtz to meet these commitments. Partners of the Helmholtz Association also acknowledge and endorse the work done by the Initiative and Networking Fund. This not only applies to the partners working directly with us in collaborative projects, but also to external experts and reviewers who have evaluated the proposed projects. Not least, these reviewers emphasised that the projects initiated by the Fund helped the Helmholtz Association raise its own international profile and that of its university partners. Many cooperative projects have been recognised and credited for managing to open up new access to strategically important research topics. The strategic review of the Helmholtz programmes also underlined the importance of activities that the Fund had facilitated. Furthermore, the international review teams chose to make special mention of this particularly productive role in their final reports.

Funding elements

HELMHOLTZ ALLIANCES: Helmholtz Alliances will identify new topics at an early stage and equip them with the appropriate financial resources. Alliances consequently aim to complement the more long-term nature of programme-oriented funding. Working together with university and other external partners, Alliances with a clear critical mass will address strategically-important topics, will occupy significant areas of future research and forward planning, and will extend and advance these to become internationally-visible beacons

Distribution of Grants 2002 to 2006

Total: 95m euros



of research excellence. Alliances will integrate national and international partners from universities, research institutions and industry. A Helmholtz Alliance's financial scope in terms of full costs will range from 5m to 10m euros per year. Half of this will be financed by the Initiative and Networking Fund. Funding will be provided for a term of five years. The first call for proposals for these Alliances was published in July 2006.

VIRTUAL INSTITUTES: Networking with universities remains an important research policy objective for the Helmholtz Association. We are currently funding 65 "Virtual Institutes" with a total of more than 46m euros. 158 university partners from 51 higher education institutions are participating in these Virtual Institutes. This funding measure attracts enormous interest. The call published in spring 2006 produced 63 new proposals. The specific integration of excellent foreign partners will enable the Virtual Institutes to achieve even greater international visibility in the future.

HELMHOLTZ(-UNIVERSITY) YOUNG INVESTIGATORS GROUPS: By enabling young researchers to lead their own research group equipped with appropriate financial and material resources, this programme aims to give them the opportunity to raise their profile for a career in science and research. At present, we are funding 52 Helmholtz-University and Helmholtz Young Investigators Groups with a total of more than 27m euros. The fourth call for a further 20 young investigators groups was published on 1 March 2006, with more planned over the coming years. The aim is to create jointly-appointed junior professorships for the selected Helmholtz-University Young Investigator Group Leaders.

HELMHOLTZ RESEARCH SCHOOLS: A further measure aimed at funding young researchers involves the Helmholtz Research Schools that were first announced in 2005. Through these, the Helmholtz Association aims to offer structured doctoral training in which students also acquire key qualifications. The first call for proposals saw three research schools selected by a panel of experts. This will be complemented in 2006 by a call for Helmholtz Graduate Schools in which the Helmholtz Centres will concentrate their structured doctoral training measures for the whole centre and so offer doctoral students from the respective centre all the requisite training under a single roof.

HELMHOLTZ ACADEMY FOR SCIENCE MANAGEMENT: Work on establishing a Helmholtz Academy has also begun. In launching this measure, the Helmholtz Association aims to create a suitable personnel planning instrument to develop and advance its own management and executive staff. The Helmholtz Academy programme is intended for management professionals from all levels and will focus on meeting the specific requirements of a research institution.

EQUAL OPPORTUNITY: To achieve greater equal opportunity in the Helmholtz Association, funding was also provided in 2006 to create career re-entry positions for researchers returning from childcare periods and to finance the Network Mentoring Programme.

SPIN-OFF INITIATIVE: Within the scope of its spin-off initiative, the Helmholtz Association launched its "EEF II" funding programme to facilitate start-ups based on spin-offs from research institutions. Proposals are assessed by a panel of external reviewers. Ten proposals were submitted in the first year, with a pronounced increase in the number of proposals received in 2006. Opportunities to resubmit proposals after revising them and to undergo coaching by a pre-review group have proven their worth as valuable measures.

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