HELMHOLTZ:
BIG QUESTIONS – BIG SCIENCE

ANNUAL REPORT 2009

HELMHOLTZ ASSOCIATION OF GERMAN RESEARCH CENTRES

Research in Germany
Land of Ideas

HELMHOLTZ
ASSOCIATION

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The 2009 Helmholtz Annual Report covers the actual costs for research in 2008 and the Senate-recommended financing for Research Programmes in the period 2009 to 2013 for the Research Fields Earth and Environment, Health as well as Aeronautics, Space and Transport, plus the financing recommendations in the Programme Period 2010 to 2014 for the Research Fields Energy, Key Technologies and Structure of Matter. The general report section presents the development of the Helmholtz Association from 2008 to September 2009.

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Helmholtz Association Registered Office
Ahrstraße 45, 53175 Bonn
Telephone 0228 30818-0, Telefax 0228 30818-30
E-mail info@helmholtz.de, www.helmholtz.de

Communications and Media Relations
Berlin Office
Anna-Louisa-Karsch-Straße 2, 10178 Berlin
Telephone 030 206329-57, Telefax 030 206329-60

V.i.S.d.P. Thomas Gazlig

Edited by
Dr. Angela Bittner (project leader)
Dr. Antonia Rötger (scientific editor, abbr.: arö)
Editing in Research Field Health:
Nicole Silbermann (SI)

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We contribute to solving 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, and Aeronautics, Space and Transport.

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.

PROFESSOR DR. JÜRGEN MLYNEK
President of the Helmholtz Association

HELMHOLTZ: BIG QUESTIONS – BIG SCIENCE

Dear Readers,

Around one year ago, a financial crisis shook the world. Many countries had to spend billions to support their economies and secure jobs. In situations like these, research, in general, and basic research, in particular, might not seem highest priority. However, exactly the opposite is true. Because it is basic research that creates the prerequisites needed for real innovation, which, in turn, is the key to economic recovery and growth. Therefore, "Big Questions – Big Science" is the motto of the Helmholtz Association's Annual Report this year. Research in the Helmholtz Association truly spans a very wide arch, ranging from fundamental questions, such as the origin of mass, progressing to health research and continuing through to the development of advanced materials which display extraordinary properties. Our Annual Report gives us the opportunity to present some of these examples to you.

The Helmholtz Association has been entrusted with addressing such grand challenges and with developing and delivering sustainable solutions by engaging in top-rate research. To ensure that we are able at all times to fulfil this task, we regularly subject all of our research activities to a thorough examination. We started the second round of programme-oriented funding at the beginning of 2008 and have now completed this review process for all six Research Fields. A total of 347 external, internationally distinguished experts and peers sat on the review panels. Their recommendations will be strictly implemented in the coming funding period. After all, the Helmholtz Association is not only Germany's largest research organisation, but also one of the most modern and dynamic – including its capacity for continual improvement to the benefit of society, industry and, of course, science.

Jürgen Mlynek

Since 2008, the further development of many of the Helmholtz Association's research infrastructures and large-scale facilities has progressed and new ones have been taken into commission to the benefit of research worldwide. A selection of milestones in the six Research Fields: >>

BIG QUESTIONS – BIG SCIENCE

Engaging in top-rate research and contributing to solving the grand challenges. This is the Mission of the Helmholtz Association. We subject our activities to an external expert evaluation once every five years to ensure that we can fulfil this mission to the very best of our ability. We have now successfully completed this evaluation process for the second time. The Helmholtz Association has continued to develop dynamically, has grown and is well-prepared to address the tasks of the future.

Outstanding successes in recent years include two Nobel Prizes for Helmholtz researchers. Following Peter Grünberg's award for Physics in 2007, Harald zur Hausen received the Nobel Prize for Medicine in 2008. Many other Helmholtz scientists and researchers also achieved great successes in the past year, which were acknowledged worldwide.

Success stories like these naturally build on the creativity and perseverance of the scientists and researchers. However, top-rate research today relies increasingly on complex infrastructures and technology platforms, along with a research management system that while setting a clear course, is also able to preserve the necessary freedoms. We also engage in a constant exchange of ideas with stakeholders from society, science, industry and politics. In order to fulfil our mission and contribute to solving the grand challenges, we must not only identify the key questions that science and research have to address. We must also be able to react quickly and tackle these questions swiftly. Our "agenda" is compiled in a continuous dialogue with our partners in politics. We implement it through our programme-oriented funding system in which we submit ourselves to a round of rigorous reviews every five years and by awarding our funds through competition. The Helmholtz Association has now undergone this evaluation process for the second time since it was established in 2001.

The evaluation process has been completed

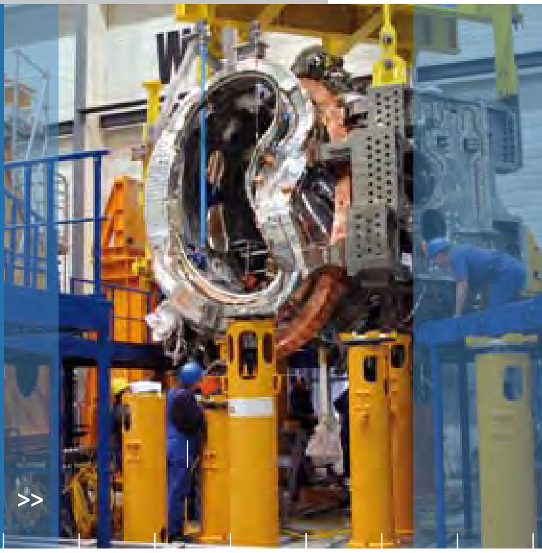
This process involves the Helmholtz Research Fields presenting themselves, their activities and their planned research projects to international review panels of independent experts who assess each programme according to the criteria of scientific excellence and strategic relevance.

The panels then issue concrete recommendations on where funding can be increased or reduced. They encourage new research initiatives and collaborations where they identify synergies and so contribute valuably to shaping the next programme period.

> Top-rate research today relies increasingly on complex infrastructures and technology platforms, along with a research management system that while setting a clear course, is also able to preserve the necessary freedoms.

The process of programme-oriented funding entered the second round at the beginning of 2008 and was completed in October 2009. A total of 347 experts from international research institu-

03|2008 >>



WENDELSTEIN 7-X REACHES ITS FIRST MILESTONE: The first two half-modules for the fusion facility Wendelstein 7-X have been completed. The gradual assembly of the large-scale experiment at the IPP in Greifswald will take around six more years. Photo: IPP

08|2008 >>

THE FIRST MAGNET DEVELOPED FOR THE FUTURE ACCELERATOR PLANT FAIR IS READY: The electromagnet is superconducting, is almost three metres long and weighs more than three tonnes. 108 such magnets are needed for FAIR at the GSI. Photo: GSI

tions sat on the review panels, enabling us to begin the next programme period, confident that we are on the right path. Indeed, the review assessments were generally exceptionally positive. But we were also very grateful for the valuable information and advice provided at a more detailed level,

A total of 347 experts from international research institutions sat on the review panels, enabling us to begin the next programme period, confident that we are on the right path.

which we will take into consideration. For example, the cross-programme strategic initiatives, such as the Climate Initiative, are a visible success. This initiative was launched in mid 2009 under the lead of the Alfred Wegener Institute and is closely connected with the climate research activities at the Helmholtz Centres in the Research Field Earth and Environment. Programme-oriented funding has proven itself to be a valuable instrument and is now being optimised in discussion with the research centres.

The budget grows with the responsibilities

The funding allocated to the Helmholtz Association by the federal and state governments amounts to a total of 2.07 billion euros in 2009. The 267 million euro increase in institutional funding, compared with 2008, (plus 15 per cent as against the previous year) comes from the Joint Initiative for Research and Innovation, in which the federal and state governments promised an annual budgetary increase of three per cent for the Helmholtz Association. Further increases in the budget result from the Helmholtz Association taking on new tasks and responsibilities: In April 2009, for example, the German Centre for Neurodegenerative Diseases was founded in Bonn and became a member of the Helmholtz Association. Besides the primary centre in Bonn, partner sites are being established in Munich, Tübingen, Rostock/Greifswald, Witten-Herdecke, Göttingen and Magdeburg, financed by the Helmholtz Association. The merger between two major research institutions in Berlin – the Hahn-Meitner-Institut GmbH (HMI) and the Berlin Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m.b.H. BESSY was completed at the beginning of 2009 to create the new Helmholtz-Zentrum Berlin für Materialien und Energie GmbH. The transfer of the Forschungszentrum Dresden-Rossendorf from the Leibniz Association to the Helmholtz Association is being prepared and is scheduled to take place in 2011. Furthermore, one-off payments came from the federal and state economic stimulus package. As a result, the Helmholtz Association received additional resources, not only for urgently needed structural repairs and redevelopment work, but also to purchase new instruments and devices and to expand research networks, for example in the field of battery research and electromobility. The excellent quality of the proposals was a key reason for these funds being approved. The financing partners felt assured that the resources could be implemented swiftly and efficiently within the Helmholtz Centres. As of autumn 2009 up to 94 investment measures with a total volume of around 198 million euros have had funding approved for the period 2009 to 2011.

New infrastructures being established for research

The Helmholtz Centres have continued to expand and enhance their scientific infrastructure in all six Research Fields. For example, the Neumayer Station III was inaugurated in the Antarctic at the beginning of the year. Its sophisticated lifting gear ensures that the polar station does not sink into the ice and can be expected to have a service life spanning 25 to 30 years. The station is operated by the Alfred Wegener Institute and serves as a basis for scientific observatories as well as a logistics centre for inland expeditions and polar aircraft.
The research aircraft HALO (High Altitude and Long Range Research Aircraft) is now being prepared for its first climate and atmosphere research missions. The new member

01|2009 >>

IN JANUARY 2009 FEDERAL RESEARCH MINISTER ANNETTE SCHAVAN OPENED A BUILDING EQUIPPED WITH A 7 TESLA MRI SCANNER AT THE MDC: Modern imaging with one of the world's strongest medical research MRI scanners will open up new insights into the human body. Foto: MDC

02|2009 >>

GERMAN ANTARCTIC RESEARCH STATION INAUGURATED IN FEBRUARY 2009: A combined building for research and accommodation on a platform above the snow's surface and with a garage built in the snow. Neumayer Station III is the first AWI Research Station to use the patented hydraulic design. Photo: AWI

of the research fleet at the German Aerospace Center (DLR) is one of the world's most efficient research aircraft.
The fusion research plants ASDEX Upgrade and Wendelstein 7-X at the Max Planck Institute for Plasma Physics in Garching and Greifswald, an associate member of the Helmholtz Association, were evaluated by the EU's "Fusion Facilities Review Panel" and passed with flying colours.
The Research Field Health is planning a unique long-term cohort study. The Helmholtz Cohort will be made up of some 200,000 subjects who will be monitored over a period of around 15 years. The study promises to produce new insights into risk factors and into the prevention of common diseases. Along with their partners from universities and the Leibniz Association, the contributors to this initiative are the German Cancer Research Center, Helmholtz-Zentrum München – German Research Center for Environmental Health, the Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch, Helmholtz Centre for Infection Research, German Centre for Neurodegenerative Diseases and Forschungszentrum Jülich.
Furthermore, new high-performance MRI scanners for cardiovascular and neurosciences research are being set up and taken into commission at various Helmholtz Centres.
In the Research Field Key Technologies, we are continuing to expand our supercomputing capacities, whereby three new supercomputers have been installed for research purposes at the Forschungszentrum Jülich. These now count among the world's fastest computers.
In the Research Field Structure of Matter, the most recent major decisions are now being implemented. For example, the accelerator PETRA, where the gluon was once discovered, has been completely refitted to make it one of the world's most powerful synchrotron radiation sources. At their respective sites in Hamburg and Darmstadt, the large-scale projects XFEL and FAIR are just about to sign the international treaties and partnership agreements which will form the basis for the financing of the projects by international consortia. The documents are due to be signed in the course of 2009.

> The major projects XFEL and FAIR at the sites in Hamburg and Darmstadt are just about to sign the international treaties and partnership agreements which will provide the basis for the financing of the projects by international consortia.

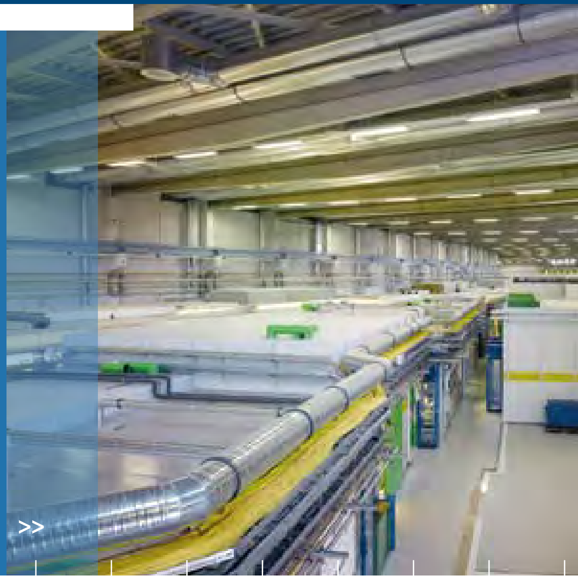
Continuing to extend our strategic partnerships

Universities are our most important partners in the German science system. This is why the Association is developing many forms of cooperation. These range from temporary project collaborations in more than 80 Virtual Institutes and seven Helmholtz Alliances funded by the Initiative and Networking Fund through to creating permanent institutions, such as "Helmholtz Institutes" on university campuses, or even mergers between a university and a Helmholtz Centre, such as in the case of the Karlsruhe Institute of Technology (KIT). With these strategic partnerships, the Helmholtz Association provides new stimuli and impetus for networking in the science system, thereby meeting one of the key commitments of the Joint Initiative for Research and Innovation. Indeed, the idea of merging the University of Karlsruhe and the Forschungszentrum Karlsruhe to form KIT managed to assert itself as one of the "Institutional Strategies" in the second round of the German Excellence Initiative at the end of 2007.
The merger became legally binding in October 2009. Other forms of collaboration between universities and Helmholtz Centres were also recognised by the Excellence Initiative as Institutional Strategies, such as the Jülich-Aachen Research Alliance (JARA) between the RWTH Aachen and the Forschungszentrum Jülich, and the research alliance between the German Cancer Research Center in Heidelberg and the Center for Molecular Biology at the University of Heidelberg. All involved benefit from this kind of collaboration: not only the universi-

05|2009 >>

NEW SUPERCOMPUTER BLUE GENE/P GETS THE GREEN LIGHT: In May 2009, the Forschungszentrum Jülich achieved a milestone in German and European supercomputing. Three new supercomputers went online almost simultaneously. The computer JUGENE that had been upgraded into a petacomplex, the supercomputer JUROPA, and the fusion computer HPC-FF. JUGENE is Europe's fastest computer for science. Photo: Forschungszentrum Jülich

07|2009 >>



SCIENTISTS HAVE GENERATED AN EXTREMELY BRIGHT X-RAY LIGHT FOR RESEARCH AT THE NEW SYNCHROTRON SOURCE PETRA III: As a result, the world's brightest storage ring X-ray source has been available for experimental operation at DESY since July 2009. The 2.3 kilometre long electron storage-ring has been converted into an X-ray radiation source. Photo: DESY

ties, which can boost their prestige with the title "Elite University", but the Research Centres, too.
By contrast, Helmholtz Institutes were conceived as branches of the Helmholtz Centres and are established at suitable partner universities where they can build on the existing expertise and competencies. Three Helmholtz Institutes were established in 2009. The GSI Helmholtz Centre for Heavy Ion Research is working together with the two new Helmholtz Institutes in Jena and Mainz.

> After founding the three Helmholtz Institutes in Thuringia, Rhineland Palatinate and the Saarland, the Helmholtz Association is now represented in all of Germany's federal states.

The Helmholtz Institute in Jena is addressing questions of laser physics and, in so doing, is collaborating with the local Friedrich Schiller University as well as with the Helmholtz Centre DESY. The Helmholtz Institute Mainz works together with the Johannes Gutenberg University in Mainz on planning for the large-scale accelerator FAIR, on the future experiments, and on the theoretical physics needed for understanding the results. Together with the Helmholtz Centre for Infection Research in Braunschweig, the Saarland University founded the joint Helmholtz-Institut für Pharmazeutische Forschung Saarland. The aim is to identify and advance new agents to combat infectious diseases. This means that the Helmholtz Association is now represented in all 16 federal states. The GSI Helmholtz Centre for Heavy Ion Research and university partners have jointly established a "think tank" to prepare and run the world's unique large-scale facility FAIR as efficiently as possible. The Helmholtz International Center (HIC) for FAIR will host the world's best scientists and researchers who come to develop new methods, models and test arrays for the work on FAIR. As soon as the particle accelerator FAIR goes online, the analysis and interpretation of the enormous volume of data will begin at the HIC.

Helmholtz Shapes the European Research Area and Beyond

The Helmholtz Association Centres participated very successfully in the 7th Framework Programme (FP7). Some 380 proposals have been approved since the beginning of 2007. Last year alone (autumn 2008 to autumn 2009) more than 180 successful project proposals were reported. All in all, the Helmholtz Centres are coordinating more than 67 projects in FP7. Within the scope of the roadmap of the European Strategy Forum on Research Infrastructures ESFRI, the Helmholtz Centres are taking part in 18 of 44 key projects, in seven of these in a lead capacity. This shows that the Helmholtz Centres' capability for taking on such responsibility is widely recognised.
The research infrastructures at the Helmholtz Centres, of which some are globally unique, attract around 4,500 guest scientists and researchers each year, in particular from Europe, Russia, America, China and India. As a matter of course, doctoral students, Young Investigators Group Leaders as well as established researchers are recruited from around the world.

We play an active research policy role

In our capacity as Germany's largest research organisation, the Helmholtz Association is an important partner in the field of science politics. As per rota, the Helmholtz Association is responsible for coordinating the Alliance of German Science Organisations in 2009, and speaks on behalf of the participating organisations.
Indeed, the Helmholtz Association and the Alliance of Science and Research Organisations joined forces to ensure that the Joint Initiative for Research and Innovation, the Excellence Initiative and the Higher Education Pact are all continued. This commitment was successful. In the run-up to the general elections in autumn this year, the federal and state governments agreed to adopt this package of pacts and so to guarantee the non-university research organisations an annual budget increase of five per cent from 2011 to 2015. We will use this

THE NEW RESEARCH AIRCRAFT HALO TAKES OFF: The DLR-operated HALO marks the start of a new chapter in German atmosphere research and earth observation. In terms of altitude, payload and range, HALO exceeds the performance capacity of all previous research aircraft (www.dlr.de/halo). Photo: DLR

ASSEMBLING KATRIN: The main spectrometer for KATRIN, an experiment for measuring the neutrino mass at the Karlsruhe Institute of Technology, will be surrounded by the world's largest Helmholtz Coil. The first experiments with KATRIN are planned for summer 2010. Photo: KIT

financial leeway to continue to expand and extend networking within the science system and to further intensify our commitment to young scientists and researchers. In publishing the brochure "Neue Impulse for die Gesundheitsforschung" (New Impetus for Health Research), the Helmholtz Health Centres, under the lead responsibility of Prof. Dr. Otmar Wiestler and Prof. Dr. Günther Wess, launched an initiative for establishing national consortiums. In addition, Helmholtz scientists under the lead responsibility of Prof. Dr. Eberhard Umbach drew up a paper of key points and guidelines on the further development of the federal government's energy research policy on behalf of the Federal Ministry of Economics and Technology, which provides a comprehensive analysis of the research needs.

We count on people

The number of doctoral students in the Helmholtz Centres has continued to grow and currently lies at around 4,400. The Helmholtz Centres achieve this by running a wide variety of programmes in the field of structured doctoral education and training. The structured path to a doctorate leads to the aspired degree in around three years and delivers additional key skills and qualifications. Some programmes are supported by the Initiative and Networking Fund, which in turn is partly financed by additional funding available from the Joint Initiative for Research and Innovation. In 2008, for example, two new Helmholtz Research Schools and three new Graduate Schools were selected for financial support from the Initiative and Networking Fund. While Graduate Schools are open to all the doctoral students at a Helmholtz Centre, places at a Helmholtz Research School are offered through an international competitive call for proposals and are awarded to particularly outstanding graduates.
The seventh Call for Proposals for Helmholtz-University Young Investigators Groups held in spring 2009 saw the review panel select seven female and thirteen male candidates. The high quality of all the proposals was remarkable, thereby verifying the great appeal that these positions have for young scientists and researchers. A position as a Young Investigators Group Leader brings a tenure track option with it and is seen as an ideal entry path for a career in science. This is also confirmed by the number of applications submitted by young scientists and investigators currently working at highly distinguished institutions in the United States, such as MIT or Stanford University. All in all, this means that 116 Helmholtz-University Young Investigators Groups now receive funding, with half the costs covered by the Helmholtz Association's Initiative and Networking Fund, and the Helmholtz Centres financing the remaining half. Some 70 Young Investigators Groups were in the funding phase in 2008, while a total of 83 Young Investigators Groups in total are being financed in 2009.
One of our key policy goals in promoting staff and young talent builds on a foundation of equal opportunity between men and women. Excellence naturally remains our prime criterion. Our "Taking the Lead" programme specifically addresses young women scientists and administrators working at the Helmholtz

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Research Centres and represents one of the strategic modules of the Helmholtz Association for promoting equality. Women also account for half the participants at the Helmholtz Management Academy. Furthermore, seven women hold board level positions in the Helmholtz Association.
Of course, we are also committed to training young people in many different trades and professions (see our Performance Record) and in educating children and youngsters. The Helmholtz Centres maintain a total of 24 School Labs, which annually attract over 50,000 students and pupils. In 2006, the Helmholtz Association co-launched an initiative on promoting science education at pre-school age. The initiative is

enormously popular: The “Haus der kleinen Forscher”, or “Tiny Tots’ Science Corner”, has meanwhile reached more than 8,000 day-care centres and kindergartens and 500,000 children throughout Germany.

The Association continues to develop

The Helmholtz Association is still a young organisation and is developing dynamically. The Association has drawn up two strategy papers for this. The Helmholtz Agenda defines the action fields that are seen as essential for the competitiveness of the Helmholtz Association and its centres in the coming years. The Liebenberg Paper drawn up by the Assembly of Members at the end of January 2009 broadens the prospects and perspectives for the Helmholtz Association’s continuing development as an organisation. These include optimising the evaluation procedures and programme-oriented funding as well as the programme portfolio with the help of a structured foresight process. We are entering into this discussion process with optimism. So, let us continue to work on creating the ideal conditions for top-rate research that is capable of contributing valuably to solving the greatest challenges in a rapidly changing world.
We trust in and are confident that the consensus reached before the elections will also apply after the elections. Because, as the financial crisis clearly showed us, the only investments that produce sustainable benefit are those that create true value. Investments in minds and in research are the very best investments that a country can make.

Whether nuclear fusion or Desertec – both mean mobilising the Sun‘s power. Megaprojects such as these could show us how best to escape the energy-climate trap. With good prospects for success, but also with technical and political risks that might well awaken emotions. There will be many paths that have to be planned in advance on unfamiliar, far away horizons. With a clear mind and good sense, and also with our heart and passion. To ensure that it does not take another 50 years before our children can benefit from our joint endeavours.

PROF. DR. HERMANN REQUARDT
Senator of the Helmholtz Association,
Member of the Board of Siemens AG

“The Helmholtz Association is predestined to contribute to solving the most pressing issues that face society today. Equipped with its large-scale facilities and unique research plants, Helmholtz is a major player in the research landscape. Established partnerships between top-flight researchers at the Association and scientists working at universities and other non-university research institutions play their part in mastering the challenges that exist by performing basic and applied research on highly complex systems in order to gain substantial new scientific knowledge and insights. In this respect, the Helmholtz Association bears substantial responsibility for shaping our future.”

PROF. DR. GERD LITFIN
Senator of the Helmholtz Association,
Chairman of the Supervisory Board of Linos AG

“Big questions lead to big science, which is closely connected with great freedom and responsibility. Research not only helps us solve scientific questions, but also raises new ones that see the relationship between nature and humanity in a prospective, far-sighted context. The Helmholtz Association and its scientists and researchers are part of this, always working hand in hand. Only with specifically targeted investments can interdisciplinary and intercultural research teams prosper. Let us look together beyond the horizons so that we no longer see any borders!”

PROF. DR. LIQIU MENG, Senator of the Helmholtz Association,
Vice-President of the TU München

“Top-rate research also calls for investments in innovative technology. Hence, several Helmholtz Association Centres have put 7-Tesla MRI systems and 9.4 Tesla MR-PET hybrid systems into service that deliver better images of the organs, and particularly of the brain and nerve tissue. The innovative medical research made possible as a result of this is of great interest to international scientists and contributes to securing Germany’s appeal as a centre of top-class research.“

PROF. DR. DR. ANDREAS BARNER, Senator of the Helmholtz Association,
Chairman of the Board of Managing Directors and Head of Pharma R&D+M,
Boehringer Ingelheim GmbH

Big Questions – Big Science

NEWS FROM THE RESEARCH FIELDS

RESEARCH FIELD ENERGY

PROF. DR. EBERHARD UMBACH
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Energy,
Karlsruhe Institute of Technology

GOALS AND ROLES

Scientists in the Research Field Energy are working on securing a long-term, sustainable energy supply and are drawing up solutions for this that are both economically and ecologically feasible. This calls for a holistic examination of the relevant energy chains, including consideration of the general frameworks and concomitant phenomena, as well as the climate and environmental consequences. Consideration of all kinds of primary energy and the broad-based exploration of innovative technologies for the efficient and effective conversion, storage and use of energy forms is absolutely essential in this respect.

The long-term goal is the complete substitution of energy resources with a limited time horizon by replacing these with energy resources that are sustainable, long-lasting and climate neutral. The short and medium-term objectives include cutting energy consumption by means of efficient conversion and usage, reducing the dependence on imports in Germany and Europe, and the study of new storage technologies capable of mitigating climate and environmental consequences, and ensuring that the special requirements needed for mobile applications are met.

The Helmholtz Association draws its energy research strategy from this overarching spectrum. This builds on the existing competence and experience of the Helmholtz Centres. The proficiency, know-how and expertise of other scientific and industrial partners are taken into account. At the same time, future fields are identified in which the Helmholtz Association must establish and expand new competencies and expertise. The energy consumption of present and future generations calls for the development of new technologies from which competitive innovations can develop. With this objective in mind, the scientists fathom out the potential of renewable energy resources, such as solar energy, biomass, or geothermal power. They are increasingly working on ways to raise the efficiency of conventional power stations and to make energy use generally more efficient. The work on generating energy through nuclear fusion will open up a new source of energy in the long term. This route represents a major scientific and technical challenge that is being advanced in international collaboration. Finally, the Helmholtz Association is contributing to nuclear safety research with its globally unique know-how to assure the safe operation of nuclear reactors as well as the treatment and disposal of highly radioactive wastes.

In addition to the many different research activities, structural developments are also taking place in the Helmholtz Association that strengthen the field of energy research. The successful merger between the University of Karlsruhe and the Forschungszentrum Karlsruhe initiated through the excellence competition launched by the federal and state governments led to the Karlsruhe Institute of Technology, in short KIT, being established, and to the creation of a KIT Centre for Energy, which will develop into the leading European centre for energy research. The Forschungszentrum Jülich and the RWTH Aachen are pooling their mutual complementary expertise and competencies in the JARA-ENERGY section of the Jülich-Aachen Research Alliance JARA in order to create an internationally pioneering research partnership and so draw up new transdisciplinary and cross-departmental energy solutions. Finally, the field of solar energy research has been strengthened with the Competence Centre of Excellence Thin-film and Nanotechnology for Photovoltaics Berlin jointly founded by the Helmholtz-Zentrum Berlin für Materialien und Energie with partners from industry and the TU Berlin.

The Research Field Energy was evaluated at the beginning of 2009 within the scope of the Helmholtz Association's programme-oriented funding. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field in the period under report up to the end of 2009 and presents the new research programmes that will form the strategic focus of energy research in the coming five years. The previous and the new structure are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as from 2010. With effect of 2010, all six research fields will be in the second funding period.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2004–2009*

Six Helmholtz Centres are currently working together in the Helmholtz Association's Research Field Energy: German Aerospace Center (DLR), the former Forschungszentrum Karlsruhe (FZK), since 1 October 2009 Karlsruhe Institute of Technology (KIT), Forschungszentrum Jülich (FZJ), Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, and Max Planck Institute for Plasma Physics (IPP) as an associate member of the Helmholtz Association. As a result of planning for the coming round of programme-oriented funding, as from 2010, the Helmholtz Centre for Environmental Research – UFZ will also be involved in the energy research field. The scientists are currently working together in four research programmes:

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

The next period of programme-oriented funding from 2010 to 2014 will see Energy Systems Analysis added as part of the cross-research-field programme Technologies, Innovation and Society. The programmes will be driven forward by interdisciplinary working groups with international collaboration. Excellent research infrastructures, test plants for large components, high-performance analysis systems and extensive computing capacities are available for their work. In dialogue with the umbrella associations of industry and science, a consensus has been developed that no relevant energy option should be abandoned in the current situation. Only then can the energy industry come to terms with the three central problems: dwindling resources, potential risks in the disposal of wastes, and the climate problem.

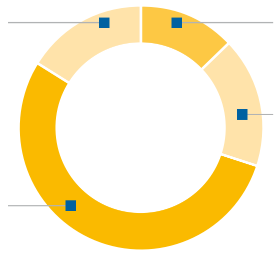
"A sustainable energy supply means constantly raising the efficiency levels at the user end, environmental and climate protection through strongly centralising the emissions (for example through innovative power station technology) as well as protecting and conserving resources through the broadest possible primary energy resource structure, including renewables and fusion. In strong contrast to areas such as short-lived communications technology, new energy technologies and systems involve development phases lasting decades and require a high degree of interdisciplinary research, including the social acceptance aspect of such technologies."

PROF. DR. ULRICH WAGNER
Senator of the Helmholtz Association, Technische Universität München

*The first funding period of the Research Field Energy began in 2004 and was extended by one year until 2009.

Structure of the Research Field Energy
Core-financed Costs 2008: 252m euros

The Research Field Energy additionally received 135m euros of external funds, providing it with a total budget of 387m euros.



THE PROGRAMMES
IN THE FUNDING PERIOD 2004–2009*

Renewable Energies

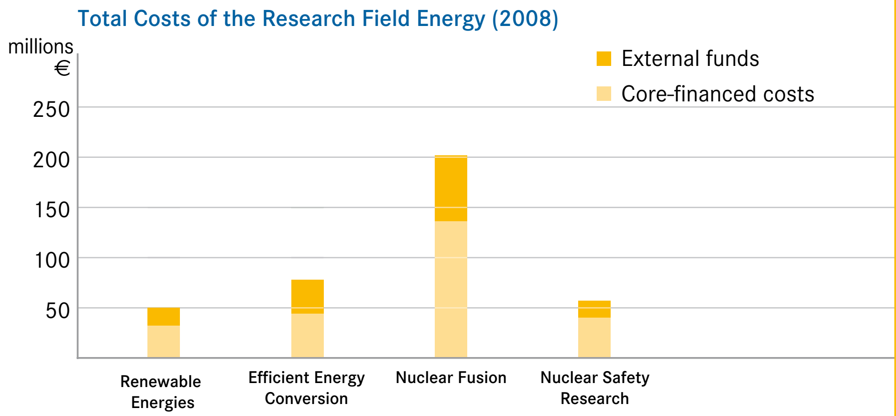
Renewable energies from solar, geothermal or biomass sources are key options for a sustainable future energy supply, since they are inexhaustible and climate friendly. Besides developing new technologies, the research aims to cut costs. Photovoltaic solar energy is currently experiencing rapid growth. Several solar companies based on technology and know-how from the Helmholtz Centres are being founded. Improvements to thin-layer photovoltaics developed through research in the Helmholtz Association will use the full potential of this innovative technology and significantly cut the price of the generated power. The remarkable boom in solar-thermal power stations has also profited greatly from work and experience gained at Helmholtz in the continuing development and testing of novel components at the large-scale test plant in Almería, Spain. Further developments aim for higher temperatures, novel thermal energy storage media and, in the long term, at ways to chemically store solar power. In the case of deep geothermics, which become practical at depths between 3,000 and 6,000 metres, the goal is to intelligently combine power generation and thermal yield. Researchers are currently working on how to use existing hot water reservoirs efficiently to tap into and use hot layers of rock through stimulated heat exchange.

In particular, systems analysis assesses technologies for using renewables on the basis of technical, economic and ecological criteria. The knowledge and insights gained help to develop scenarios for a future energy supply and so contribute to an objective discussion on possible options in the future. Biomass stores solar energy and, as the only renewable carbon source, plays a special role. Biomass can be used not only to generate heat and power, but also and above all can produce chemical raw materials and fuels. The sustainable use of biomass, currently being studied and explored in other programmes of the Helmholtz Association, will become part of the research programme “Renewable Energies” as from 2010.

Efficient Energy Conversion

Fossil energies, such as mineral or crude oil, natural gas or coal will continue to play a major role in the energy supply for decades to come. A substantial share of the future alternative energy sources, such as synthetic gases or synfuels made of biomass, for example, will be converted into electricity in power stations or used as fuels. Here there is great potential for making savings by raising the efficiency of the conversion technologies. This is where the Efficient Energy Conversion programme sets in. Scientists explore new technologies for power stations and fuel cells, and study the use of superconductivity in the power-generating industry. Other topics include new materials, better solutions for high-performance gas turbines and CO_2 separation. A particular investment is being made in fuel cells for stationary and mobile applications. In the former, attention focuses on solid oxide fuel cells (SOFC). While in the latter, attention is on polymer electrolyte fuel cells (PEMFC and DMFC). Another highly promising area for efficient energy conversion lies in superconducting current limiters and superconducting components for the power grid with which power could be transmitted in the future with practically zero energy losses.

*The first funding period of the Research Field Energy began in 2004 and was extended by one year until 2009.



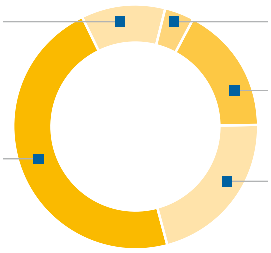
Nuclear Fusion

Nuclear Fusion is strategic, preventive research. In a few decades, a demonstrator fusion power plant could generate power, and from the second half of this century, the first fusion power plants could go online and permanently resolve some of humanity's energy problems. Scientists are working in close collaboration with national and international partners on the R&D for this. So, fusion research in the Helmholtz Association is part of an overarching European fusion programme. The German fusion programme is coordinated by the "Entwicklungsgemeinschaft Kernfusion", with three Helmholtz Centres represented.
The research priorities at Helmholtz are, as agreed with the international partners: To contribute to building and later operating ITER, a large-scale tokamak experiment, and to building and operating the European-supported 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 power generation through fusion is technically feasible. The experiment will additionally deliver data needed for building a demonstrator power plant. WENDELSTEIN 7-X aims to show that the stellarator concept, which shows great advantages for stationary operation, is suitable for a fusion power plant.
To support this strategic master plan, the Helmholtz Association is conducting further reaching experiments, developing the relevant base theory and working on new technologies. For example, plasma-wall interactions are being studied, high-performance plasma heaters developed, and new materials researched in order to prepare components for a demonstrator power plant. The ASDEX Upgrade was recently commissioned as the world's first divertor fusion device lined with a tungsten wall.

Nuclear Safety Research

Nuclear technology know-how and expertise will still be needed in Germany for decades to come as part of a strategically planned preventive research policy, even if the decision is upheld to abandon nuclear energy as a power source. Hence, research on the safety of nuclear reactors and on the safe disposal of nuclear wastes is absolutely indispensable. The work done in the Helmholtz Association's Nuclear Safety Research Programme ensures that broad-based expert knowledge remains available in Germany in all areas relating to the safety of nuclear reactors and of nuclear waste disposal on a level with the international state of science and technology, and that German researchers continue to play an active part in all relevant international projects, bodies and committees. The Karlsruhe Institute of Technology (KIT) and the AREVA NP GmbH have established the "AREVA Nuclear Professional School" in Karlsruhe as the first component in the KIT School of Energy. The aim is to provide professional development and in-service training for young engineers and scientists as experts in all fields of nuclear technology, a research field that offers first-class career prospects.

Structure of the Research Field Energy
Core-financed Costs Plan 2010*: 290m euros
(including non-programme-bound research)



*First year of the new Programme Funding Period 2010–2014

THE PROGRAMMES
IN THE FUNDING PERIOD 2010–2014

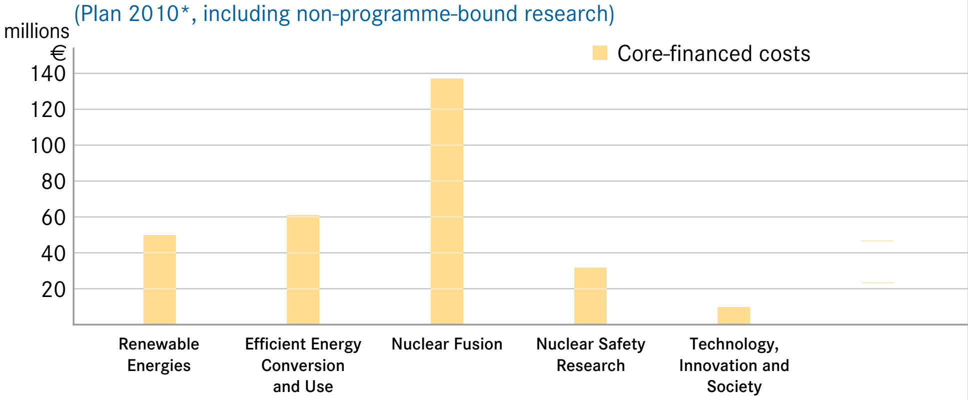
For the second funding period, the Helmholtz Centres in the Research Field Energy partly re-adjusted and expanded their strategy to address the major challenges. In particular, energy research in the Helmholtz Association will in future not only focus on power generation, but will rather consider all application scenarios across the whole process chain.
The Research Field will organise its work in four programmes in the next funding period. The fifth programme "Technology, Innovation and Society" will be run together with the Research Field Key Technologies (Page 52 ff.), and include research on Energy Systems Analysis. A cross-programme initiative for developing energy storage systems is planned that will be funded with a total of 14.49 million euros between 2010 and 2014.

- Renewable Energies
- Efficient Energy Conversion and Use
- Nuclear Fusion
- Nuclear Safety Research
- Technology, Innovation and Society

Renewable Energies
The catalogue of topics is being expanded. Besides topics on generating power from solar and geothermal energy, research projects are being added on biomass and solar fuel generation. The research on photovoltaics is continuing to follow the development of thin-layer solar cells to raise the efficiency level to as near as possible to its theoretical limits with the lowest possible input of material and energy. Solar-thermal power plants located in Earth's sun belt could contribute substantially to the global generation of power as from around 2030. Commercial solar power plants have been built for several years now, however with conservative technological approaches. The successful market launch of newer technologies calls for further cost cuts. The long-term aim is to provide solar fuels via thermal processes based on concentrating solar systems. The geological subsurface in Germany offers great potential for generating heat and power. Geothermal research pools the expertise and competencies of the participating centres to develop possible technological solutions. The feasibility and economic efficiency of geothermal power generation is being studied in Groß Schönebeck.
In addition, research activities on producing energy from biomass will begin in the Renewable Energies Programme and will include biomass conversion and biogas production on a small technological scale. The close collaboration between the Helmholtz Centres and other research institutions opens the way to comprehensive research on the energetic usage of biomass in Germany.

Efficient Energy Conversion and Use
Various research approaches are being pursued to raise the utilisation ratio of renewables and fossil energy sources. For example, the intelligent coupling of energy availability and usage through power and heat storage systems, mobile energy storage systems, heat transfer systems or synthetic fuels, dovetailing the various demand situations, such as cogeneration of heat and power plus work on thermo-chemical processes for processing non-conventional energy sources such as biomass to form higher-value fuels. The power stations and plants of the future must convert these various and different primary energy carriers as efficiently, as environmentally friendly and as reliably as possible into useful energy. This calls for innovative boosts for components such as turbo machines and materials that are capable of resisting higher temperatures.
CO_2 separation from power stations calls for research on gas separation methods and the development of new concepts, since CO_2 separation must not be bought at the expense of a higher use of resources. In the medium term, solutions need to be developed that enable existing power stations to be retrofitted. The research goals in the field of fuel cells aim to increase the lifetime and performance, to reduce the costs and develop new processes and methods for analysing aging mechanisms and for quality assurance processes.

Core-financed Costs of the Research Field Energy
(Plan 2010*, including non-programme-bound research)



*First year of the new Programme Funding Period 2010–2014

Please note: Due to the Helmholtz Association's Energy Storage Initiative, the costs in the Energy Field are only provisional figures. The final figures are expected at the beginning of 2010.

Research and development on superconducting components for power grids can contribute to reducing the losses suffered when transmitting electrical energy. To make full use of stochastic energy flows, such as wind and sun, innovative concepts are needed for storing energy.

Nuclear Fusion

The Helmholtz Association's Nuclear Fusion Programme is currently pursuing two priority goals. On the one hand, the German contribution to building and operating the international tokamak experiment ITER in Cadarache and, on the other, the completion and operation of the stellarator Wendelstein 7-X in Greifswald. ITER aims to prove the physical and, in some cases, technological feasibility of nuclear fusion under power plant-like conditions. However, ITER alone cannot provide all the information needed for building the demonstrator fusion power plant (DEMO). In particular, the development of suitable structural materials needs to be advanced with great priority parallel to ITER. The potential for improving the magnetic confinement of the fusion plasma has not yet been fully exploited. An outstanding concept is provided by the stellarator. In principle, it makes a permanently operational fusion plant feasible and so is seen as an alternative to the tokamak. The experiment Wendelstein 7-X aims to qualify the stellarator line to the extent that this, together with the results from ITER, makes the building of a stellarator DEMO possible (from around 2040).

Nuclear Safety Research

The Nuclear Safety Research Programme is divided into three topic areas. Nuclear Reactor Safety, Safety of Nuclear Waste Disposal, and Radiation Protection.
The Nuclear Reactor Safety topic involves work on reactor and plant design as well as on phenomena and processes in the case of incidents within or events beyond the design basis. International developments are studied and co-designed under the aspects of reactor safety, new safety concepts, new technologies and minimising radioactive wastes, and are assessed in comparison with existing reactors.

For the topic Safety of Nuclear Waste Disposal, work is being done, on the one hand, on immobilising highly radioactive wastes by means of vitrification and on reducing the radiotoxicity of the minor actinides by means of partitioning and transmutation. On the other hand, various final disposal concepts in deep geological repositories are being studied. An important aspect is to define and validate standards for certifying the long-term safety of final repository systems based on geochemical criteria, independent of site, but considering the specific utilisation. In radiation protection research, scientists are developing methods for determining person-specific radiation dosages and recommend measures for radiation protection when radionuclides are identified in the environment, in foods, as well as in cases of radiation exposition in medical treatment, plus emergency protection following possible nuclear facility incidents.

Technology, Innovation and Society

This cross-research-field programme aims to study and research ecological, economic, political, ethical and social aspects of new technologies to support decisions by policymakers, industry and society. The programme topics in the field of "Energy" aim for a holistic view of energy research and energy technology. They contribute to monitoring the current transition of the global energy system towards a sustainable focus. The programme takes the whole energy chain process into sight from the production of primary energy carriers via conversion, storage, distribution and use as well as their innovative phases. The goals are to assess individual technologies and technical systems for providing and using energy as well as the development of innovation and implementation strategies under consideration of the policy of sustainable development.

PROJECTS

Helmholtz-Zentrum Berlin für Materialien und Energie

WHEN CELLS AGE

Working in their laboratory at the Helmholtz-Zentrum Berlin in Adlershof, Dr. Alexander Schnegg and Dr. Klaus Lips are tracking down aging processes. However, the cells they are investigating in-between the enormous magnetic coils have nothing to do with biology, even if the Sun is their elixir of life. Rather, these are solar cells, or to be more precise, thin-film solar cells made of amorphous silicon. The Sun releases electrons in these cells so that the power can flow. Unfortunately, the Sun also impairs their function. In the first 100 operating hours their efficiency drops by between ten and twenty per cent, and only then stabilises. This aging process was already observed in 1976 and is called Staebler-Wronski Effect in recognition of the scientists who discovered it. However, what exactly happens is still not clear. Previously, there were simply no analysis procedures that were sensitive enough to study the damage caused in the ultra-thin layers.

> The efficiency of ultra-thin solar cells drops by between ten and twenty per cent in the first 100 operating hours.

The solar researchers headed by Lips and Schnegg are now using tailor-made electron paramagnetic resonance spectroscopy methods (EPR spectroscopy in short) to gain new insights into the material. In the EPR Solar project, physicists from Berlin coordinate the collaboration with solar experts at the Forschungszentrum Jülich, with EPR specialists at the TU München and the FU Berlin, as well as with simulation professionals at the Max Planck Institute for Iron Research in Düsseldorf. The project has been funded by the Federal Ministry of Education and Research since 2008 for a five-year term in total. By the end of this period, the researchers not only want to understand the processes taking place in the material itself, but also want to advance the development of EPR analysis.
After all, thin-layer solar cells are seen as a cost-efficient alternative to the expensive solar cells made of single crystalline silicon, many of which already shimmer blue on roofs practically everywhere. Although they only achieve half their efficiency at rates of up to nine per cent, the thin layers of amorphous silicon, which are only a few nanometres thick, use much less material and can easily be vapour deposited on substrates like glass or plastic. “This means they already pay back their energy consumption in less than a year, rather than only after two to four years, and that is the decisive advantage,” says Schnegg.

> “If we are able to prevent solar cells from aging, the power generation costs will fall by up to 30 per cent and thin-layer solar technology would already be competitive today.”

The aging processes in amorphous silicon are, as far as we know today, generated by defects in the nuclear structure, caused, in turn, by the sunlight. Defects like these impair the power flow and so reduce the efficiency levels. Hydrogen atoms are thought to play an important role both in the formation and repair of the defects, which also exist in the material itself. However, it is still unclear where these hydrogen atoms reside and exactly how they affect the defects.
To explain these questions, the researchers use a particular physical characteristic of the defects. Because that is exactly where the unpaired electrons are found that possess a magnetic moment. This so-called spin is influenced by the atoms in the surrounding area like a compass needle, a process that can be observed with the help of EPR spectroscopy. The physicists do this by attaching an external magnetic field and additionally beam microwaves into the samples. Knowing at which energies the spins change direction allows conclusions to be drawn as to the type of defects and how they are distributed. So it is possible, for example, to recognise whether a hydrogen atom really is directly nearby.
Meanwhile, the researchers have modified their method in such a way that they can gain this information millions of times more precisely than previously possible directly from the solar cell’s photocurrent. Hence, they automatically only take defects like these into consideration. “Since the project began, we have been able to substantially improve the sensi-

THE EPR SPECTROMETER ENABLES THE HELMHOLTZ RESEARCHERS TO EXAMINE DEFECTS IN SOLAR CELLS THAT REDUCE THE EFFICIENCY LEVEL. PHOTO: HZB

tivity and resolution of the EPR spectrometer," says Lips. And so the scientists were able to acquire new insights into where the hydrogen atom actually sits in the amorphous silicon.
The physicists expect to make further progress with their new Terahertz EPR spectrometer which they have set up at the Synchrotron Radiation Source BESSY at the Helmholtz-Zentrum Berlin in Adlershof. "It's really been worth the effort," says Schnegg, "for if we can prevent the solar cell from aging, the cost of energy generation would fall by up to 30 per cent, and thin layer solar technology would already be competitive today." UTA DEFFKE

Karlsruhe Institute of Technology

ALGAE AS ENERGY SUPPLIERS

Algae convert the greenhouse gas CO_2 back into biomass, with the added extra that a high proportion of the oils produced can be used as fuels. Two research groups at the Karlsruhe Institute of Technology are now working on optimising this process. The scientists headed by Professor Dr. Clemens Posten at the Institute of Process Engineering in Life Sciences are developing self-contained photo bioreactors capable

"Microalgae are something new, which is why we have to continue to advance our extraction processes."

of converting solar energy into biomass five times more efficiently than is possible with open basins, and so save water and fertilisers. And engineers headed by Dr. Georg Müller from the Institute for Pulsed Power and Microwave Technology are working on an extraction method for producing oils out of the biomass. Because conventional processes use a lot of energy to achieve this. Müller can already build on experience gained with sugar beet, grapes and apples. His trick: strong and only a few microsecond-long high-voltage pulses perforate and crack open the cell membranes, making it easier to extract the contents without having to heat them. This method is currently being adopted by the sugar industry saving almost 30 per cent of the energy. "Microalgae, however, are something new, because they contain more than 30 per cent of energetically exploitable oils. We have to continue to advance our extraction methods to achieve this," explains Müller. Some 50 per cent of the cost of producing biodiesel from algae is currently caused by the complex extraction of lipids from the plant cells. "We can do better than that," says Müller with conviction. "Our approach can quickly be transferred into large-scale production."
Even the residual post-extraction biomass still has a utility value, because KIT colleagues from the Institute for Technical Chemistry are simultaneously running a novel hydrothermal gasification plant which is capable of producing methane or hydrogen from the waste. ARÖ

PLATE REACTORS WITH AN IDEAL LIGHT MANAGEMENT SYSTEM FOR CULTIVATING MICROALGAE. Photo: Florian Lehr, KIT

SUITABLE MINERAL PHASES CAN BE QUICKLY AND SPECIFICALLY PRODUCED IN AUTOCLAVES BY SOWING "CRYSTAL SEEDS". PHOTO: KIT

Karlsruhe Institute of Technology

NEW CEMENT SAVES ENERGY AND CO_2

A lot of energy is consumed in the built environment. Not only for heating, but also – perhaps not so well known – for producing building materials. The cement industry alone uses between two and three per cent of the worldwide energy demand for its energy intensive production processes and emits five to seven per cent of the anthropogenic greenhouse gas CO_2 produced by its raw materials and fuels into the atmosphere. The potential for making savings here is huge, and scientists from the Karlsruhe Institute of Technology now want to tap into this. They have developed a new process for producing cement that only consumes half as much energy and emits even less carbon dioxide. "This development builds solely on completely new insights gained into the processes taking place as the material sets," explains Dr. Peter Stemmermann, who heads the project."

"We need less lime and can work at lower temperatures and so can save at least half the energy and even more greenhouse gases emissions as well."

Conventional cement is made by burning limestone and clay in rotary kilns at around 1,450° Celsius. Subsequently, the clinker brick is finely ground together with other additives to produce the finished cement. This produces huge amounts of carbon dioxide, not only through the high kiln temperatures that swallow large amounts of fuel, but also because lime, the main component, releases 480 kilograms of CO_2 per tonne of cement. "The high lime share is the key factor, which is why we started there," says Stemmermann. So, Stemmermann and his team studied the processes in detail before and while the conventional cement set. Two results were decisive. On the one hand, structural studies using the Karlsruhe Synchrotron Radiation Source ANKA show that only around half the lime is needed for the cement to bond with water and set, the so-called hydration stage. "That was a surprise," explains Stemmermann. "The hydration process involves two steps. First, the surrounding water leaches out the calcium ions from a layer that is just a few nanometres thick and replaces these with protons. This layer then has a low calcium level. However, it is only this leached product that, in a second stage, actually forms the calcium-silicate-hydrate phases that are decisive for the hardness of the cement by reacting with water." These CSH phases grow in the form of thin, strutted films so that the cement can set. By contrast, the other half of the lime is bound in the form of calcium hydroxide and other calcium hydrates and even reduces the quality of the cement, because these hardly set and can easily be affected by acids.

And so the idea was that much less lime could be used and the burning could be dispensed with if the basic ingredients could be left to react with water in autoclaves, a kind of pressure cooker, with temperatures up to 300° Celsius. This produces polycrystalline phases that grow in water and are stabilised by hydrogen bonds. However, to ensure that the cement can still store water and set, these hydrogen bonds have to be destroyed, for example, by grinding. "That's the crux, we need less lime and manage with lower temperatures," emphasises Stemmermann. But the scientists also used another observation to their advantage. Conventional cement often continues to react many years later, even though the required hardness is already seen after a month. The nucleus of the cement minerals only has a mechanical function, as a support particle. "Then we can also simply add grains of sand around which the cement material can then settle as a thin layer, like a skin," says Stemmermann, describing the line of thought.

Together, these two approaches save at least half the energy and even more greenhouse gas emissions as well. "And that's a modest estimate. At lab scale, we can achieve a lot more, but we now want to transfer the method to the industrial scale." Meanwhile, the composition of the new cement and the process steps have been patented under the name of "Celitement". After two years of support funding by the KIT Innovation Department and the Helmholtz Enterprise Fund,

the day finally came in spring 2009. The Karlsruhe Institute of Technology (KIT), the inventors and the industrial partners from the SCHWENK Group founded the Celitement GmbH company. This will now build a pilot plant that aims to deliver some 100 kilograms of the new binder per day as from 2011. As from 2014, the industrial partner aims to establish a plant capable of producing 30,000 tonnes per year. "For the cement industry, these are still test-tube dimensions," says Stemmermann, "but it is the first step into a mass market." ANTONIA RÖTGER

Forschungszentrum Jülich

HIGH-TEMPERATURE MATERIALS INCREASE EFFICIENCY

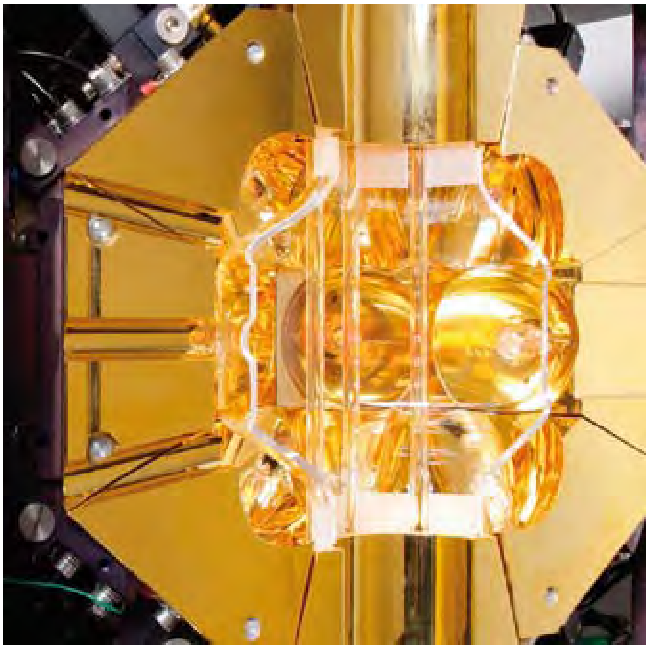
Even modern, fossil fuel fired power stations blow around half of the primary energy into the atmosphere. To make this much more efficient, scientists headed by Professor Dr. Lorenz Singheiser from the Institute of Energy Research at the Forschungszentrum Jülich are developing new materials that can withstand higher operating temperatures and extreme loads without changing their inner structures through aging. "There can hardly be any more demanding scenarios for materials to withstand than steam turbines that have to operate trouble free over decades without signs of fatigue," says Singheiser.

Together with ThyssenKrupp VDM, he developed a new high-performance steel by adding titanium and manganese to stabilise the basic structures of chromium and iron, thereby raising the heat resistance. The materials built on this basis, which material experts are now working on, withstand temperatures of up to 650° Celsius. This operating temperature would reduce carbon dioxide emissions by around a quarter compared to present-day values. Further improvements are on the horizon. Singheiser and his team are also studying nickel-based super alloys that can withstand temperatures of up to around 750° Celsius over long periods of time.

The first E.ON steam driven power station, working at temperatures of up to 720° Celsius, is scheduled to go online as early as in 2014 with the help of the results from Jülich. In just under 20 years, estimates Singheiser, the efficiency of coal-fired power stations could be increased to 55 per cent.

> "In just under 20 years, it might be possible to increase the efficiency of coal-fired power stations to 55 per cent. And efficiency rates of 65 per cent are conceivable with gas and steam driven power stations."

It currently lies at 45 per cent. In the case of gas and steam driven power stations, efficiency rates of 65 per cent are conceivable. ARÖ



HIGH-TEMPERATURE MATERIALS ARE TESTED FOR THEIR RESILIENCE IN RADIATION HEATERS. Photo: Forschungszentrum Jülich

Max Planck Institute for Plasma Physics

LOOKING FOR THE RIGHT MATERIAL FOR ITER'S WALL

The Sun shows us how and releases energy by fusing atomic nuclei. Nuclear fusion could also become a climate friendly source of energy on Earth as well. The experimental reactor "ITER" (Latin for "path") aims to demonstrate the feasibility of this technology. Countries from around the world are collaborating on building the future test reactor ITER in Cadarache, southern France. The aim is to achieve 500 megawatts of fusion power. The running of the test reactor is being prepared in numerous projects. For example, scientists from more than twenty institutions of the European Fusion Programme are working together to study how the fusion fuel will interact with the wall of the plasma chamber.

> "The plasma chamber walls for ITER must be resistant against the high thermal loads that can occur in cases of plasma instability."

The scientists have to succeed in confining the fuel – a thin ionised hydrogen gas in a plasma state – in a magnetic cage and then in heating it up to ignition temperatures of over 100 million degrees. The interplay between the extremely hot fuel and the wall of the surrounding vessel represents one of the greatest challenges for the research. "The plasma chamber wall for ITER must be resistant against the high thermal load that can occur in cases of plasma instability," explains Dr. Rudolf Neu from the Max Planck Institute for Plasma Physics (IPP) in Garching, deputy head of the project group. "Furthermore, it has to store the smallest amounts possible of the radioactive fuel component tritium, produce as little material dust as possible and be resistant to material mixes that occur when wall material is eroded by plasma particles and is later deposited on other parts of the wall." Most of the problems could be avoided by using tungsten as a wall material. The IPP fusion device ASDEX Upgrade in Garching is the only one in the world that can experiment with a wall completely covered in tungsten – and the first results are highly promising.

The background: Energy rich plasma particles can knock atoms out of the wall, which can then penetrate the plasma and contaminate it. In contrast to light hydrogen, the heavy atoms from the wall are not fully ionised, not even at the high fusion temperatures. The more electrons that are still bound to the nuclei, the more energy they withdraw from the plasma and radiate this as ultraviolet or X-ray light. This causes the plasma to cool, dilutes it and so reduces the fusion output. If contamination by light atoms is still tolerable in concentrations of just a few per cent, the limit for heavy particles such as iron, chromium or even tungsten is much lower. This is why present-day plants all use light materials, such as beryllium or carbon.

These materials are also planned for the wall of the test reactor ITER. In the large-scale ITER plant however, this is no longer that easy. For example, the sputtering of carbon or beryllium is relatively high under bombardment with hydrogen. In the case of the high hydrogen flows from the large ITER plasma, this would result in strong material erosion. A tungsten wall would avoid the problems of the light elements. The metal possesses advantageous thermal properties, low sputtering levels through hydrogen and reveals no long-term depositing of tritium. However, the question remains of how many heavy tungsten particles are able to penetrate into the plasma core. Their number must not exceed a share of several hundred thousand parts in the ITER plasma.

The Garching experiment ASDEX Upgrade is a pioneer in testing tungsten as a wall material. Despite poor experiences gained elsewhere, Garching had already begun to coat special parts of the wall with tungsten in 1996, instead of otherwise fully covering the wall with carbon tiles. In so doing, the scientists counted on the cold plasma edge of ASDEX Upgrade, which acts much like the later ITER. Two years ago, experiments using a pure tungsten wall began – with success. The tungsten concentration remained below the critical threshold and the desired plasma states could be reached

TUNGSTEN COATED WALL TILES ARE FITTED INTO THE PLASMA CHAMBER OF THE ASDEX UPGRADE FUSION DEVICE. PHOTO: IPP

with only minor quality losses. Now the task is to carefully check and verify the tungsten's compatibility in the ITER relevant plasma states. To do this, comparative experiments are planned on the JET plant, the Joint European Torus in Britain, which is twice the size of ASDEX Upgrade, in order to be able to transfer the results with reliability to the even larger ITER.
ISABELLA MILCH

German Aerospace Center (DLR)

SOLAR POWER FROM THE DESERTS

In just six hours, the world's deserts receive more energy from the sun than humankind uses in one whole year. The Desertec Industrial Initiative, which was founded in October 2009 by a number of major industrial companies, aims to provide 15 per cent of the European electricity demand by 2050 through imports from solar thermal power plants in North Africa and the Middle East. The Desertec concept builds on research projects and detailed studies carried out by German Aerospace Center. "From 2025 onwards, this electricity will be less expensive than mid-load electricity from fossil fuel fired power plants," says Professor Dr. Hans Müller-Steinhagen from the Institute of Technical Thermodynamics at the DLR, where this work has been done. Because the technology works. Solar thermal power plants have been working reliably in the United States for more than 20 years, and DLR engineers have substantially improved the performance of many key components and operational procedures since then. In early 2009, the world's largest solar power plant (Andasol 1) went online in Andalusia, followed by an identical power plant Andasol 2 later in the same year. Andasol 3 is already under construction. DLR experts have made significant contributions to the success of these plants. Andasol 1 produces 50 megawatts of power. And what's more, for up to 20 hours per day in summer. 520,000 square metres of parabolic trough collectors catch the solar heat at temperatures up to 400°C, and two giant tanks filled with liquid salt store the excess energy not required for electricity generation during the midday hours. The stored energy enables the plant to continue delivering the full power for up to eight hours after sunset.

"The Desertec Industrial Initiative aims to provide 15 per cent of the European electricity demand by 2050 through imports from solar thermal power plants in North Africa and the Middle East."

After years of hard work and slow progress, this technology is now entering the markets worldwide at a rapid rate. Major international companies, including Siemens, RWE, Deutsche Bank and Münchner Rück in Germany, have joined forces to kick-start the Desertec concept, which may involve an investment of 400 billion euros up until 2050 for construction of solar thermal power plants in North Africa and high voltage direct current lines from Africa to Europe. Most of this investment will be recovered from the sales of the provided electricity. This means that the concept developed by the DLR scientists, which not only secures energy supply but also reduces greenhouse gas emissions and provides the conditions for sustainable growth of the MENA countries, may be implemented quickly.
ARÖ

ANDASOL 1: 520,000 SQUARE METRES OF MIRRORED SURFACE CAPTURES THE SUNLIGHT. Photo: Solar Millenium AG

RESEARCH FIELD
EARTH AND ENVIRONMENT

PROF. DR. KARIN LOCHTE
Vice-President of the Helmholtz Association, Coordinator of the Research Field Earth and Environment, Alfred Wegener Institute for Polar and Marine Research

GOALS AND ROLES

Humankind influences its environment to a significant extent and is in turn increasingly dependent on its changes. Climate change, increasing vulnerability to natural hazards, species decline and extinction and other critical developments have been observed for decades, and important resources, such as drinking water or fertile soils threaten to become scarce. This is why the Helmholtz Association is engaged in foresighted, preventive research for the future. The research centres in the Research Field Earth and Environment study the fundamental functions of System Earth and the interactions between society and nature, thereby creating a sound knowledge base for securing the long-term foundations of society.

The Research Field aims to understand the complex changes of Earth and environment in detail and to develop future scenarios so that decision-makers in politics and society receive sound scientific recommendations for their actions.

The diversity of questions calls for the effective and efficient use of the scientific infrastructure and new kinds of strategic research networks within and beyond the Helmholtz Association. Expertise and resources are pooled through national and international collaboration with universities and research institutions, for example in Virtual Institutes and also in increased collaboration and cooperation activities at European level. The 18 current Helmholtz Virtual Institutes demonstrate the excellent links and connections between the individual centres and university partners. In addition, the Research Field is also contributing to two Excellence Clusters: "The Ocean in the Earth System" (University of Bremen/AWI), and "Integrated Climate System Analysis and Prediction" (University of Hamburg/GKSS), as well as a Graduate School ("Global Change in the Marine Realm", University of Bremen/AWI). These collaborations developed as part of the Excellence Initiative of the German Government and demonstrate the high level of cooperation with partners outside the Helmholtz Association. Within the Karlsruhe Institute of Technology, the former Forschungszentrum Karlsruhe and the University of Karlsruhe combine their efforts in the KIT Centre "Climate and Environment", which will provide important contributions to the Research Field Earth and Environment.

The Climate Initiative is a new research collaboration focusing on regional climate analysis and prediction. It pools the expertise and competencies of various Helmholtz Centres in close collaboration with universities and non-university research groups in order to study and explore the regional impact of global climate change. Socioeconomic aspects are also taken into account to draw up concrete recommendations on the sustainable cultivation of forests and agricultural areas as well as on efficient water management. The Climate Initiative also works closely together with the regional Helmholtz Climate Offices (Southern, Central, and Northern Germany, Polar Regions and Sea Level Rise), and the newly founded Climate Service Centre as a communication platform for climate relevant questions.

A further initiative with the strong participation of university partners is represented in the "Water Science Alliance", which strategically focuses the expertise and competencies in water and hydrological research.

Cross-centre and cross-institutional research projects at international level are playing an ever more important role in the

The Research Field Earth and Environment was evaluated at the beginning of 2008 within the scope of the Helmholtz Association's programme-oriented funding. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field in the period under report up to the end of 2008 and presents the new research programmes that form the strategic focus of the Research Field in the coming years. The previous and the new structure are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as from 2010. With effect of 2010, all six research fields will be in the second funding period.

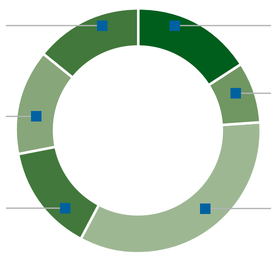
Helmholtz Association. For example, five Helmholtz Centres have been conducting research together with the UN Organisation ECLAC (Economic Commission for Latin America/Spanish: CEPAL) and partners from Latin America since 2007 in the initiative "Risk Habitat Megacity" in order to draw up strategies for sustainable development in megacities and conurbations. A further responsibility for the Research Field lies in promoting young scientists and researchers. We are continually extending and expanding the existing measures and structures, in most cases in cooperation with external partners. In the field of education and training, these are the Graduate Schools and Helmholtz Research Schools. In the field of independent, autonomous research the Young Investigators Groups are promoted. Funding was obtained for the UFZ's Helmholtz Interdisciplinary Graduate School for Environmental Research with its six university partners, for the AWI's Helmholtz Research School on Earth System Science with two university partners, and also for a further Helmholtz Graduate School (AWI's Helmholtz Graduate School for Polar and Marine Research). Furthermore, 15 Helmholtz Young Investigators Groups are currently being funded. The successful networking of the Research Field Earth and Environment in teaching and concomitant measures aimed at promoting young scientists and researchers are also reflected institutionally. In 2008, for example, and as part of the Jülich-Aachen Research Alliance – JARA – the Forschungszentrum Jülich and the RWTH Aachen joined forces in the "German Research School for Simulation Science".

"In 2050, at least nine billion people will live on Earth. They all want to lead a happy life, need food, sustenance and water, energy and a place to live. They would like to be mobile and have prospects for their children. Enormous challenges for a world in which a billion people are starving today and well over a billion people have no access to drinking water. Massive investments in scientific research, in practical technical solutions are fundamental prerequisites for managing and mastering these problems. Technical progress is able to secure the capacity of the environment. The Helmholtz Association has taken up this challenge. The scientists are looking for solutions to these problems. In doing so, they contribute to the peaceful development of the Blue Planet.

PROF. DR. KLAUS TÖPFER,
Senator of the Helmholtz Association, Former Under Secretary General United Nations and Founding Director of the Institute for Advanced Sustainability Studies in Potsdam.

Structure of the Research Field Earth and Environment
Core-financed Costs 2008: 227m euros

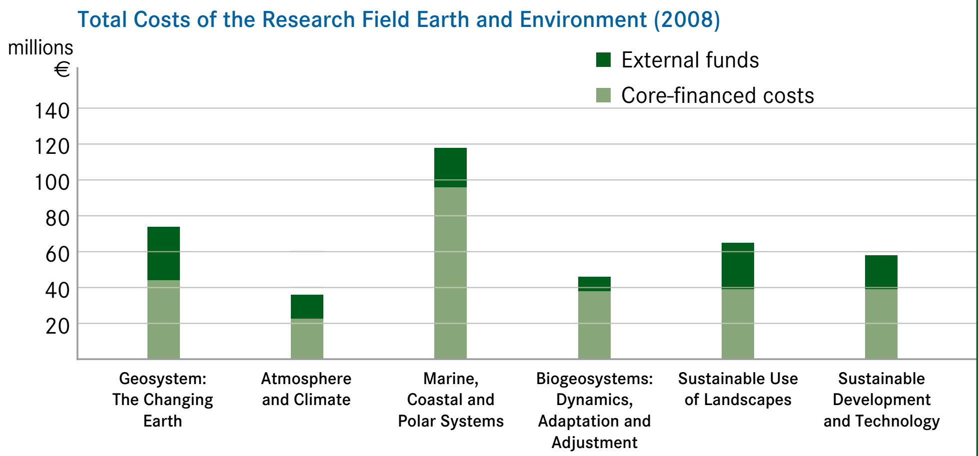
The Research Field Earth and Environment additionally received 119m euros of external funds, providing it with a total of 396m euros.



PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2004–2008

Eight Helmholtz Centres contributed to the Research Field Earth and Environment in the first funding period: Alfred Wegener Institute for Polar and Marine Research, Forschungszentrum Jülich, Forschungszentrum Karlsruhe (now KIT), GKSS Research Centre Geesthacht, Helmholtz Centre for Infection Research, the Helmholtz Zentrum München – German Research Center for Environmental Health, the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, and the Helmholtz Centre for Environmental Research – UFZ. Environmental and Earth System research focuses on the grand challenges that national and international bodies have identified. Natural disasters, climate fluctuation and climate change, water availability and dynamics, the sustainable use of resources, biodiversity and ecological stability as well as the socio-political dimension of global change. The Research Field addressed these central tasks of Earth and Environment Research in six programmes during the first programme period:

- 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



THE PROGRAMMES
IN THE FUNDING PERIOD 2004–2008

The Geosystem: Changing Earth Programme
This programme focuses on the physical and chemical processes taking place within the Earth System and on the complex interactions between the various spheres, such as the geosphere and atmosphere. Major research infrastructures like near Earth satellites, research aircraft as well as an Earth-embracing network of geophysical and geodetic stations operated by the participating research centres create a comprehensive observation system for recording the change processes. Research topics include Earth's magnetic and gravity field, natural resources and material cycles, as well as the development of foresighted preventive strategies for natural disasters. Further key research priorities include the processes of natural climate variability and the use of subterranean space, for example, to store carbon dioxide.

Atmosphere and Climate
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, *inter alia*, how human activities impact the chemical composition of the atmosphere and, consequently, the climate. To enable them to predict global and regional climate changes, they analyse chemical and microphysical processes and the effects of feedback mechanisms.

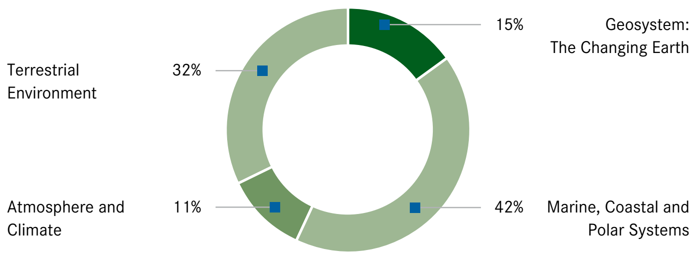
Marine, Coastal and Polar Systems
The biological and geological nature of global marine systems and coastal regions is the object of research conducted in this programme. Special emphasis is placed on the polar regions. The processes and interactions taking place within these systems are particularly important for the global climate. The research efforts 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 use the analyses of the natural climate archives and the observations of recent processes to model future scenarios more precisely.

Biogeosystems: Dynamics, Adaptation and Adjustment
This programme investigates how biogeosystems respond to human intervention and environmental change. The researchers study elementary components like soils, microorganisms, flora and groundwater, and how they interact. This enables them to recognise negative developments at an early stage and to develop methods to counteract them.

Sustainable Use of Landscapes
This research programme examines how human activities lead to land use changes and influence landscapes, ranging from urban, densely populated and intensively used areas, to contaminated former opencast mining areas. Also to seminatural landscapes, such as deserts and semiarid landscapes are considered that only allow extensive, i.e. non-intensive, cultivation. In so doing, the consequences of climate change for land usage purposes are examined. Socio-economic and legal questions also enter into the studies.

Sustainable Development and Technology
This research programme develops technologies for material flow processes, such as water, carbon, wastes or building materials in order to save resources, reduce emissions and allow the regeneration of natural resources. By combining socio-economic systems research with technology impact assessment and by collaborating with other research fields, it is possible to offer integrated strategies for sustainable development.

Structure of the Research Field Earth and Environment
Core-financed Costs Plan 2010*: 256m euros
(including non-programme-bound research)



* Second year of the new Programme Funding Period 2009-2013

THE PROGRAMMES
IN THE FUNDING PERIOD 2009–2013

The Research Field Earth and Environment has rearranged the research programmes for the coming years. The previous programme "Sustainable Development and Technology" will no longer be continued within the Research Field Earth and Environment. A large proportion of this programme has been transferred to the Research Fields Energy and Key Technologies. The previous programmes "Biogeosystems: Dynamics, Adaptation and Adjustment" and "Sustainable Use of Landscapes" merged in 2009 and now form the programme "Terrestrial Environment". The Research Field pools its research activities in four programmes since 2009:

- Geosystem: The Changing Earth
- Marine, Coastal and Polar Systems
- Atmosphere and Climate
- Terrestrial Environment

To address overarching research topics and to create methodological and organisational synergies, the programme is additionally establishing and expanding cross-cutting programme and research field initiatives such as "Climate" (AWI, FZJ, KIT, GFZ, GKSS, HMGU, UFZ), "Integrated Earth Observation System" (Network EOS: AWI, DLR, GFZ, GKSS, FZJ, KIT) and methodological working groups in the field of "Modelling" (AWI, GFZ, KIT, FZJ, HMGU, GKSS, UFZ).
A further key element is to be seen in the joint creation and operation of cross-programme infrastructures, such as the research aircraft HALO or the "Terrestrial Environmental Observatories" (TERENO). The latter will establish up to four selected terrestrial observatories in regions that are representative of Germany by 2010, thereby creating a TERENO Network on the basis of existing research stations and long-term data series.

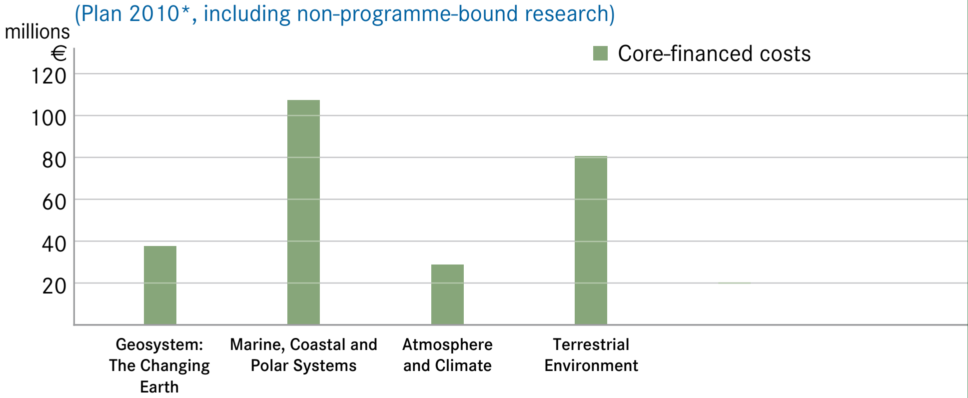
Geosystem: The Changing Earth

The analysis of physical and chemical processes within the Earth System and interaction between geosphere, atmosphere, hydrosphere, pedosphere, and biosphere and their impact on the human habitat lie at the heart of this programme. Its mission is to observe, explore and model the relevant geoprocesses to assess the state of the Earth System and recognise changes and trends. Global geophysical and geodetic observation infrastructures, regional Earth System Observatories, near Earth satellites, airborne recording systems, mobile instrument arrays and drilling rigs plus an analytical and experimental infrastructure provide the instrumental backbone. These observation systems have been integrated into national and international collaborations. The programme focuses on Earth's magnetic and gravity fields, its natural resources and material cycles, climate variability and climate impact on the human habitat. It furthermore addresses applied aspects such as preventive strategies for natural disasters, or using subterranean space to store carbon dioxide. These core areas contribute to the three topic fields of the programme "Earth System Dynamics and Risks", "Climate Variability and Climate Change", plus "Sustainable Use of Resources".

Marine, Coastal and Polar Systems

The research programme focuses on the observation and analysis of past, present and future changes to the poles, the oceans and the Earth System as a whole in a multidisciplinary approach. The research addresses the current changes in the Arctic, the Antarctic and their respective coastal regions. In addition, coastal regions in lower latitudes are being studied with emphasis on the effects of direct human impact. In the polar regions, the processes governing global climate change as well as the ecosystems' response to change are being studied. This is complemented by detailed studies of the palaeoenvironmental archives and by process studies, allowing far-reaching conclusions to be drawn from the Earth's past. The programme also aims to develop a model system with which it can forecast medium-term developments. In this model, the influence on climate dynamics by the cryosphere, the oceans, the marine biosphere and the geo-chemosphere can be analysed. It also considers biodiversity and the flow of energy and matter in differing regional and time scales. Studies on the changes of the

Core-financed Costs of the Research Field Earth and Environment
(Plan 2010*, including non-programme-bound research)



*Second year of the new Programme Funding Period 2009-2013

Earth's climate and the human impact on this complex system aim to enable medium-term predictions on a scientific basis to aid political and social decision processes. To achieve these goals, modern research infrastructures such as vessels, aircraft and polar stations are used. The new Neumayer Station III is not only fulfilling its function as a research basis for long-term observations, but also strengthens Germany's role in the Antarctic Treaty system, the international treaty guaranteeing free access for research to the Antarctic region.

Atmosphere and Climate

The research programme addresses the role played by the atmosphere in the climate system as well as processes that have a decisive influence on climate changes, natural disasters, air quality and, hence, quality of life on Earth. In connection with this, we are studying the stratosphere, troposphere and biosphere and their complex interactions in the global change. Research priorities include investigations of the water cycle and the biochemical cycles of environmentally relevant trace gases and aerosols. Data from long-term aircraft and satellite measurements, ground-based stations, major simulation chambers such as AIDA, and SAPHIR, and numerical modelling (transport, climate models, etc.) form the basis for these analyses. The numerical models are constantly advanced in order to quantify the ecological and socio-economic consequences resulting from the climate changes and acquire knowledge necessary to guide future actions as a protection against various forms of detrimental changes. Particular emphasis is on the regional scale. The new research aircraft HALO will contribute significantly to the success of the programme. It will commence its first missions with research for this research programme.

Terrestrial Environment

The Terrestrial Environment Programme aims to preserve the foundations of human life and develop options for the sustainable use of resources. Hence, the programme has close links with climate change research. Since climate change cannot be stopped by the mitigation of greenhouse gas emissions alone, additional strategies need to be developed aimed at adapting and reducing the vulnerability of our ecosystems. To this end, new technical solutions are designed in the fields of agricultural, bio, energy and environmental technologies. User conflicts at the interface between food production, bio-energy and nature conservation are studied and strategies developed for adapting to the global change at regional level. Mechanisms that regulate the growth of microbes and plants are analysed for a sustainable biomass production system. In the field of water resources systems, we take a novel ecotechnological approach to protecting and providing water of high quality and sufficient quantity. A thorough understanding of the processes of groundwater systems and analysis of the vulnerability of groundwater bodies is developed in order to assess the consequences of groundwater degradation for humans and for ecosystem stability. The responsible use of chemicals calls for an in-depth knowledge of the fate of chemicals in the environment. It opens up new opportunities for lower risk substances as well as problem-specific rehabilitation strategies for contaminated mega-sites. The research work is complemented by the establishment of a technological-methodological platform for the purposes of observation, integrated analysis and assessment of terrestrial systems. Innovative measuring and monitoring concepts, integrated modelling approaches as well as methodological issues of up-scaling at long-term observation sites such as TERENO play a special role in this project.

PROJECTS

Alfred Wegener Institute for Polar and Marine Research

RESEARCH AROUND THE NORTH POLE

The North Pole region is an area with unique ecosystems and valuable natural resources. Today it is experiencing particularly rapid change as a result of global climate change. However, research in the High Arctic is a cost and time intensive effort, because the "data archives" in the Arctic Ocean lie under metres of snow and ice. The ice cover also determines which areas research vessels can reach at all. "Sometimes we return with more data than expected and sometimes with less," says Dr. Wilfried Jokat from the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven. Jokat and his colleagues brought back a lot more data than they had hoped for last autumn. The thin sea ice cover had made ocean areas navigable that had previously not been accessible. From August to October 2008, the German research vessel and icebreaker Polarstern sailed around the Pole – passing through the North-West and North-East Passages in a single season, the first research vessel ever to have done this. "Just three years ago, I would have said this is completely impossible," says Jokat, who headed the 47-strong team of scientists from twelve nations.

During the voyage the researchers concentrated on the region of eastern Siberia. "The entire area north of the Behring Strait is highly interesting but hardly explored." Jokat and his team above all wanted to know what it looked like during the last ice age. It was known that North America and Europe were covered by glaciers. But was the land to the east also covered in ice? "The initial results from this expedition clearly say: "Yes," says Jokat. "For example, we found the scrours that icebergs typically leave on the sea floor." However, where the ice came from and how far it extended is still open to debate. Did the glaciers spread across from Canada or did eastern Siberia possibly have its own ice sheet? "This would mean that previous reconstructions of how the ice sheets were distributed would be incorrect."

And another aspect was focused on by the scientists and researchers headed by Jokat. "We do not know what factors determine when and how quickly the ice and warm periods change." One school of thought is that the formation of the Isthmus of Panama around three million years ago caused a change in ocean circulation. Ever since, the interchange between ice and warm periods has proceeded comparatively quickly. Model simulations for Greenland, for example, predict that today's island glaciers could completely melt away within an estimated 5,000 years – in geological terms just a blink of the eye. "We do not know how normal or unusual it is in Earth's history for this to occur so quickly. Perhaps faster interchanges already took place five or ten million years ago. Because we don't know this for sure, we can currently do no more than estimate as well as we can how significant the speed of ice retreat today really is," says Jokat.

"We do not know what factors determine when and how quickly the ice and warm periods change."

Predictions on natural resource deposits in the Arctic are also vague. Just under a third of the previously undiscovered natural gas deposits worldwide are said to be located around the North Pole, plus 13 per cent of the currently unrecorded deposits of mineral oil, says an assessment published by American geologists in "Science" in May 2009. Samples that could confirm or refute these assumptions hardly exist. As part of the Integrated Ocean Floor Drilling Program (IODP), scientists from the Alfred Wegener Institute drilled a revealing sediment core. "But we have just this one core," says Jokat, leaving everyone to think for themselves what this means. However, the US industry also collected drill cores as part of its own exploratory activities in the 1970s and 1980s. The researchers are now comparing these with the data from circumnavigating the North Pole to identify parallels and differences in the glacial history of North America and Canada with that of Siberia.

But even that is not enough. To draw sound conclusions, the basic parameters we use for climate and natural resources models must be as accurate as possible. "Otherwise the model

AN OCEANOGRAPHIC MEASURING DEVICE IS LOWERED INTO THE ICEHOLE WITH THE HELP OF A TRIPOD. PHOTO: STEFFEN SPIELKE, AWI

runs are unconstrained, and may be biased by current thinking." The data from the voyage round the North Pole will help in this respect. "Our current equipment allows us to sample down to 10 metres beneath the ocean floor. With different technology and equipment, we might manage to go down as far as 500 metres." The Alfred Wegener Institute has already submitted its proposals for deep scientific drilling. Wilfried Jokat is convinced. "Carrying on here is worth it, absolutely." For, to be able to predict how this region will develop, the scientists have to look back into the past. Only when the history is known will the entries in the long-term forecasting models also be correct. CORNELIA REICHERT

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

TRAINING AND INSTRUCTION COURSES ON THE TSUNAMI EARLY WARNING SYSTEM

The German-Indonesian Tsunami Early Warning System (GITEWS) for the Indian Ocean is technically operational and is now being tested and optimised for everyday operation. "The most important task now is to train the people locally on site, for example, the experts and specialists who will take over the technical operation and maintainance of the instruments," says Project Leader Dr. Jörn Lauterjung from the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, which coordinates the project. Working together with the authorities, training and instruction courses are now being run for the population so that they can respond appropriately to the warnings.

"The most important task for us now is to train the people locally on site who will take over the technical operation and maintenance of the instruments."

Countless consultations and negotiations with the Indonesian partners and authorities on site, with international partners in Indonesia, as well as with the Intergovernmental Oceanographic Commission (IOC) of UNESCO were needed to move the project forward. This was then followed by major scientific challenges, since the geology off the Indonesian coast is such that earthquakes can occur very close to the coast, meaning that early warning times are very short. Hence, the new system must allow operators to decide quicker than with other early warning systems as to whether a tsunami really is pending or not, to avoid false alarms. "However, the time, effort and cost have been worth it. We are internationally very visible with this achievement and now other countries are asking for our know-how, such as Australia, for example," says Lauterjung. For their management of the highly complex project, Dr. Jörn Lauterjung on the German side and Dr. Sri Woro Harijono from the Meteorological, Climatological and Geophysical Service of Indonesia (BMKG) were presented with the Roland Gutsch Project Management Award 2009. The system will be transferred fully to Indonesia at the end of March 2010. Although it cannot prevent natural disasters, such as tsunamis, it can help people reach safety in good time. The project idea came with the tsunami that killed almost a quarter of a million people in late 2004. ARÖ

EVACUATION COURSES TRAIN SCHOOL PUPILS AND STUDENTS HOW TO ACT PROPERLY. Photo: GITEWS

PALEOCLIMATE RESEARCHERS AT THE TSWAING LAKE DRILLSITE IN SOUTH AFRICA. PHOTO: GFZ

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

THE NAVEL OF AFRICA

You could translate “Inkaba yeAfrica” as the Navel of Africa. Geoscientists Professor Dr. Maarten de Wit from the University of Cape Town in South Africa and Professor Dr. Brian Horsfield from the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences are coordinating this mammoth international project that combines basic research on the Earth System with applied research of relevance to human habitat and activity in the south of the continent. “Africa’s Navel” also alludes to the cradle of humanity which lies in Africa. “The scientists recognise this area of the world as a prime example of modern Earth System research,” explains GFZ researcher Dr. Robert Trumbull, who is also contributing to the project. For example, the Intergovernmental Panel on Climate Change (IPCC) declares southern Africa to be one of the main areas where climate change will have a very strong impact. A major research organisation such as the Helmholtz Association is ideally equipped for collaborating with African partners to understand this complex system, from the fundamental processes in the ocean and atmosphere through to the effects on human habitat and activity.

The Alfred Wegener Institute in Bremerhaven, for example, is studying how the ocean currents interact around southern Africa. For instance, the Benguela Current transports cold water from the Antarctic northwards along Africa’s Atlantic coast. The cool water prevents practically all the rain from reaching inland areas. On the other side of the continent, the Agulhas Current not only brings tropical warmth from the Equatorial region southwards along the Pacific Coast, but it also sends rainfall to southern Africa. Climate changes influence these ocean currents as well as the rainfall. When GFZ researchers in South Africa analysed the deposits and sediments in the circular Tswaing crater lake, with its 1,130 metres in diameter, they were able to read the climate record of the last 200,000 years and hence the two last major glacial cycles on Earth in this region. The Tswaing archive indicates that temperatures in South Africa were seven or eight degrees colder when enormous masses of ice buried Earth’s northern hemisphere under it, including the areas where the cities of Berlin and Hamburg are located today. When the climate at Tswaing warmed up again, it also became dryer. This is why water could then be in even shorter in supply in southern Africa, if climate change causes the temperatures to rise. Water is already a rare commodity in South Africa, because the ocean currents in the Atlantic and Indian Oceans prevent much rain from falling in the southern regions of the continent. Many users are already competing for the water. People not only need drinking water, but also water for washing, for flushing toilets, for irrigating fields and for the livestock. Industry, too, consumes large volumes for manufacturing trucks and cars, machines, steel and fertilisers. And a great deal of water is needed for mining, South Africa’s most important industry.

> “The Research Project Inkaba yeAfrica extends from pure basic research through to engineering and technology, for example, on mineral resources and mining.”

South African miners not only mine coal, but also extract the world’s greatest volumes of gold and platinum, chromium and diamonds from out of the ground. The downsides to mining include the high water and energy consumption and the enormous tailings dumps full of toxic substances.

In one of more than 20 projects, Inkaba yeAfrica studies mineral resources from genesis to disposal. How did the platinum deposits and coal seams develop, how are they used, what consequences does this have for the environment, and what changes might be conceivable? “In answering these questions, Inkaba yeAfrica not only considers mineral resources, but also extends from pure basic research through to engineering and technology in its projects,” explains Trumbull.

Inkabe yeAfrica delivers the results and the data basis needed for making political decisions on how business and industry, farmers and private households should prepare for

climate change. Which cereal crops will still flourish in more arid or hotter areas? And how much water can probably be expected to be available in 20 years' time for households, farming, mining or industry? ROLAND KNAUER

Forschungszentrum Jülich

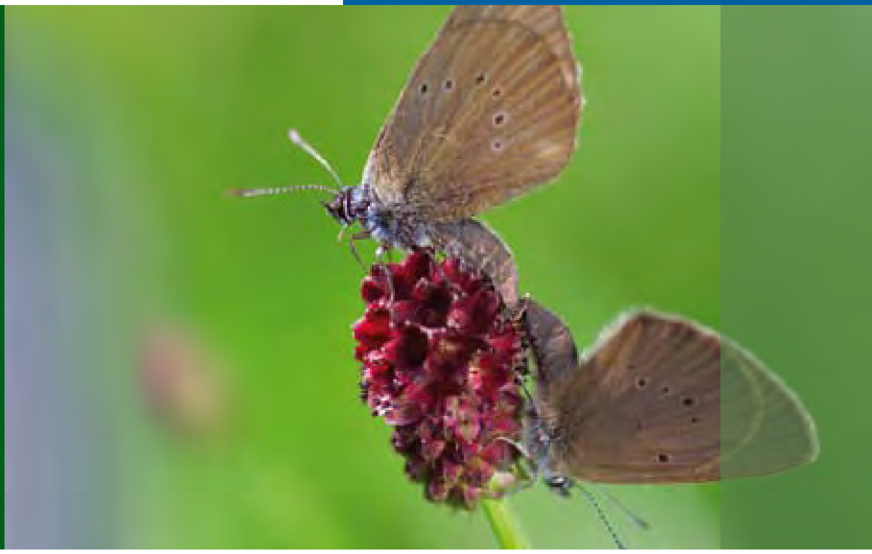
GERMANY'S LANDSCAPES AND CLIMATE CHANGE

Helmholtz scientists and researchers are running a major project called TERENO (TERrestrial ENvironmental Observatories) to study how climate change and land use change affect regional terrestrial systems in Germany. The Helmholtz Association is establishing four observatories in selected landscapes, extending from the Alps and alpine foothills through to the north-eastern German lowlands to spend 15 years observing and recording changes, e.g. in the water and soil quality, precipitation patterns, vegetation and biological diversity. Prof. Dr. Harry Vereecken from the Forschungszentrum Jülich is coordinating the project to which the Helmholtz Centres DLR, GFZ, HMGU, KIT and UFZ are contributing.

"We want to find out how rising temperatures or changes in the hydrological regime influence the carbon cycles in the soils."

Researchers from Jülich working on the "SoilCan" component are just installing some 120 lysimeters in the ground beneath the observatories in order to study the material and water flows there. "Only little is known so far of what happens in the lower layers of the soil," says Vereecken. However, the soils themselves also influence the climate, because they store a large proportion of the carbon and then, over time, gradually release it into the atmosphere again as CO_2. "We want to find out, for example, how rising temperatures or changes in the hydrological regime influence these processes," says Vereecken. After they have been used for measurements in one place, the lysimeters will be moved from more humid to drier areas and from cooler to warmer regions. "This will enable us to observe what happens when soils are exposed to greater aridity, for example, as has already been predicted for eastern Germany."
With TERENO, the Helmholtz Association aims to create a knowledge base that makes it possible to give concrete recommendations on how agriculture and forestry as well as local authorities can adapt the country's cultivation management to the changing conditions. ARÖ

A LYSIMETER CONTAINS AROUND 1.5 CUBIC METRES OF SOIL AND NUMEROUS MEASURING DEVICES. Photo: Firma Umweltmonitoringsysteme



Helmholtz Centre for Environmental Research – UFZ

ALARM: CLIMATE CHANGE RIPPING HOLES INTO THE NETWORK OF LIFE

“Species diversity is just as important as the climate when we think about feeding humanity, but we lack the detailed regional and temporal data on flora and fauna that enable us to make better predictions on how ecosystems will develop,” explains Josef Settele from the Helmholtz Centre for Environmental Research – UFZ. The EU project called ALARM has created an initial overview of key habitats in Europe and their specific problems.

“Species diversity is just as important as the climate when we think about feeding humanity, but we lack detailed regional and temporal data.”

ALARM stands for “Assessing LArge scale environmental Risks for biodiversity with tested Methods”. Scientists and researchers from 35 countries and 68 partner organisations (including seven mostly small and medium-sized companies) worked on this comprehensive research project between 2004 and 2009 coordinated by Settele and six colleagues. Together, they have, for the first time, developed uniform methods for assessing quantitative data on the environmental risks for biodiversity in various landscapes in Europe. One of the driving factors is the regional impact of climate change, which forces flora and fauna to adapt extremely quickly to new conditions. Furthermore, climate change encourages invasions by alien animal and plant species that may displace indigenous species and can cause substantial damage as harmful weeds or pests in woods and fields, thereby leading to substantial costs, plus ever more soil sealing, increasing fragmentation of landscapes and habitats caused by an ever tighter network of roads and the intensification of agriculture. Environmental chemicals from farming and industry often exert a subtle influence on the reproduction rates of insects and invertebrates which, in turn, are eaten by vertebrates, such as birds. It is the interaction between all these factors that is decisive and triggers species loss. “The question of whether climate change is good or bad for the species cannot be answered in this sense. There are winners and losers. However, of the 300 or so European butterflies that we studied, some 70 benefited, while the other 230 tended not to,” says Settele. Pollinating insects, such as bees, bumblebees, hoverflies and butterflies play a decisive role for the ecosystems. That the pollination levels in many landscapes in Europe have fallen strongly has been observed over a longer period of time. In the case of crops, this leads to harvest losses, in the case of wild plants it means less offspring all the way through to threats for survival. Although wheat, oat and rye are pollinated by the wind, fruit trees, hazelnut bushes and other vitamin suppliers are dependent on insects for forming the fruits. “We cannot say what a bee is worth, but we can say what it contributes,” believes Josef Settele, thereby calculating: “All the pollinator-dependant fruits, nuts and herbs and spices on the world market in 2005 would have cost around 153 billion euros.”

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ALARM has made it possible for the first time to catalogue the spread of many pollinating insects in greater detail. The problems faced by beekeepers with their colonies of bees have been known for some time, but now information on wild insects, such as bees, bumblebees, hover flies and butterflies is being added. “The problem is that we previously lacked good data, above all on the more common species, such as the Peacock Butterfly and Small Tortoiseshell, which are not so interesting for specialised colleagues,” explains Settele. This is why the UFZ researchers have organised a network of volunteers together with the Gesellschaft für Schmetterlingsschutz (GfS). These volunteers regularly walk along specific routes and count the butterflies (www.tagfalter-monitoring.de). The first analyses indicate that 2009 was a relatively good year for many butterflies – but some usually more common species

THE DUSKY LARGE BLUE WILL SUFFER UNDER CLIMATE CHANGE. IT RELIES ON SANGUISORBA HERBS AS WELL AS ON CERTAIN ANTS FOR SUCCESSFUL REPRODUCTION. PHOTO: ANDRÉ KÜNZELMANN, UFZ

such as the small tortoiseshell were observed less frequently. The mass invasion of the Painted Lady also gave the general public the impression that it had been a good year for butterflies. The collected results on the risks for biodiversity will be published in an atlas in early 2010. In this atlas, ALARM researchers have also combined the distribution areas of certain plants with the IPCC climate scenarios and land use maps to identify where certain butterflies will continue to have good chances of survival in the future. Some butterfly species, such as the Dusky Large Blue, only survive under unique symbiotic conditions which call for specific meadows or certain harvesting regimes. “These maps show us where it would be worth looking carefully. And we also see where nature conservation management could be transferred from south to north if the climate change continues.” A bright idea that Settele and a team of international colleagues now wants to pursue in the research project called CLIMIT. ANTONIA RÖTGER

GKSS Research Centre Geesthacht

WAVE RADAR CALCULATES THE FORCES AT SEA

Some 80 wind turbines are to be erected in the North Sea to the west of Sylt. A technical challenge, because such an offshore wind farm is not only exposed to waves and weather, but itself also influences the wave patterns. To examine this question, GKSS scientists headed by Dr. Friedwart Ziemer and experts from the Technical University of Saint Petersburg have developed a radar system with which the waves can be measured more precisely. “With radar devices built especially for us, we can try to monitor how big waves form, what forces they develop in the process and how these waves overlap,” reports Ziemer. At the research platform FIN03 off Sylt at the future site for the offshore wind farm, Ziemer and colleagues have already installed a permanent radar device. The FIN03 platform is coordinated by the Fachhochschule Kiel and will also be used as a permanent station within the overarching metrological network COSYNA (Coastal Observation System for Northern and Arctic Seas). COSYNA was initiated by the GKSS Research Centre Geesthacht in order to study the state and development of the North Sea.

> “We are trying to monitor how big waves form and what forces they develop in the process.”

In autumn 2009, Ziemer and colleagues will sail round FIN03 on the research vessel Friedrich Heincke with two more Doppler radars on board to measure what turbulences the platform itself generates and to what extent the current and swell affect the platform. The results can be taken into consideration in the design of the offshore wind farm as a whole, where many platforms stand in rows, and hence, turbulences can certainly build up. We do not yet know how strong these effects can be and whether they already have to be taken into consideration when designing wind farms at high sea. However, we will be able to say something about this at the end of 2009,” believes Ziemer. ARÖ

THE GEESTHACHT COASTAL RESEARCHERS’ WAVE RADAR ON THE MEASURING PLATFORM FINO3. Photo: F. Ziemer, GKSS

RESEARCH FIELD HEALTH

PROF. DR. OTMAR D. WIESTLER
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Health,
German Cancer Research Center

GOALS AND ROLES

Our society and our health system face enormous challenges. Rising life expectancy, on the one hand, and steadily decreasing birth rates, on the other. This leads to an ever greater proportion of elderly people in the population. Accordingly, chronic and age-related diseases, like degenerative diseases of the nervous system and the skeleton, cancer, cardiovascular and metabolic diseases, lung diseases and chronic inflammatory diseases are becoming ever more important. Moreover, increasing global mobility facilitates the spread of newly emerging infectious diseases or the proliferation of infectious diseases widely believed to have been eradicated long ago. This demographic and socioeconomic change has far-reaching consequences for the global health system, with health research worldwide facing major challenges. Chronic major diseases such as cancer, cardiovascular diseases, diabetes, lung diseases, neurodegenerative disorders, infections and environmental hazards are the main topics of Helmholtz Health Research. Scientists study and explore the cause and genesis of these often complex diseases and develop new preventative, diagnostic and therapeutic strategies.

In recent years, the participating centres have increasingly drawn on new forms of collaboration with strong partners from medical schools, universities, other research organisations, and industry. Closely interacting with local partners from medical school, the Helmholtz Health Centres have begun to establish Translation Centres at their respective sites. At these centres, Helmholtz scientists and colleagues from medical school work closely together under one roof to make the exchange between lab and clinic even more efficient and to accelerate the transfer of research findings into clinical practice.

To strengthen the research in the field of degenerative disorders of the brain, such as Parkinson's or Alzheimer's, the German Centre for Neurodegenerative Diseases (DZNE) was founded in June 2009. As a member of the Helmholtz Association, the DZNE based in Bonn maintains close collaborations with university partners in Göttingen, Magdeburg, Munich, Tübingen, Witten, and Mecklenburg-Western Pomerania. This flagship model is also attractive for other thematic fields.

The Helmholtz Association's strategic alliances also play an important role in the fundamental biomedical sciences. A strategic alliance in basic research has been established between the DKFZ and the Zentrum für Molekulare Biologie Heidelberg (ZMBH) at the University of Heidelberg. Expertise and competence in basic and translational research on complex neuropsychiatric diseases was pooled as part of the new strategic alliance JARA-BRAIN between the University Hospital Aachen and the Health Field at the Forschungszentrum Jülich. New models of collaboration with leading enterprises like Siemens Health Care or Bayer Schering Pharma are also being explored.

One of the future key tasks aims to advance German health research by integrating the expertise and competence at the Helmholtz Health Centres, university hospitals and other research organisations to create strong strategic partnerships. The gain in biomedical knowledge and scientific insights in socioeconomically relevant areas of disease will represent one of primary activities in newly formed consortiums and networks to drive forward the production of concrete clinical applications. The initiatives developed by Helmholtz Health Research in fields like diabetes, cancer, cardiovascular diseases or preventative medicine ("Helmholtz Cohort") simultaneously invite strong partners to come and make an active contribution. Such a development will have a strong and sustainable effect on German Health Research and will serve to consolidate our leading international position.

The Research Field Health was evaluated at the beginning of 2008 within the scope of the Helmholtz Association's programme-oriented funding. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field in the period under report up to the end of 2008 and presents the new research programmes that form the strategic focus of the Research Field for the coming years. The previous and the new structure are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as of 2010. With effect of 2010, all six research fields will be in the second funding period.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2003–2008*

In the first programme period, ten Helmholtz Centres cooperated in the Research Field Health. These contributors included the Helmholtz Centre for Infection Research, the German Cancer Research Center, the Forschungszentrum Jülich, the Forschungszentrum Karlsruhe, the GKSS Research Centre Geesthacht, the Helmholtz Zentrum München – German Research Center for Environmental Health, the GSI Helmholtz Centre for Heavy Ion Research, the Helmholtz-Zentrum Berlin für Materialien und Energie, and the Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch, plus the Helmholtz Centre for Environmental Research – UFZ. The scientists collaborated in seven programmes:

- Cancer Research
- Cardiovascular and Metabolic Diseases
- Function and Dysfunction of the Nervous System
- Infection and Immunity
- Environmental Health
- Comparative Genome Research
- Regenerative Medicine

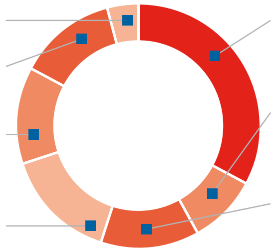
"What's important? Emphasis on selection and promotion of individual scientists using excellence as the major criterion. National and international collaborations to enlarge horizons and provide sufficient critical mass. State of the art infrastructure. Groundbreaking basic research as the foundation for translational research. Focus on understanding the molecular causes of major human diseases including cancer, heart disease, infectious diseases and neurodegenerative diseases and on translating the findings from basic research into advances that directly benefit patients."

PROF. DR. MARY OSBORN
Senator of the Helmholtz Association, Max Planck Institute for Biophysical Chemistry, Göttingen.

*The first Funding Period in the Research Field Health began in 2003; it was extended by one year up to 2008.

Structure of the Research Field Health
Core-financed Costs 2008: 290m euros

The Research Field Health additionally received 119m euros of external funds, providing it with a total budget of 409m euros.



THE PROGRAMMES
IN THE FUNDING PERIOD 2003–2008*

Cancer Research

Around 450,000 people in Germany are diagnosed with cancer each year, with more than half of the patients dying from the consequences of the disease. Due to the prolonged course of the disease and poor prognosis, cancer often has serious psycho-social and socio-economic consequences. Hence, cancer research aims to gain a better understanding of the biology of tumour cells, to unveil the genetic basis of the disease and to identify cancer risk factors. The programme focuses on the development of innovative diagnostic techniques and therapeutic treatments based on molecular, cell biological, immunological and radiophysical insights and technologies. The impact of the immune system in cancer and the analysis of the causality of infections and cancer are central to the research programme. Medical engineering also plays a key role in the cancer research programme, above all by developing new imaging methods and strategies for radiation therapy, which allow more precise diagnosis and therapy, as well as early detection and disease prevention. The market introduction of a prophylactic vaccine against human papillomaviruses (HPV), which can cause cervical cancer, is an outstanding example of successful research transfer. In 2008, Prof. Dr. Harald zur Hausen from the German Cancer Research Center was acknowledged for his discovery with the Nobel Prize in Medicine.

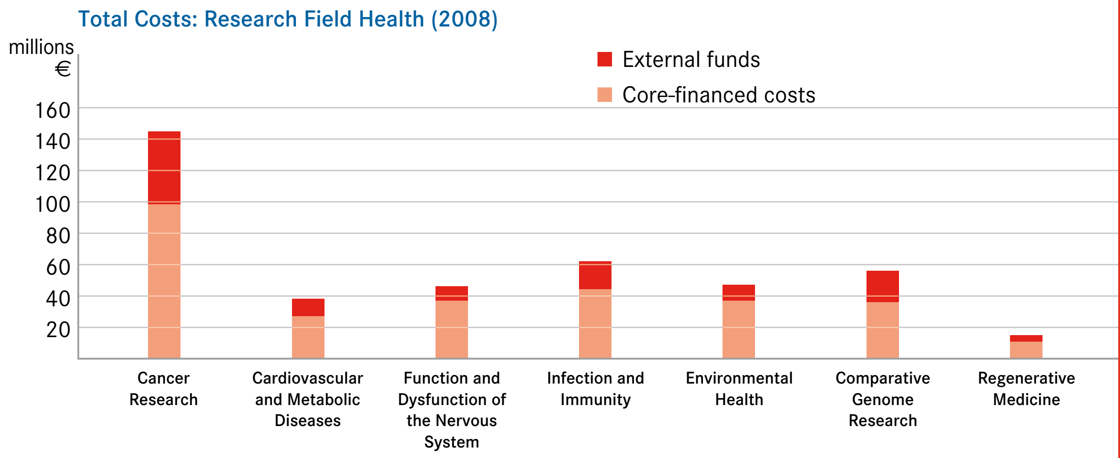
Cardiovascular and Metabolic Diseases

Cardiovascular diseases are the most common cause of death in western industrial countries. Major risk factors are high blood pressure, diabetes, increased blood fats, tobacco consumption and obesity. These diseases are a tremendous burden on the public health system. To reduce the incidence of these diseases in the long-term, scientists study causes of vascular diseases and high blood pressure, heart and kidney disease, and metabolic diseases, such as diabetes and adiposity. In addition, new ways of preventing, diagnosing and treating such illnesses are being developed. To achieve these goals, researchers use various methodological approaches from genetics, genomics and systems biology, cell biology, and epidemiology.

Function and Dysfunction of the Nervous System

Longer life expectancy increases the risk of neurological and psychiatric illnesses. Neurosciences research at the Helmholtz Association deepens the knowledge of the causes. In the first round of programme-oriented funding, research focused on degenerative diseases of the central nervous system, such as Parkinson's or Alzheimer's disease, as well as epilepsy, brain tumours or cognitive impairments following strokes. To analyse the relevant underlying mechanisms, it is necessary to look closely at single biomolecules and cells, but also to examine the neural system as a whole. Scientists use state-of-the-art non-invasive imaging devices to investigate normal and pathophysiological mechanisms in living human brains, e.g. magnetic resonance imaging (MRI) positron emission tomography (PET) and magneto-encephalography (MEG), as well as genomics, cell biology and appropriate animal models.

*The first Funding Period in the Research Field Health began in 2003; it was extended by one year up to 2008.



Infection and Immunity

More than 17 million people worldwide die of infectious diseases every year – that accounts for one third of all deaths. International mobility causes pathogens to spread faster than in the past. In view of the growing threat posed by infectious diseases, researchers are studying the molecular and cellular processes occurring in the course of an infection to understand how and why specific pathogens trigger symptoms. Working in parallel they study the development of immunity, the fundamental mechanisms used by host organisms to prevent or control infections. These findings enable them to come up with new strategies for combating infectious diseases and to develop effective immunotherapeutic agents for treating other chronic diseases, such as autoimmune disorders and cancer.

Environmental Health

How strongly do environmental factors affect human health? What molecular and cellular mechanisms underlie these disorders, and what role does genetic disposition play? What new preventative and therapeutic strategies can we derive from this? Answering questions like these is the responsibility of this research programme. The research focuses on common diseases, such as inflammations of the respiratory tract, allergies and cancer, whose development is substantially influenced by environmental toxins, such as particulate air-borne pollutants (aerosols), chemicals and ionising radiation. The scientists take two approaches. On the one hand, they identify the toxic agent and analyse its disease-triggering mechanism to develop strategies for risk assessment and risk reduction. On the other hand, they examine mechanisms of disease genesis to evaluate the role that environmental factors play here.

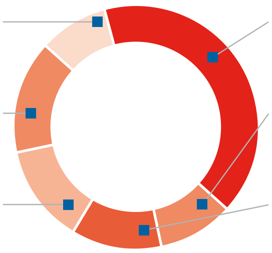
Comparative Genome Research

Comparative Genome Research opens up new insights into the conditions of human health and disease at genetic and cellular level. To explain the molecular causes of diseases, scientists initially decipher genetic programmes of model organisms, such as the mouse, and apply their findings to analogous mechanisms in the human genome. Proteome research complements the information acquired on the genetic components of diseases by feeding in information on gene products, the proteins, and their intercellular, disease-relevant interactions. Scientists from this programme contribute significantly to the National Genome Research Network.

Regenerative Medicine

In light of the demographic development, regenerative medicine is becoming ever more important in the therapy of age-typical diseases. In this programme, scientists developed materials, procedures and systems for use in tissue engineering and organ replacement systems, which can support or even replace diseased organs. Furthermore, researchers are ambitiously attempting to improve the interface between technology and organism, for instance to re-establish sensory functions through neural coupling when wearing an artificial hand.

Structure of the Research Field Health
Core-financed Costs Plan 2010*: 339m euros
(including non-programme-bound research)



*Second year of the new Programme Funding Period 2009–2013

THE PROGRAMMES
IN THE FUNDING PERIOD 2009–2013

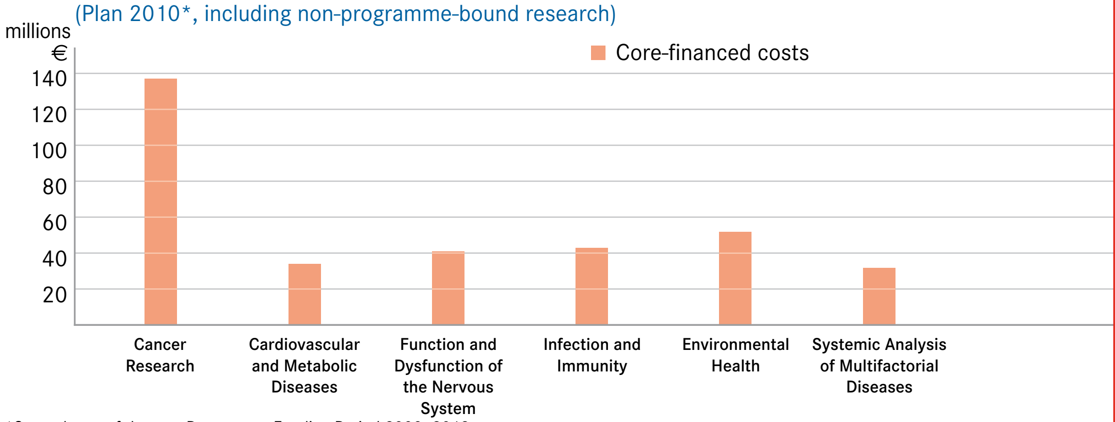
The programmes and participating centres underwent a strategic-scientific evaluation at the beginning of 2008. Planned research goals and appropriate strategies for the successful implementation of the individual programmes were presented to high-ranking, international review panels for critical assessment.
In the second period of programme-oriented funding beginning in 2009, research will build on three pillars: Excellent basic research; Analysis of complex biological systems (Systems Biology); and Translation of research findings into clinical application. The structure and goals of the Helmholtz Health Field were jointly reassessed, focused and largely tailored to the work and objectives of the leading Helmholtz research centre. Hence, interactions with partners from medical school are of particular importance in translational research and will be implemented in jointly established Translation Centres.

- Cancer Research
- Cardiovascular and Metabolic Diseases
- Function and Dysfunction of the Nervous System
- Infection and Immunity
- Environmental Health
- Systemic Analysis of Multifactorial Diseases

Nine Helmholtz Centres are collaborating in these programmes in the current funding period: The Helmholtz Centre for Infection Research, German Cancer Research Center, Forschungszentrum Jülich, GKSS Research Centre Geesthacht, Helmholtz Zentrum München – German Research Center for Environmental Health, GSI Helmholtz Centre for Heavy Ion Research, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch, Helmholtz Centre for Environmental Research – UFZ and German Centre for Neurodegenerative Diseases.

New programme-specific priorities:
The key priorities to be addressed intensively in the individual programmes include:
- in the field of cancer research, the development of test methods that provide information on the patients' responsiveness to certain forms of therapy and their chances of recovery (predictive methods for personalised therapy); advancement of innovative radiation methods for tumour treatment, such as heavy-ion therapy, and the relevance of stem cells in cancer development and progression;
- in the field of cardiovascular research, the analysis of frequently occurring metabolic malfunctions and their impact in the development of cardiovascular diseases;
- in the field of diseases of the nervous system, the analysis of the underlying molecular, cellular and systemic processes; moreover, the development of novel imaging methods, such as MRI/PET technology for the simultaneous analysis of anatomical and functional details of organs and their testing in clinical studies;
- in the field of infection research, the intensified study of zoonoses, meaning viral or bacterial diseases, which can be transferred from animals to humans (for example SARS);

Core-financed Costs of the Research Field Health
(Plan 2010*, including non-programme-bound research)



*Second year of the new Programme Funding Period 2009–2013

- in the field of environmental diseases, the field of inflammatory diseases caused by environmental factors (for example, nanoparticles) and therapeutic measures gained from these insights; furthermore, strengthening basic research on chemical modifications of the human genome and the associated changes in genetic control;
- in the field of analysis of multifactorial diseases, the development and characterisation of suitable animal models to gain a better understanding of the complex molecular changes during disease progression.

Strategic cross-programme initiatives

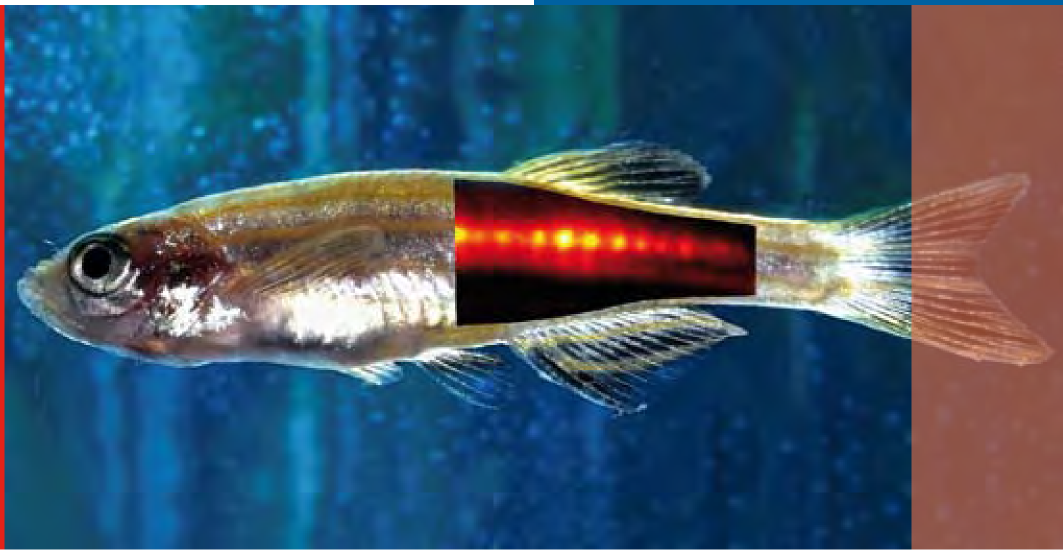
To be able to respond as quickly as possible to new developments, a flexible system of cross-cutting activities was created to contribute to the collaborative further development of important resources and technologies. These include systems biology, imaging techniques, regenerative medicine and disease models. The Research Field Health launched initiatives in two research policy and strategically significant subject areas: firstly, epidemiology and secondly, translational research.

Epidemiology and Preventive Medicine: The Helmholtz Cohort

Most chronic human diseases are typically diagnosed at a late stage, when the consequences of a disease are irreversible and possibly fatal. To meet this challenge, all Helmholtz Health Centres will expand their competence in the field of epidemiology. Epidemiological research aims to identify both the genetic and the environmental risk factors so as to prevent diseases or to detect and treat these at an early stage.
To create a unique national resource for future epidemiological research, Helmholtz Health Research has taken the first step towards establishing a major, prospective cohort study ("Helmholtz Cohort") in Germany. This long-term study will examine healthy individuals for clinical parameters as well as their habits at the time of recruitment, and will subsequently monitor them over a period of 15 to 20 years. The following Centres are participating in the initiative alongside university partners: German Cancer Research Center, Helmholtz Zentrum München, Max Delbrueck Center (MDC) Berlin-Buch, Helmholtz Centre for Infection Research, German Centre for Neurodegenerative Diseases, and Forschungszentrum Jülich.

Expanding Translational Research

Translational health research is another cross-programme priority. This comprises all projects jointly tackled by basic researchers and clinical scientists to transfer highly-promising approaches as quickly as possible into clinical application. Five Helmholtz Centres are currently establishing local Translation Centres in cooperation with university hospitals to significantly accelerate the process. The formation of strategic alliances with partners from the pharmaceutical industry, biotechnology and medical technology considerably reinforced the expertise in this field. The Helmholtz Health Centres' declared goal is to take a leading national and international role in this field. Health Research will also create joint standards to train young scientists and improve career development prospects to offer excellent researchers attractive working conditions in national and international health research.



PROJECTS

Helmholtz Zentrum München –
German Research Center for Environmental Health

MELODIOUS MICROSCOPE

Researchers at the Helmholtz Zentrum München use laser flashes and ultrasonic signals to look into live tissue. Extremely short laser flashes penetrate the body of a zebra fish centimetre deep. The living organism responds with weak tones that the human ear cannot perceive. A sensitive microphone reliably records the ultrasonic sounds. This sound pattern contains all kinds of information that the team headed by Professor Dr. Vasilis Ntziachristos, Director of the Institute for Biological and Medical Imaging at the Helmholtz Zentrum München can convert into three-dimensional, high resolution images from inside the fish's body.
"Our new method – Multispectral Opto-Acoustic Tomography (MSOT) – enables us to transcend the borders of light microscopy," says Laboratory Head, Dr. Daniel Razansky. For light waves are already strongly diffused just under the surface of the object, only allowing exterior views, at most.

"X-ray and ultrasound can only make structures visible, but not biochemical reactions."

Ultrasonic signals, on the other hand, are first generated deep in the living body and so allow a completely new insight, even into molecular processes. The advantage of opto-acoustic imaging differentiates it from classical imaging methods. "X-ray and ultrasound can only make structures visible, but not biochemical reactions," says Razansky. The researchers from Munich have already demonstrated this successfully in their experiments with threadworms, zebra fish and mice. Hence, they have been able to obtain novel 3D insights into the innards of a zebra fish. They did this by transmitting short laser flashes for just a few nanoseconds into a fish whose body contains fluorescent pigment molecules. The laser flashes light up the pigments. At the same time, however, these molecules become a little warmer and expand a little. "The rapid expansion of the pigments causes a small shock wave," explains Razansky. A microphone placed just a few centimetres above the fish's body picks this up as an ultrasonic wave. The three-dimensional image has a resolution of 40 micrometres.

"The method could provide a resolution of ten micrometres in the future in a depth of up to five centimetres."

The conversion of ultrasonic signals into image data was a particular challenge for the researchers. To pick the individual pixels out of the sound waves, they developed a complex mathematical algorithm. In countless tests, they learnt how soft and harder structures in the body distort the sound waves. Only then could a specifically designed computer programme interpret the measured sound data of unknown structures, such as those in the zebra fish. The Helmholtz scientists meanwhile have a better understanding of the connection between acoustic signal and body. "The method could achieve a resolution of ten micrometres in a depth of up to five centimetres," believes Razansky.
Ntziachristos and Razansky see many applications in medicine, in particular since recent years have seen numerous pigments approved for clinical use. In the future, the technology could facilitate the examination of tumours or coronary vessels in humans, for instance, the early recognition of breast cancer. And if the molecular effects of new cancer drugs are pursued over a longer period of time in an animal, this could accelerate the development of new drugs. Perhaps the effectiveness of cancer drugs could even be observed and assessed directly in the patient's body. Razansky can even imagine the early diagnosis of Alzheimer's.
Razansky believes initial clinical studies on patients using the MSOT method might even be feasible in around two years. Before then, they will still have to check numerous marker substances in addition to the already tested fluorescent pigments for suitability. These could circulate in the blood system for several days and help track down pathogenic processes. Docked onto cancer cells, they could make biochemical reactions visible during tumour growth via ultrasonic signals.

THE NEW MSOT METHOD ALLOWS INSIGHTS INTO CELLULAR PROCESSES IN LIVING ORGANISMS (HERE A ZEBRA FISH). PHOTO: HGMU, TU MÜNCHEN

To ensure that the method can also be used by physicians in the future, the research group has already designed a prototype for a hand-held MSOT probe that focuses the laser flashes on a specific region of the body and can capture the resulting sound waves. Even the strict Review Consortium of the European Research Council (ERC) was impressed by the potential for biomedical imaging and awarded Ntziachristos an ERC grant worth two million euros at the end of 2008. Medical engineering and technology companies are already showing an interest so that MSOT prototypes could quickly lead to a marketable light-sound microscope for research, hospitals or the pharmaceuticals industry. JAN OLIVER LÖFKEN

Forschungszentrum Jülich

THE PERFECT TEAM: MRI MEETS PET

Together with Siemens Healthcare, researchers from Jülich have developed a combined device comprising a 9.4 Tesla magnetic resonance imaging (MRI) scanner and a positron emission tomograph (PET). Using this hybrid system 9.4T MR-PET, also known as "9 komma4", they have been developing the machine since spring 2009 to be able to gain even clearer insights into the brain; the two imaging methods complement each other perfectly. The MRI scanner produces images with the highest resolution, while the PET scanner shows molecular processes taking place in the brain. The 20 million euro device was financed by the Federal Ministry of Education and Research and Siemens.

The magnetic field of 9.4 Tesla is up to six times higher than conventional devices and is almost 200,000 times stronger than the Earth's magnetic field. The "9komma4" with its high field strength can create images of the structures of the brain with a previously unattained resolution. Now it is possible to localise pathological tissue, such as a tumour, as well as metabolic disorders in the brain precisely down to a millimetre," says Prof. Dr. N. Jon Shah, Director of the Institute for Neuroscience and Medicine at the Forschungszentrum Jülich. This will clearly advance the study and early recognition of neurodegenerative diseases such as epilepsy, stroke, dementia, Alzheimer's or multiple sclerosis.

"The combined device makes it possible to localise pathological tissue and metabolic disorders of the brain precisely down to a millimetre."

In cases of multiple sclerosis or even tumours or strokes, water accumulates around the pathological tissue. Simultaneous measurement with MRI and PET has made it possible, for the very first time, to also compare changes in the biochemistry of the brain with changes in the water content. For cancer diagnosis, the researchers in Jülich are developing a special radionuclide for labelling tumours. The "9komma4" can then help to characterise the cancerous tissue before an operation. SI

PROF. DR. N. JON SHAH AND THE "9KOMMA4". Photo: Forschungszentrum Jülich

PICTURE LEFT: TUMOUR CELLS IN CELL GROUPS; PICTURE RIGHT: MODIFIED TUMOUR CELLS SEPARATING FROM EACH OTHER PHOTO: JOHANNES FRITZMANN, MDC

Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

TRACKING DOWN METASTASES

Most cancer patients do not die of the original tumour, but rather of the metastases. Hence, the worried question asked when cancer is diagnosed is: Will the tumour spread? As far as colon cancer is concerned, at least, this uncertainty may soon be a matter of the past. Cancer researchers at the Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch and the Charité Universitätsmedizin Berlin have identified several genes which could, in the future, make it possible to predict the course of the disease and lead to a more targeted therapy.

Patients suffering from colon cancer have a longer life expectancy when the activity of the metastasis gene MACC1 is at a low level.

Some 73,000 people contract colon cancer every year in Germany. Chemotherapy and radiation therapy manage to cure around half the patients. However, some 20 per cent of those affected already have metastases when they are diagnosed and in around a third of the cases metastases later develop despite the success of the first therapy. More than 25,000 die of colon cancer every year in Germany. It is the second most common cause of death among cancers, only second to lung cancer. This is why the aim is to recognise patients who have a high risk of developing life-threatening metastases in the liver, lung or lymph nodes at an early stage so that they can be more intensively treated and cared for. The cancer researchers at the MDC and Charité have moved a step closer to this goal. They discovered a gene that for the first time makes it possible to predict with a high probability the formation of metastases in colon cancer at an early stage. Then they soon found more than a hundred genes suspected of advancing the dangerous spread of colon cancer.

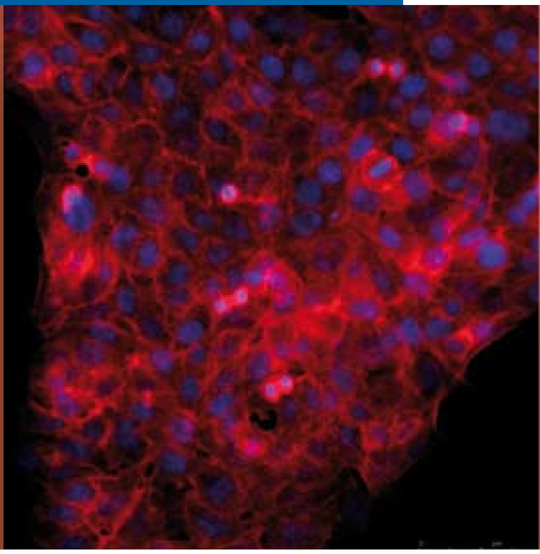
The first metastasis gene MACC1, discovered by Prof. Dr. Ulrike Stein, Prof. Dr. Peter M. Schlag and Prof. Dr. Walter Birchmeier, not only promotes cancer growth, but also the formation of metastases. "When MACC1 activates a certain signalling pathway, cancer cells can grow more quickly, can break away from their cell groups and can settle as metastases in organs located far away from the original tumour," explains Stein.

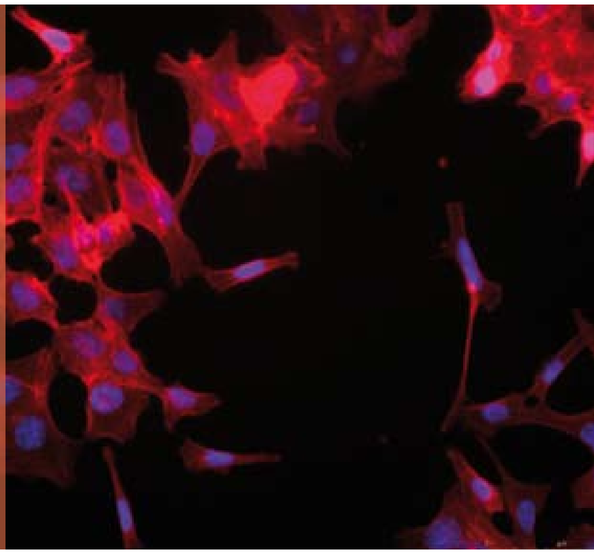
The researchers were able to show that patients suffering from colon cancer have a longer life expectancy if the activity level of the MACC1 is low. On the other hand, colon cancer patients with high MACC 1 levels have a much greater risk of metastasis and so a less favourable survival prognosis. The researchers tracked down the gene by comparing healthy tissue with the tissue samples of 103 colon cancer patients. Of these patients, 60 were free of metastases at the time of their operation. 37 were still free of metastases five years after the operation and therapy. When they were first diagnosed, they had low MACC 1 levels in the colon tumours. 23 patients, however, had developed metastases after five years. They had shown high MACC 1 levels in the tumour tissue. Whether the newly discovered metastasis gene also allows a more exact prediction of the course of other cancers is still an open question.

To see what genetic changes favour the formation of metastases, Dr. Johannes Fritzmann and his colleagues from the MDC and Charité examined 150 tissue samples from colon cancer patients with and without metastases.

"When MACC 1 activates a certain signalling pathway, cancer cells can grow more quickly and can settle as metastases in organs located far away from the original tumour."

They identified 115 genes that have mutated both in the primary tumour as well as in the metastases that it formed and so discovered a genetic signature that differentiates between metastatic and non-metastatic tumours. The researchers examined one of the 115 genes in closer detail and discovered that one gene, called BAMBI, is more active in metastatic tumours and metastases than in tumours that do not form any metastases. BAMBI connects two important signal-





ling pathways and so promotes the formation of metastases. The cancer researchers hope that their results will contribute to indicating at an early stage whether a tumour will spread or not. Then the physicians could decide whether a patient requires a more intensive therapy or whether the patient can be spared from this. BARABARA BACHTLER

Helmholtz Zentrum München /
German Cancer Research Center

WHO STAYS HEALTHY?

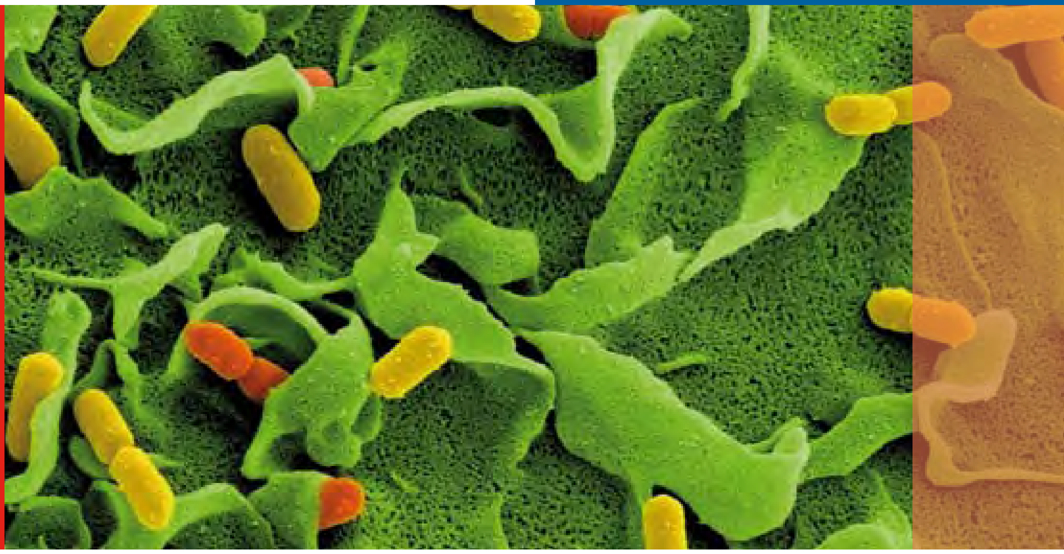
The Helmholtz Cohort will be the largest nationwide population study ever to be held in Germany, with a total of 200,000 study participants. Its aim is to gain new insights into the causes of common multifactorial diseases, such as cancer, diabetes, dementias and cardiovascular diseases. Prof. Dr. Dr. H.-Erich Wichmann from the Helmholtz Center Munich and Prof. Dr. Rudolf Kaaks from the German Cancer Research Center are the scientific coordinators of this major project.

> "With this large-scale cohort study we want to find out what risk factors are responsible for the development of diseases, and how great their impact actually is."

At the start of the examination period, the participants in the Helmholtz Cohort have to be at least 20 years old and healthy. Over a period of ten to twenty years, they will be invited to undergo regular medical examinations and will, inter alia, be asked about their living habits. Specially developed questionnaires are used for this, for example, on the topics of personality, lifestyle, stress, nutrition, physical activity, use of medications and socioeconomic status.
Regular blood samples will also be taken and stored in a biobank, and modern imaging methods will be used as well. In the course of the examination period, some participants will develop diseases. The previously collected data will then be of inestimable value for tracking down the causes of disease development.

"In carrying out this large-scale cohort study we want to find out what risk factors are responsible, from an epidemiological perspective, for the development of diseases, and how great their impact actually is. With this knowledge, we could open up new future paths for prevention and early detection of disease," says Rudolf Kaaks.
The three-year planning and pilot phase began in early 2009. Questionnaires are being developed, examination concepts drawn up, data collection methods and paths for recruiting subjects tested and collaborative survey partners recruited in order to be able collect and analyse the data. After the three-year planning period, the process of recruiting the Helmholtz Cohort will begin. SI

RISK FACTORS FOR THE MAJOR COMMON DISEASES ARE TO BE IDENTIFIED IN THE NEW COHORT STUDY. Photo: Helmholtz Association/A. Spicker



Helmholtz Centre for Infection Research

FAR-REACHING CHANGES TO INVASION PROTEIN

Pathogens and the organisms they infect are engaged in a constant evolutionary contest: The hosts build up cellular and molecular defence lines, while pathogens continuously refine their invasion methods. To bind precisely to the corresponding structures on their host cells, pathogens often carry distinct modules on their surface. Changes to those docking modules enable them to infect new host species. This can lead to disastrous consequences when animal pathogens become human pathogens: The Plague, Spanish Influenza, and AIDS developed like this. Today, the whole world closely monitors new pathogens when they arise for signs of cross-species contamination potential.

> "We wanted to produce lab mice which can be infected with Listeria monocytogenes, the bacterium responsible for the disease listeriosis. Usually, mice are immune to this disease"

Structural biologists, headed by Prof. Dirk Heinz at the Helmholtz Centre for Infection Research in Braunschweig are studying the molecular interaction between the docking proteins of pathogens and their hosts. For the first time, they succeeded in emulating the change process of a pathogen that normally takes place spontaneously in nature, and thus changing the host spectrum of the pathogen. "We wanted to produce lab mice which can be infected with Listeria monocytogenes, the bacterium responsible for the disease listeriosis. Usually, mice are immune to this disease," says Dr. Wolf-Dieter Schubert, head of the research group „Molecular Host-Pathogen Interactions". "Because we use mice for research, this will be necessary to develop and test new drugs against listeriosis." The pathogen enters the human body via contaminated food and leads to severe – often fatal – illnesses in immunocompromised people. With the help of its invasion protein internalin A, the pathogen binds the protein E-cadherin on the surface of human intestinal wall. This binding initiates the invasion of the bacterium. In mice, this process does not work since internalin A cannot bind to murine E-cadherin. The structural biologists from Braunschweig wanted to change that by altering the binding region of internalin A in such a way that it can also bind the mouse receptor protein.

Their studies took them into the microscopic world of molecules and atoms, where measurements are made in Ångstrom – one ten millionth of a millimetre. This high resolution is necessary to determine the spatial arrangement of atoms of the amino acids, i.e. those building blocks that provide a protein with both structure and function. The question was: Which amino acids are necessary for the binding of the docking modules and which block this interaction? Powerful particle accelerators found at the DESY or BESSY synchrotrons in the Helmholtz Association and capable of a targeted high performance X-ray structural analysis can give the necessary answers.

At first, Heinz and his co-workers analyzed the crystal structures of the single internalin A molecule and of its complex bound to human E-cadherin. These analyses gave a clear picture of the interaction between the binding modules. "Consequently, we could extrapolate changes to optimise the binding – without having to revert to using computer simulations or randomly generated mutants," says Schubert. A substitution of only two out of more than 500 amino acids in the docking module of the internalin should be sufficient.

> "Such small changes like this also take place in nature and can lead to dangerous zoonoses such as SARS or swine flu."

In the next step, the researchers generated an internalin A variant in which those two amino acids have been replaced by others. This modified protein now binds to the murine E-cadherin almost as well as the native protein binds to the human E-cadherin. Finally, in the key biological experiment, the researchers applied the genetically changed Listeria bacteria carrying the modified internalin A on their surface to mice. Remarkably,

INVASION OF *LISTERIA MONOCYTOGENES* IN HUMAN DENDRITIC CELLS. PHOTO: DR. MANFRED ROHDE, HZI

the pathogen now was able to infect the epithelial cells of the small bowel of the mouse. It is the assumption that they would spread similarly from there, as they do in humans. Currently, Listeria with modified internalin are used for the development of new therapies against listeriosis. The structural biologists from Braunschweig, together with cooperation partners, are following new approaches that have arisen from their work on Listeria.

Their findings can also lead to the development of so-called bacterial ferries: targeted stimulation of the immune system within an organism using antigens – effectively 'vaccination with a pill'. "In Listeria, small changes in a single invasion protein were sufficient to broaden the potential host spectrum," says Heinz. "Such small changes like this also take place in nature and can lead to dangerous zoonoses such as SARS or swine flu." HELMUTH PROKOPH

Max Delbrueck Center Molecular Medicine (MDC) Berlin-Buch

REGULATORS OF (STEM) CELL BIOLOGY

It has been known for several years now that microRNAs play an important role in gene regulation. They co-determine which proteins are produced in a cell. If this regulation is out of synch, metabolic diseases, cancer or neurodegenerative diseases, for example, can develop. The research groups headed by Dr. Matthias Selbach and Prof. Dr. Nikolaus Rajewsky from the MDC were now able to show that a single microRNA can control the formation of hundreds of proteins. "MicroRNAs turn many switches, but most of them only slightly. This can completely change the fate of a cell," says Selbach. Nikolaus Rajewsky's research team, along with colleagues from Canada and the United States, was able to prove that microRNAs also play a role in stem cell biology in a study using flatworms. The flatworms, or planaria, have the extraordinary ability to produce a completely new viable animal from a separated part of the body. This is possible thanks to its stem cells, which account for 30 per cent of its body cells.

"MicroRNAs turn many switches, but most of them only slightly. This can completely change the fate of a cell."

"Some of the microRNAs associated with stem cells in flatworms also exist in humans. The study of microRNAs in flatworms could therefore provide insights into stem cell biology and the regeneration mechanisms of humans," says Rajewsky.

These results from the MDC are possibly of great importance for ongoing research since microRNAs have a great potential for diagnosis and therapy of various diseases. SI

THE FLATWORM SCHMIDTEA MEDITERRANEA IS A POPULAR OBJECT OF STUDY IN STEM CELL RESEARCH. 30 PER CENT OF ITS BODY CELLS ARE STEM CELLS. PHOTO: MDC

PROF. ANDREAS TRUMPP AND DR. MARIEKE ESSERS TRACKING DOWN STEM CELLS WITH A FLOW CYTOMETER. PHOTO: VOLKER STEGER, DKFZ

German Cancer Research Center

CANCER STEM CELLS IN THEIR SIGHTS

Stem cell research can help to develop new cancer therapies. A new research field at the German Cancer Research Center (DKFZ) in Heidelberg builds on this context. Professor Dr. Andreas Trumpp is Head of the Department for Stem Cells and Cancer and is Managing Director of the Heidelberg Institute for Stem Cell Technology and Experimental Medicine (HI-STEM) founded in 2008, which aims to combine basic stem cell research with applied research and development activities. Trumpp and his staff are now testing a new therapy concept in a clinical study with leukaemia patients that specifically targets cancer stem cells.

"The most potent of these cancer stem cells are in a kind of deep sleep and so survive, since radiation or chemotherapy only kill off those cells that actively divide."

According to the cancer stem cell hypothesis, a tumour is mainly made up of growing cancer cells which can generally be destroyed quickly by means of chemotherapy drugs or radiation. By contrast, cancer stem cells from which the tumour originated are much more resilient. These form by mutating from normal stem cells or mature body cells and often account for less than one per cent of all the cancer cells. "The most potent of these cancer stem cells are in a kind of deep sleep," says Andreas Trumpp. In this resting phase, they survive the cancer therapy, since radiation or chemotherapy only kill off those cells that actively divide. Months or even years later, single surviving cancer stem cells might become reactivated and cause tumour relapse and progression to form metastases. Trumpp and his staff are working on how to wake up sleeping cancer stem cells, i.e. stimulating their cell division to sensitize them for chemotherapy-mediated killing. In the search for a suitable wake-up signal, the researchers made an important discovery. They were able to prove that dormant, blood forming stem cells in the bone marrow of mice respond to the immune signalling molecule interferon alpha with a strikingly increased division rate. This indicated that the same signal might also activate the sleeping, malignant blood stem cells of certain leukaemia patients.

This led to a collaboration with the group headed by Prof. Dr. Andreas Hochhaus from the University Hospital in Jena, who is examining the effectiveness of various therapies in patients affected by chronic myeloid leukaemia (CML). A class of highly efficacious drugs, so-called tyrosine kinase inhibitors (TKIs), is available for this type of cancer, which is caused by a specific mutation within blood-forming stem cells. These inhibitors block specifically the reproduction of these cancer cells without harming normal cells. While in the majority of patients the leukaemia virtually disappears, the TKIs have to be taken life long since after stopping of TKIs, the leukaemia reappears relatively quickly. This suggests that in contrast to normal leukaemic cells, leukaemia stem cells are resistant to TKIs. Interestingly, in some patients, who had been previously been treated with interferon alpha, which was the treatment of choice before the new TKIs were introduced in 2001, the leukaemia did not return after the TKIs were stopped. Results from Trumpp's research group now suggest that interferon alpha may have activated the resting leukaemic stem cells in CML patients and therefore made them vulnerable for the subsequent TKI therapy.

The researchers now want to verify this suspicion in a clinical study with the German CML Study Group. This will involve patients who will receive a short pulse of highly-dosed interferon alpha followed by the standard therapy with the TKIs Imatinib or Dasatinib. Blood and bone marrow samples are taken in the course of the study to examine whether the additional interferon treatment has led to a quicker decline in the number of both, leukaemic cells in general and leukaemic stem cells in particular. Patients who achieve complete molecular remission and who then remain cancer-free after a number of years after stopping treatment with TKIs would be viewed as cured. This would be one of the first cancer therapies to be based on the specifically targeted activation and destruction of cancer stem

cells. We are examining whether interferon alpha could also affect other forms of cancer," says Andreas Trumpp. In principle, each cell possesses receptors for this signalling substance, so, possibly any cancer stem cells could be activated by this strategy. On the other hand, CML might be a special form of cancer for which both the waking signal for the leukaemic stem cells as well as an effective, specifically targeted chemotherapy is available, notes Hochhaus. It may however be possible that – by using various tumour-specific drugs – the principle of "first awakening and then killing" could be applied to a whole series of cancer diseases in the future. JOACHIM CZICHOS

Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

T-CELLS HELP DAMAGED MOUSE HEARTS

High blood pressure leads to cardiac damage and heart rhythm disorders (arrhythmias) and thereby can cause structural heart disease. The hormone angiotensin II plays a decisive role in this process. Besides its direct effect on the vascular system and the heart, angiotensin II also causes inflammation and can activate the immune system. Activated inflammatory cells, T lymphocytes, and macrophages, are all suspected of being involved in disease processes triggered by angiotensin II.

> "These experiments have given us new insights into the role that the immune system plays in the development of cardiac damage through high blood pressure."

The team headed by Dr. Dominik Müller and Dr. Heda Kvakan from the "Experimental and Clinical Research Center" (ECRC) at the MDC and from the Helios Clinic in Berlin-Buch examined this issue. In their experiments with mice, the researchers suppressed the immune system by administering regulatory T cells. This recently discovered lymphocyte class is capable of maintaining the immune system in equilibrium.

"As a result, the cardiac damage in the animals largely failed to occur, the development of fibrosis was avoided, and the generation of arrhythmias was suppressed," explains Heda Kvakan. The regulatory – or suppressor – T cells managed to bring the inflammatory cells under control. Thus, an excessive immune reaction generated by angiotensin II was suppressed and damage to the heart could be avoided. "These experiments have given us new insights into the role that the immune system plays in the development of cardiac damage through high blood pressure. However, experimental therapy with regulatory T cells is not new. Immunologist and cancer specialists have focused on regulatory T cells earlier. "We still do not know what side effects therapeutic suppression of the immune system by the regulatory T cells could have," says Dominik Müller. "Thus, we cannot tell the patients to take a billion or so regulatory T cells and call me in the morning," he adds. Effective therapies for high blood pressure already exist today. The future will show to what extent regulatory T cells could possibly be considered as a therapy. More important is the recognition that hypertension influences immunity and that the immune responses can be brought under control. SI

THE CARDIAC DAMAGE IN MICE WAS REDUCED AFTER THE INFLAMMATORY PROCESSES HAD BEEN SUPPRESSED. Photo: MDC

RESEARCH FIELD KEY TECHNOLOGIES

PROF. DR. ACHIM BACHEM
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Key Technologies,
Forschungszentrum Jülich

GOALS AND ROLES

In the Research Field Key Technologies, scientists from the Helmholtz Association are working together on generic technologies that promise new methods and innovative solutions for the grand challenges facing society. These grand challenges are also addressed in the various research areas of the Helmholtz Association. In addition, scientists are focusing on technologies that could benefit from the Research Field's large-scale infrastructure, thereby reaching the industrial application stage even faster. This includes work in areas such as nanoelectronics, nanotechnology, quantum technology, microsystems technology, technologies at the interface between biology and physics, advanced engineering materials and supercomputing. Supercomputers have become the third pillar of scientific research alongside theory and experiment. They allow complex systems to be simulated and hypotheses to be tested, providing us with new insights into the hidden realms of reality. Novel materials with tailor-made properties make it possible to develop innovative products, such as storage media with increased capacities, energy-saving lightweight materials for vehicles, and biocompatible implants for medical applications. In areas where application potential has been identified, research is intensified until the innovations are ready for use in specific applications. Technological advances and pioneering innovations are set in motion by basic research and creative work. Nobel Laureate Peter Grünberg and his GMR effect are a good example of how the results of groundbreaking research can be transferred to future key technologies and lead to innovative products of high economic and industrial relevance within a timeframe of 10 to 15 years. The Helmholtz Centres in Jülich, Karlsruhe and Geesthacht are pooling their broad-based expertise and interdisciplinary potential to lay the foundation for the next generation of key technologies. A high potential for innovation has been identified at the interfaces between disciplines – involving physics, chemistry, materials science, the life sciences and nanotechnology. This potential can be exploited on several levels (atomic, molecular, nanometre and micrometre) and is strongly supported by modelling and simulation. Helmholtz-specific technology platforms cooperate closely on this with selected universities. They function as focal points for a broad user community made up of universities and industry. As a large-scale facility with high visibility, the petascale European Supercomputing Centre at Jülich will be firmly established as part of the German Gauss Centre for Supercomputing and as an architect of the Partnership for Advanced Computing in Europe (PRACE). It will be made available to all scientific research communities in Europe.

With this move, the Research Field contributes decisively to the High-Tech Strategy for Germany, particularly in the areas of "Innovations for a communicative and mobile life: nanotechnology, microsystems technology, optical technologies and materials technologies" as well as "Innovations though generic technologies: information and communications technologies". The Research Field sets the pace for innovation and develops these fields of the future, which will secure Germany's leading position and consolidate its economic strength.

Research on the next generation of generic key technologies is built upon a broad scientific basis. This allows the potential advantages to be identified and the opportunities and risks for society to be evaluated. Part of this process involves taking our partnerships with universities to a whole new level. The recently founded Karlsruhe Institute of Technology (KIT) and the Jülich-Aachen Research Alliance (JARA) are interesting examples of such new long-term partnerships on very different scales.

The Research Field Key Technologies was evaluated at the beginning of 2009 within the scope of the Helmholtz Association's programme-oriented funding. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field during the period under report up to the end of 2009 and presents the new research programmes that form the strategic focus of the Research Field for the coming five years. The previous and the new structures are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as from 2010. With effect of 2010, all six research fields will be in the second funding period.

PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2005–2009

Three Helmholtz Centres cooperate in the Research Field Key Technologies: Forschungszentrum Jülich, Forschungszentrum Karlsruhe, which merged with the University of Karlsruhe on 1 October 2009 to form the Karlsruhe Institute of Technology (KIT), and GKSS Research Centre Geesthacht. The Research Field also fulfils an interdisciplinary function in its supercomputing programme, providing computing capacities and specialised support for complex research questions to users from the different disciplines – from climate research and biology to material design. Furthermore, this Research Field is responsible for materials research in the Helmholtz Association, which is problem-driven in the various Research Fields. The scientists work on the following four programmes:

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

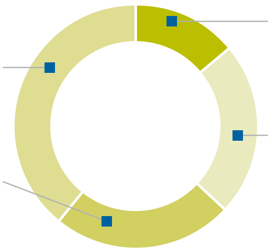
This work is characterised by close cooperation with industry and by the coordination of networks linking research institutions and commercial enterprises. The Research Field unites the common interests of science and industry and acts in a concerted manner within the European Union and on the international stage. The scientists involved also liaise with companies and associations, and provide information for political decision makers on the opportunities and risks associated with new technologies. Wherever existing competencies complement each other, this synergy is exploited for cross-programme cooperations. One example is molecular electronics, which has been established at the interface between information technology and nanotechnology at Jülich and Karlsruhe. The Research Fields Energy, Aeronautics, Space and Transport, Health, and Earth and Environment also benefit from work on the key technologies.

"For me, one of the most exciting developments is the increasing tendency of universities and large-scale research institutions to join forces in the form of strategic cooperations. By working together, appropriate research infrastructures can be created, questions of the future can be addressed, and fundamental insights can be gained. All in all, it creates an environment in which we – and hopefully many young people – will be inspired to address the big questions and pursue great research."

PROF. DR. KATHARINA KOHSE-HÖINGHAUS
Senator of the Helmholtz Association, Faculty of Chemistry, University of Bielefeld

Structure of the Research Field Key Technologies
Core-financed Costs 2008: 112m euros

The Research Field Key Technologies additionally received 35m euros of external funds, providing it with a total budget of 147m euros.



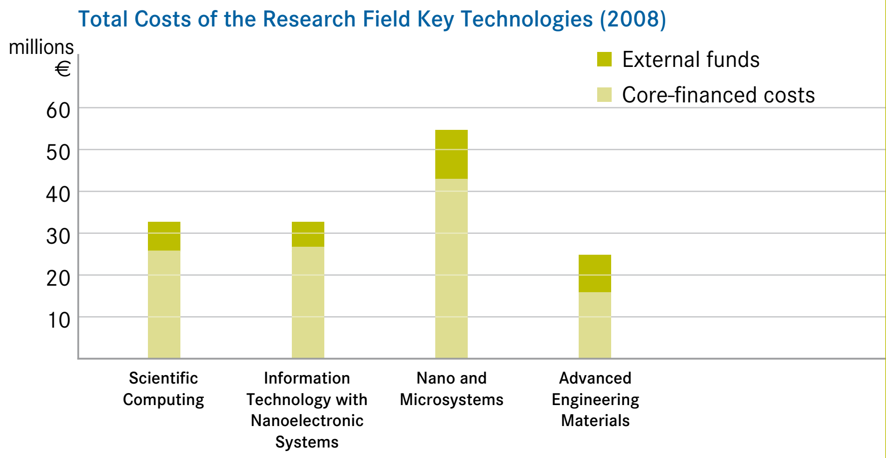
THE PROGRAMMES
IN THE FUNDING PERIOD 2005–2009

Scientific Computing

The processing of large volumes of data and the modelling of complex systems are important tools for research. By focusing on supercomputing and grid computing, this programme provides science in Germany with indispensable infrastructures. At the John von Neumann Institute for Computing in Jülich and the Grid Computing Centre Karlsruhe, experts work on improving methods, tools and application development, and provide support for numerous internal and external users from other research fields and institutions. This research programme also aims to construct and operate the latest and most powerful generation of supercomputers. Making sense of the growing floods of data supplied by accelerators and satellites poses a special challenge. The concept of grid computing, whereby computers are networked to form clusters, allows increasing volumes of data to be analysed.

Information Technology with Nanoelectronic Systems

Semiconductor components are becoming smaller and smaller but they have yet to reach the limits of miniaturisation. Research in this programme anticipates industrial development and explores quantum electronic, magnetoelectronic, ferroelectric, redox-switching and molecular nanostructures. Ultra-high-frequency electronics and bioelectrical signal processing are also part of this programme. The scientists perform basic research on materials and the processes that take place within them. They explore information processing in logic devices, the storage of information in random access memories and mass memories, the transfer of information on the chip and system level, and they also develop new sensors.



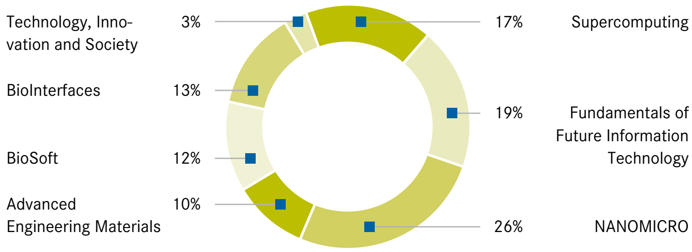
Nano and Microsystems

While microsystems technology is already very close to the application stage, nanotechnology still requires extensive basic research. In this programme, new functional microsystems structures made from plastics, metals or ceramics are developed and the application potential of nanostructured materials is examined. Components are developed for micro-optics, micro-process engineering, gas analysis, microfluidics and the life sciences – usually in cooperation with industry. In the case of nanstructured systems, the most important processes are investigated and materials with new properties are developed. Nanofabrication plants will emerge at the interface between micro- and nanotechnologies, making it possible to manufacture nanostructured systems with tailor-made properties on an industrial scale. For the first time ever, researchers at the Forschungszentrum Karlsruhe succeeded in directly observing the key steps in molecular self-organisation processes on the single-molecule level.

Advanced Engineering Materials

This programme develops novel metallic and functional polymer systems for application as lightweight materials in transport and energy technology, chemical process engineering, future hydrogen technology, and medical technology. Helmholtz scientists collaborate with national and international partners from science and industry on questions associated with alloy and polymer development and processing, as well as the development and testing of components and processes.
Breakthroughs have been achieved in materials development both in the synthesis of high-temperature titanium aluminides for high-performance turbines in aviation and energy generation, as well as in the development of novel magnesium recycling alloys for transport technology. The simulation of magnesium extrusion processes and the failure assessment of lightweight aluminium components using simulation techniques are two of the most successful areas in this research programme.

The Structure of the Research Field Key Technologies
Core-financed Costs Plan 2010*: 204m euros
(including non-programme-bound research)



*First year of the new Programme Funding Period 2010–2014

THE PROGRAMMES
IN THE FUNDING PERIOD 2010–2014

The Research Field Key Technologies conducted a comprehensive evaluation of its plans for the upcoming programme period using strategic and scientific criteria. In doing so, the Research Field repositioned itself and incorporated activities from the Research Fields Health and Structure of Matter. The "Condensed Matter" programme, for example, was transferred from the Research Field Structure of Matter and split between various programmes in the Research Field Key Technologies. The Research Field will be re-launched with six programmes on 1 January 2010. In addition, it will contribute to the "Technology, Innovation and Society" programme in cooperation with the Research Field Energy.

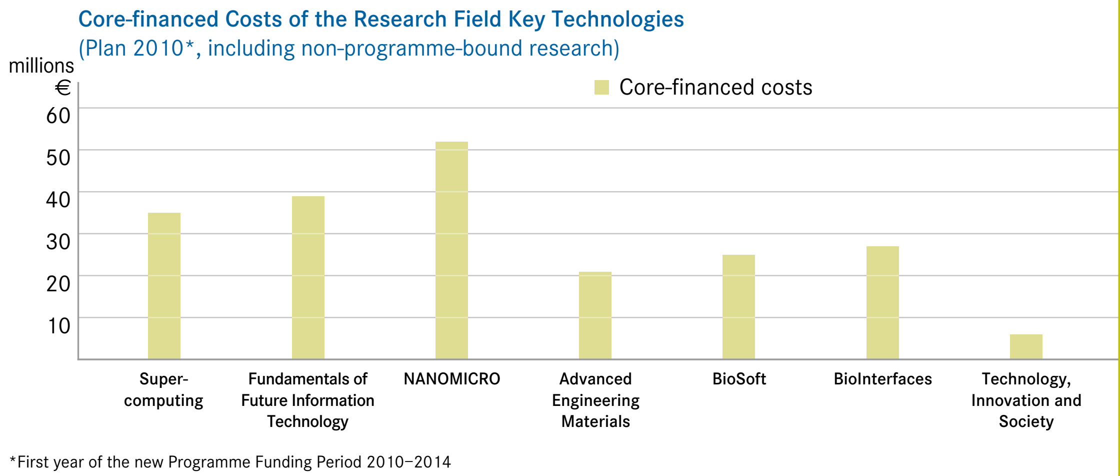
- Supercomputing
- Fundamentals of Future Information Technology
- NANOMICRO: Science, Technology, Systems
- Advanced Engineering Materials
- BioSoft: Macromolecular Systems and Biological Information Processing
- BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces
- Technology, Innovation and Society

Supercomputing
As the successor to the Scientific Computing programme, this programme consolidates the simulation laboratories and provides users from other research fields and institutions with even better access. Working together with the users, the algorithms are tailored to the high-performance computers at an early stage. At the end of May 2009, three new supercomputers went into operation at Forschungszentrum Jülich. All three were designed for research purposes in close cooperation with partners from industry: JUGENE, JUROPA and HPC-FF are now available for European research. With a performance of one petaflop, the JUGENE supercomputer was the fastest computer in Europe and the third fastest in the world at the time of its inauguration.

Fundamentals of Future Information Technology
This programme builds on the results of the former programme "Information Technology with Nanoelectronic Systems". It aims to develop new materials, components and functions for the computers of tomorrow. According to Moore's Law, the size of components on a chip will continue to shrink at a rapid pace. But how much smaller can these components actually become before they lose their physical functionality? In around 15 to 20 years, we will approach a characteristic size of 5 nanometres. According to what we know today, this represents the physical limit for conventional electronics. To go beyond this limit, researchers will have to exploit new phenomena and develop new concepts for components.

NANOMICRO: Science, Technology, Systems
The new programme combines microsystems technology and nanoscience with solid-state physics and chemistry. The broad scope of the programme ranges from knowledge-oriented research to systems that are ready for application. Driven by the fundamental questions of society, basic research findings are transferred directly to applications. Energy storage is one example of an area that was re-conceived and extremely positively evaluated. Work has now begun on all aspects of this topic. Nanomaterials and processes constitute the core of the programme, while optics and photonics are the emerging fields of application. The technical facilities central to the programme have been combined to form the Karlsruhe Nano Micro Facility, which is operated as a user facility for the scientific community as part of the Helmholtz infrastructure.

Advanced Engineering Materials
This programme continues the successful work pursued in the first programme period. The development of extremely light magnesium and titanium aluminide alloys as well as functionalised polymer materials for lightweight construc-



tion has been expanded to include the functionalisation of magnesium and titanium alloys for use in biocompatible implants. Research is conducted on material characterisation and simulation techniques from the microscale to the level of complex components. This delivers the theoretical principles for optimising fabrication processes and for evaluating the efficiency of innovative lightweight structures. Building on the Helmholtz Initiative FuncHy, work is conducted in collaboration with the Research Field Energy on functional materials for the storage of solid hydrogen in tank systems. The results will then be used, for example, in wind power stations or for solar energy, as well as for mobile tank systems in vehicles. Part of the programme involves the creation and expansion of research platforms such as the Magnesium Innovation Centre (MagIC) or the Lightweight Materials Assessment, Computing and Engineering Centre (ACE). These platforms pool expertise and infrastructure and make them available to external partners from research and industry. This constant exchange facilitates technology developments with a high degree of maturity, adding to the competitiveness of German industry.

BioSoft: Macromolecular Systems and Biological Information Processing

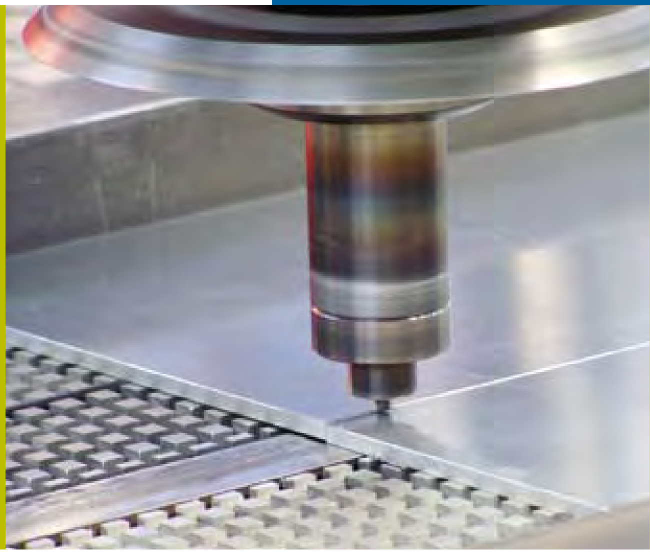
Fascinating research areas are currently emerging alongside new technological approaches at the interface between physics, chemistry and biology. In the area of soft matter, the properties of macromolecules and their cooperative behaviour are examined on length scales ranging from nano- to micrometres. The realisation that what appear to be the simplest of molecular machines often display a confusing complexity – and even more so the networks of genes and proteins in living cells – has brought about a radical change in the life sciences. This programme therefore aims to identify the complex structures and mechanisms that determine the behaviour of soft matter and biological systems. It will improve our understanding of both and thus facilitate the development of new materials and technologies. The programme combines soft matter research with structural biology and cell biophysics. It is based on the close interaction between experimental research and theory and the simulation sciences. With the EU Network of Excellence “Soft Matter Composites – A new approach to nanoscale multi-functional materials (SoftComp)”, which is coordinated by Forschungszentrum Jülich, the programme boasts a strong European dimension. Moreover, it offers broad interdisciplinary training for PhD students and young scientists within the framework of its International Helmholtz Research School “Biophysics and Soft Matter”.

BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces

The aim of biologists, chemists, physicists, IT specialists, engineers and mathematicians working on the BioInterfaces programme is to control living systems. Their primary focus is therefore on the smallest “living” units of a biological system – the cells, their cellular components, and the interfaces between the cells, between cells and their environment, and between molecules, such as proteins in signal cascades. The interfaces are logical relay stations that influence cell behaviour. The programme ranges from pure basic research right up to the development of application-oriented technologies and products.

Technology, Innovation and Society

This interdisciplinary programme is not confined to one Research Field. It investigates the ecological, economic, political, ethical and social aspects associated with new technologies and aids decisions in politics, industry and society. The emphasis in the Research Field Key Technologies is twofold: On the one hand, the focus is on the social expectations of science, sustainable development, and the knowledge society with its implications for social decision-making processes. On the other hand, opportunities and risks associated with key technologies are investigated, as are the factors that promote and inhibit innovations, particularly those in nanotechnology, information and communications technology, and neuroscience.



PROJECTS

GKSS Research Centre Geesthacht

PERFECT CONNECTIONS: IPSUS

The welding tool looks like a drill. Where the two materials to be welded meet, it plunges its elongated pin into the material and turns until its broad shoulder rotates on the material surface. The frictional heat causes the material to soften as it is stirred by the tool. The machine travels quickly along the interface of the two sheets. Behind, the material cools – and the welding seam is complete. Without additional filler material. However, the most important part remains hidden from the eye, namely the inner structure of the material in and around the joint. It decisively influences the material's characteristics and, hence, its performance.

Instead of, as in the past, subsequently examining samples under the microscope, the researchers now want to observe in-situ how the microstructure of the various materials transforms as the joint is made.

The researchers want to observe in-situ how the microstructure of the various materials transforms as the joint is made.

The Virtual Institute IPSUS was established in 2007 to observe in-situ metallurgical phenomena when joining. To achieve this goal the project leader Dr. Jorge dos Santos from the GKKS Research Centre in Geesthacht and partners from IPSUS have developed an array of joining and measurement instruments to be used at the synchrotron radiation source at the Helmholtz Centre DESY in Hamburg.

On the one hand, their insights will serve to optimise the joining process for each material: rotational speed, welding speed, axial force. On the other hand, and more importantly according to Jorge dos Santos, IPSUS also aims to support material developers. They can then directly design the alloys in such a way that they are weldable and so do not lose their excellent properties after fabrication. "Friction stir welding (FSW) has revolutionised production technology," says Jorge dos Santos. This method, developed in the 1990s, also makes it possible to joint materials that were previously difficult or even impossible to weld. Aluminium alloys, for example, magnesium, or special steels. "The future belongs to these materials," believes the scientist. For they form the basis of the lightweight engineering sector in aircraft, motor vehicles, and in the case of ODS steels would even be suitable for fusion reactors – if they can at some stage be jointed reliably and without any loss of quality. The decisive advantage of friction stir welding is provided by the low process temperatures. This ensures that no fluid phase is formed, rather just a plastic phase. The material reorganises itself. Precipitates grow or coalesce, partially or completely dissolve in the matrix. These micro and nanostructures eventually determine the properties of the end product. How strong is it, how elastic, how resistant against corrosion or fatigue? The IPSUS researchers use high energy X-ray radiation capable of observing structures on the nanometre scale to take a look inside the materials. At their beam line at the HASYLAB in Hamburg, they have set up a special friction stir welding machine so that the synchrotron beam can sample the weld during its production. In the meantime, the beam detector delivers reliable (i.e. in situ) and very valuable results. In the future, the researchers want to use high-speed detectors in order to observe the processes with an even better temporal resolution.

However, the experimental work is not everything, far from it. "To gain the most complete possible understanding of the process it is supported by modelling work," explains Jorge dos Santos. For the microstructure, the researchers are building on existing models for metallurgical processes which they feed with new data direct from the scattering experiments. "The hope is that we will, at the end of the day, perhaps no longer need any more experiments, but rather can run everything through on the computer," he says. The modelling of the jointing process will also contribute to this. Its primary information lies in the temperature distribution and the visualisation of the material flow. This, too, has already been achieved, assures Santos. Finally, the scientists continue to characterise the probes in order to compare these results with those produced by the models.

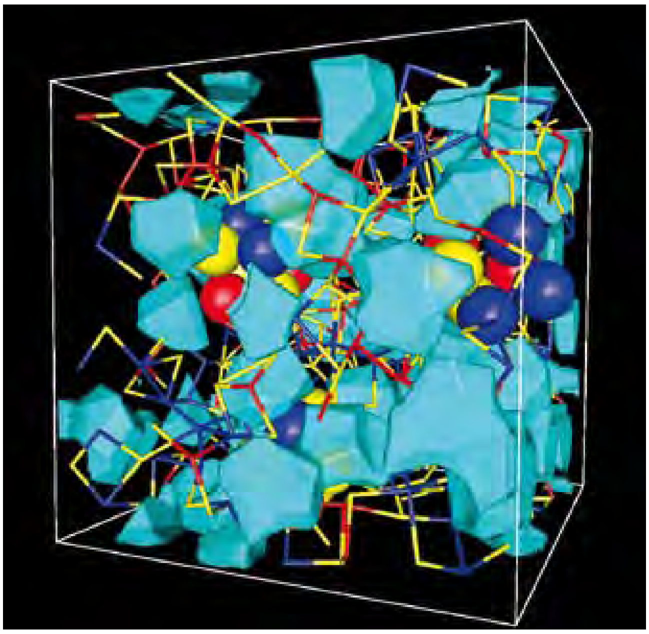
THE FRICTION STIR WELDING PROCESS FIRST HEATS THE MATERIALS THROUGH, THEN STIRS THEM WITH THE TIP OF A TOOL, AND FIRMLY JOINTS THEM. PHOTO: GKSS

It is clear that not all the required skills and expertise can be found under a single roof. This is why IPSUS is organised as a “Virtual Institute” so that the expertise existing at various institutions can be pooled. The GKSS is responsible for the process development and modelling as well as for the scattering studies and part of the characterisation. The Karlsruhe Institute of Technology is experienced in dealing with fusion materials, the Max Planck Institute for Iron Research knows all about so-called TWIP steels. The Universities of Manchester and Cranfield were consulted for modelling the microstructure and the process, while experts from the Ruhr University Bochum contributed their expertise in high-resolution electron microscopy. Last but not least, scientists at the TU Berlin can use the results for a similar jointing method. And industry is on board with an advisory panel. UTA DEFFKE

Forschungszentrum Jülich

STRUCTURAL SECRETS OF STORAGE MEDIA

Physicists at the Forschungszentrum Jülich have explained the structure and processes in materials that form the memory of rewritable optical storage media, such as DVD-RAM and Blu-ray discs. Only the underlying principle was clear. The material can be switched selectively with a laser writing head from an ordered, crystalline form into a disordered state and back. These processes are accompanied by changes in reflectivity, which can be measured by laser.
“The rearrangement of the atoms lasts only a few nanoseconds, i.e. is extremely fast. We asked ourselves what sort of structure makes this possible,” explains Dr. Robert Jones. Jones and his team carried out simulations on the supercomputer JUGENE to find out what occurs when molten DVD material cools into an amorphous mass, as happens when information is written. They adjusted their model sequentially using measurements of the crystal structures which Japanese colleagues had made on the synchrotron SPring-8.
The supercomputer JUGENE calculated the position and motion of 460 atoms during the 0.3 nanoseconds of the cooling phase. The computation took a total of four months. The results provide insights that no microscope can supply. Ring-like structures comprising four atoms are decisive for the rapid switching, and they occur in both the amorphous and the crystalline material. The presence of cavities is also important, so that the building blocks can rearrange quickly without breaking too many atomic bonds. “With this insight, we can approach the material design of new storage media much more systematically,” says Jones. ANGELA WENZIK



SIMULATION OF THE DVD STANDARD ALLOY GST SHOWS THE RING STRUCTURES AND BRIGHT BLUE CAVITIES WHOSE INTERPLAY FACILITATES THE RAPID PHASE CHANGE. THE ELEMENTS ARE GERMANIUM (RED), ANTIMONY, (BLUE), TELLURIUM (YELLOW). Photo: Forschungszentrum Jülich

72 CABINETS HAD TO BE SET UP AND MANY KILOMETRES OF CABEL LAID UNTIL ALL THE PROCESSOR UNITS WERE PROPERLY CONNECTED WITH EACH OTHER.
PHOTO: FORSCHUNGSZENTRUM JÜLICH

Forschungszentrum Jülich

SUPERCOMPUTERS

At the end of May 2009, the Forschungszentrum Jülich proudly presented its three new supercomputers: JUGENE, JUROPA and HPC-FF. With a computing capacity of 1 petaflop – equal to 1 quadrillion computational operations per second – Jugene ranks third in the league table of the world's hundred fastest computers as published in June. The Tandem Juropa – HPC-FF still holds tenth place with 308 teraflops – or 308 trillion computational operations per second. However, the race for computing power is not an end in itself, says Prof. Dr. Dr. Thomas Lippert, Director of the Jülich Supercomputing Centre (JSC) at the Forschungszentrum Jülich. "Meanwhile, supercomputers are, besides theory and experiment, the third pillar on which research stands, and their efficiency and performance capacity create the prerequisites for solving extremely complex questions."

"The race for computing power is not an end in itself. Its efficiency and performance capacity create the prerequisites for solving extremely complex questions."

Where real-life experiments are too dangerous, such as in safety assessments of nuclear power stations, are too complicated and expensive, such as in the case of the fusion reactor ITER, or are even impossible, such as in studying the causes and consequences of climate change, computers serve as virtual labs today. Using simulations, researchers try to replicate reality and predict future behaviour. "Supercomputers are the only option for solving many scientific problems at all," says Lippert. They can calculate much faster, because they not only run on one processor, but rather hundreds of thousands run in parallel. 290,000 processors lie in Jugene. A process that would preoccupy a normal PC over ten years can be completed here in 20 minutes, making it possible to repeat with various parameters. However, supercomputing is also a science in itself. On the one hand, it calls for special technology. It is – in the case of Jugene – accommodated in 72 telephone kiosk sized cabinets. The confusing mass of countless processors is linked together via a very fast network through which the data are exchanged. "However, not alone the computing power is decisive," emphasises Lippert, "you also have to know how to use it." When a programme runs on many processors, it is like a major building site. It's all about distributing the tasks properly, not all of them can be done simultaneously. Which processor receives new data when and where, how these arrive in good time and reliably, all this has to be cleverly organised and programmed. To support the specialist scientists from various subject areas in optimising their simulations for the respective supercomputer, four dedicated simulation labs were set up at the JSC: for plasma research, for molecular systems, for computational biology, and for atmospheric and climate research. Teams work here that have both the corresponding specialist expertise as well as being experts in supercomputing itself.

The simulation labs and other facilities at the JSC not only offer services for the users of supercomputers. They also carry out their own research and development work. New software tools, for example, that analyse how the simulation programmes could be further optimised. The development of new computers is also on the agenda. Because supercomputers are one-offs whose computer architecture meets the special requirements of research. The computer clusters Juropa and HPC-FF were designed in Jülich, for example, and were then turned into reality together with companies like Intel, Bull, SUN, Melanox and ParTec. The supercomputer HPC-FF exclusively serves European fusion research. For particularly demanding tasks it can be coupled with Juropa. The users of the supercomputers in Jülich come from universities, from other Helmholtz Centres, from the Max Planck Society, and from industry. With the new computers, the JSC will also become increasingly attractive for European researchers, believes Lippert. "The seemingly record-breaking computing power sends out an important signal, namely that excellent research can be done here." To coordinate the activities of the individual European countries in the field of supercomputing and to strengthen their position in competition with the United States and Japan, the Partner-

ship for Advanced Computing in Europe" (PRACE) was initiated in 2007. "The aim is to provide users with more tailor-made capacities," says Dr. Thomas Eickermann from the JSC, Project Manager for PRACE. In Germany, the supercomputing activities have already been pooled by merging the three supercomputing centres in Jülich, Stuttgart and Garching to form the Gauss Centre for Supercomputing. UTA DEFFKE

Karlsruhe Institute of Technology

NANOSTRUCTURES IMPROVE LITHIUM-ION BATTERIES

Li-ion batteries are currently seen as the best candidates for use in vehicles or for stationary energy storage. But even the most modern battery with a weight of around 100 kilograms would only give an electric car a range of around 100 kilometres, while long charging times and aging features are problematical. We are working on new materials to substantially increase the energy density of such Li-ion batteries," explains Dr. Sylvio Indris, Young Investigators Group Leader at the Institute of Nanotechnology, Karlsruhe Institute of Technology.

> "To charge and discharge the battery, lithium in the electrodes constantly has to be inserted into or extracted from the electrodes. These composite materials can be fitted quickly and so accelerate the charging process."

Indris and his team are studying ceramic materials for this, such as oxides and chalcogenides, which they have provided with three-dimensional nanostructures. "We are working with crystallites of 4 to 50 nanometres, but are also studying structures made of hollow spheres of 14 nanometres diameter and 3 nanometres wall thickness," says Indris. Electrodes made of such structured materials can absorb much more lithium than conventional electrodes made of graphite or cobalt oxides and store much more energy. Charging is also quicker. "To charge and discharge the battery, lithium constantly has to be inserted into or extracted from the electrodes. These composite materials can be fitted quickly and so accelerate the charging process," explains Indris. Using methods like X-ray scattering and nuclear spin resonance spectroscopy, the researchers headed by Indris are studying how the structures in the electrodes change and how various materials for electrodes and electrolytes act during battery operation. In so doing, they try out lots of different concepts, ranging from ultra stable solid state batteries made of vapour deposited components through to batteries where the electrodes are printed on paper. "We need batteries for all different kinds of applications and so have to pursue various approaches," says Indris. ARÖ

TO STUDY REACTION MECHANISMS DURING BATTERY OPERATION, THE PHYSICISTS USE INTENSIVE X-RAY RADIATION FROM THE SYNCHROTRON RADIATION SOURCE ANKA. Photo: S. Indris, KIT

RESEARCH FIELD STRUCTURE OF MATTER

PROF. DR. HORST STÖCKER
Vice-President of the Helmholtz Association.
Coordinator of the Research Field Structure of Matter,
GSI Helmholtz Centre for Heavy ion Research

GOALS AND ROLES

The Helmholtz Research Field Structure of Matter explores the constituent parts of matter and the forces acting between them over completely different orders of magnitude, from the smallest units, elementary particles, to the largest structures in the universe. The work not only focuses on individual particles, but also on complex phenomena in solids and liquids that form as a result of the interactions taking place between myriads of atoms. Basic research also helps to open up the path to insights that facilitate the development of novel materials with tailor-made electronic, mechanical or thermal properties. A particular strength of Helmholtz research comes into play in this research field: the operation and utilisation of large-scale facilities and complex infrastructures for research purposes. Whether particle accelerators, synchrotron radiation or neutron sources – the Helmholtz Association makes big, sometimes globally unique scientific infrastructures available that are used by numerous researchers from home and abroad. With the planned X-ray laser, European XFEL, being built at the Deutsches Elektronen-Synchrotron DESY in European collaboration, an X-ray source is being created whose maximum capacity is ten billion times higher than all previously built facilities. A further large-scale facility is being established at the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt. The "Facility for Antiproton and Ion Research" FAIR is an accelerator facility of the next generation that will supply ion beams of a previously unattained intensity and very high energies. With its alliances, the Helmholtz Association has created new structures in order to offer the very best research conditions through strong networking. Hence, the Research Field Structure of Matter successfully continued two Helmholtz Alliances in 2008, namely, "Physics at the Terascale" and "Cosmic Matter in the Laboratory," the latter beginning with a kick-off event held in April. The network "Physics at the Terascale" brings together Germany's top-rate scientists to do research at the limits of the achievable accelerator energy. The aim is to endow particle physics in Germany with an ever stronger profile and ever more influence in an increasingly global research landscape. Thus, the particle physicists from two Helmholtz Centres, the Deutsches Elektronen-Synchrotron DESY and the Karlsruhe Institute of Technology, and colleagues from a total of 17 universities and the Max Planck Institute for Physics in Munich have joined forces. With the second Alliance "Cosmic Matter in the Laboratory", a new institute, "ExreMe Matter Institute" (EMMI) was founded on the grounds of the GSI, which, by networking leading research institutions in this field, will form a think tank for research at the FAIR facility. In the study and exploration of matter under extreme conditions, such as prevailed shortly after the Big Bang, unique insights are to be expected. They will contribute valuably to the planning of experiments to be carried out at the new large-scale facilities being built at the GSI, DESY and CERN. At the turn of the year to 2009, the Hahn-Meitner-Institut merged with the research centre BESSY to become the largest research institution in Berlin.

The Research Field Structure of Matter was evaluated at the beginning of 2009 within the scope of the Helmholtz Association's programme-oriented funding. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field in the period under report up to the end of 2009 and presents the new research programmes that form the strategic focus for the Research Field in the coming five years. The previous and the new structure are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as from 2010. With effect of 2010, all six research fields will be in the second funding period.

PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2005–2009

Six Helmholtz Centres work together in the Research Field Structure of Matter: Deutsches Elektronen-Synchrotron DESY, Forschungszentrum Jülich, Karlsruhe Institute of Technology (formerly Forschungszentrum Karlsruhe), GKSS Research Centre Geesthacht, GSI Helmholtz Centre for Heavy Ion Research and the Helmholtz-Zentrum Berlin für Materialien und Energie. In the current programme period that continues until the end of 2009, the scientists work on 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

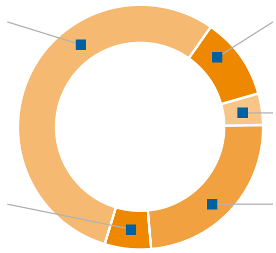
All the programmes build on a close interaction and cooperation between theory and experiment, and several programmes are scientifically and technologically interlinked. The primary goal is to continually advance the research infrastructures, to exploit these most efficiently, and to give users the best possible support and so strengthen the leading role of Helmholtz scientists in this field together with their national and international partners.

"To solve the major social problems system-oriented thinking and action are needed that build on the principles of research and training. A decisive role is played here by the intellectual and cultural diversity that can be secured from collaborating with each other across the borders of traditional disciplines. The vision of "sustainability" is also important in questions of the future, such as climate change, energy and food. Although the commonly-used term with its goal of achieving permanent development passes the lips easily, the path to its realisation involves a great deal of time and effort. Turning this into reality not only requires the right intellectual approaches, but also efficient technologies with optimised material flows."

PROF. DR. RALPH EICHLER
Senator of the Helmholtz Association,
President of the ETH Zurich

Structure of the Research Field Structure of Matter
Core-financed Costs 2008: 440m euros

The Research Field Structure of Matter additionally received 144m euros of external funds, providing it with a total budget of 584m euros.



THE PROGRAMMES
IN THE FUNDING PERIOD 2005–2009

Elementary Particle Physics

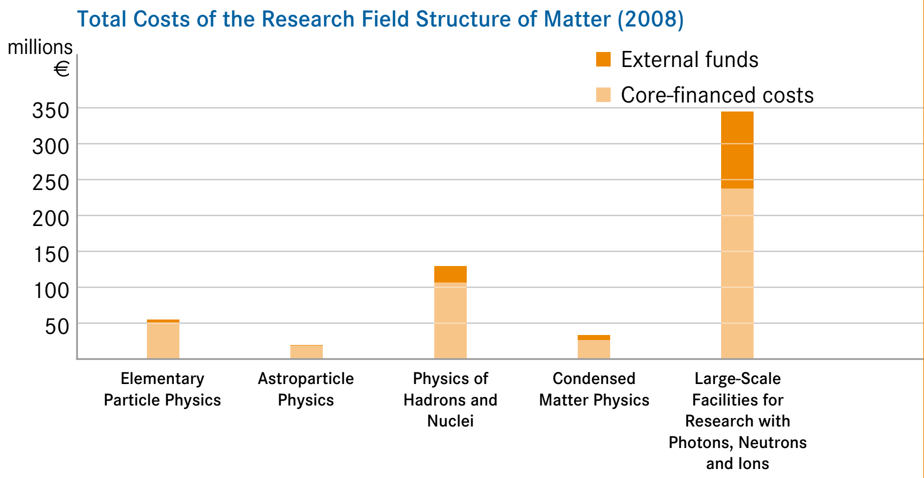
This programme studies the smallest building blocks of matter and the forces acting between them. The insights gained have a direct impact on our understanding of the evolution of the early universe. The origin of mass, the unification of all the fundamental forces at extremely high energies, as well as the reconciliation of quantum physics with the general theory of relativity all rank among the basic questions of physics. To solve these questions, the researchers are on the tracks of new particles and in search of the supersymmetry partners of all presently known particles. Besides the accelerator capacities around the world, the scientists also have access to high-performance computers for analysing data and modelling questions of theoretical physics related to their research. With the Grid Computing Centre (GridKA) at the Karlsruhe Institute of Technology a high-performance computer centre has been established that is internationally networked and has been in operation since 2007. At DESY, the National Analysis Facility was founded within the framework of the Terascale Alliance. This means that strong computer connections with CERN and all the other participating centres in Europe, the United States and Asia are available simultaneously. This will play a decisive role in analysing the enormous volumes of data produced by the Large Hadron Collider (LHC) at the European Research Centre CERN. After the closure of HERA, the programme already reoriented itself towards LHC physics in 2008.

Astroparticle Physics

Astroparticle physics is a relatively young interdisciplinary research area. It combines the study of the smallest building blocks with the exploration of the largest structures of the universe. Astroparticle physicists study the sources of cosmic radiation and the mechanisms of cosmic accelerators. They explore astrophysical objects using not only visible light, but also protons and nuclei, neutrinos and high-energetic gamma radiation as messengers from space. At the same time, researchers from this programme investigate the so-called dark matter, whose presence could previously only be inferred from its gravitational effect. The programme has three core focuses: studying electrically charged cosmic radiation at high energies (Pierre Auger Observatory, Argentina), the search for high-energy cosmic neutrinos (IceCube neutrino telescope, Antarctica), and determining the neutrino mass to a previously unattained degree of precision (KATRIN, Karlsruhe). To achieve these goals, the research field has to develop, build and operate large-scale detector arrays with an efficient infrastructure, often in remote areas far away from existing research centres.

Physics of Hadrons and Nuclei

Neutrons and protons (hadrons) are made up of quarks that are bound together through the strong interaction. Scientists in the Physics of Hadrons and Nuclei programme focus on the following fundamental topics: quark confinement in hadrons, the spontaneous breaking of chiral symmetry, the origin of hadron mass, properties of the nuclear multi-particle systems, exotic nuclei at the limits of stability, the generation of super-heavy elements, the behaviour of extended nuclear matter in astrophysical objects such as neutron stars and supernovae. The search for quark-gluon-plasma in the ALICE project at CERN is another research topic. In the field Structure of Nuclei, the SHIP collaboration succeeded in generating element 112 via so-called warm fusion reactions, an



achievement recently officially confirmed by the relevant international body, the International Union of Pure and Applied Chemistry. Building on this, there is growing hope that it will be possible to advance into the long-sought field of super heavy nuclei. With the Facility for Antiproton Ion Research (FAIR), a next generation accelerator facility is being built at GSI. FAIR will open up new dimensions for the study of matter and antimatter and hence will contribute to gaining an understanding of the strong interaction, the origin of chemical elements in the universe and the properties and characteristics of antimatter in comparison with matter. In addition, FAIR also opens up new opportunities for nuclear and plasma physics as well as for applications in radiobiology and materials research.

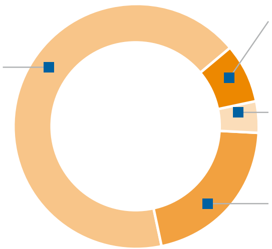
Condensed Matter Physics

The Condensed Matter Physics programme studies the properties and characteristics of solids, of so-called soft matter, and of liquids. Scientists investigate the interactions between electrons and atoms that determine the mechanical, thermal, electronic, magnetic and optical properties and characteristics of matter. The focus is on systems made up of many particles that reveal new complex properties. These include nanosystems, for example, which mark the transition from atoms to solids. The programme's main goal is to explore new and unusual states in these materials. The programme benefits from large-scale facilities at the research field which make neutron, ion and synchrotron beams available as probes. Scientists also use spectroscopic methods, high-resolution electron microscopy, plus supercomputers that enable them to carry out theoretical modelling and computer simulations. As from 2010, the programme will move to the Research Field Key Technologies.

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

This programme encompasses the large-scale facilities that are particularly important for nuclear and molecular physics, plasma physics and condensed matter physics, for structural molecular biology, chemistry and materials sciences, earth and environment research, as well as for engineering. The programme concentrates on the efficient use of existing photon, neutron and ion sources and their constant adaptation to the changing needs of the user community. The European X-ray laser XFEL is being built by the European XFEL GmbH in close collaboration with the Helmholtz Centre DESY and further international partners and is to deliver X-ray flashes of an extremely high intensity as from 2013. This will then enable scientists to film reactions in chemical or biological systems, for example, and unravel the atomic details of molecules. Moreover, the world's strongest magnet for neutron experiments is being constructed at the Helmholtz-Zentrum Berlin für Materialien und Energie. Combining this with a unique probe environment, scientists expect great advances in materials research, such as a fundamental understanding of high-temperature superconductivity. PETRA III was completed on time and in budget, so that the first electron beam could already be stored in the ring in the first half of 2009. As from autumn 2009, science will have available the world's best storage ring source for hard X-ray radiation.

Structure of the Research Field Structure of Matter
Core-financed Costs Plan 2010*: 444m euros
(including non-programme-bound research)



*First year of the new Programme Funding Period 2010–2014

THE PROGRAMMES
IN THE FUNDING PERIOD 2010–2014

The challenges faced by the research field remain largely unchanged compared to the former programme period, the research conducted in the research field is integrated into national and international roadmaps which determine the focus of the research work in the individual programmes on timescales of 10 to 15 years. This basic research simultaneously delivers many different impulses for technological developments.
The research field is responsible for outstanding, in many cases unique large-scale facilities. Hence, it contributes decisively to implementing the Helmholtz Association's large-scale facilities mission and, in so doing, also contributes valuably to strengthening its international visibility. The large-scale facilities are used by the Helmholtz Centres for their own research, but are largely available for several thousands of users from home and abroad. In the first half of 2009, international experts reviewed the strategic focus of the research field and the programmes. The coming programme period plans, *inter alia*, a coordinated participation between the HZB, Forschungszentrum Jülich and GKSS in research activities at the neutron source FRM-II in Garching. The research field's own research in the programme "Photons, Neutrons and Ions" is to be decisively expanded and upgraded. Furthermore, the "Condensed Matter Physics" programme will be transferred to the Research Field Key Technologies.

The following summarises the most important planned measures in the four programmes.

Elementary Particle Physics

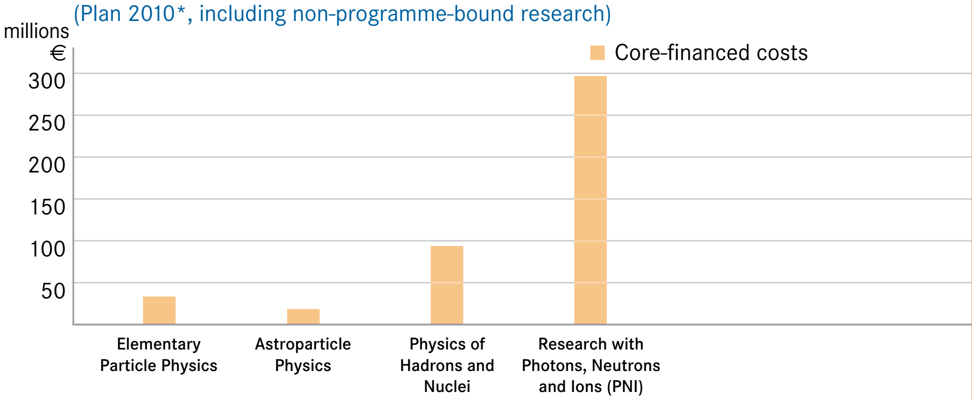
DESY is one of the world's leading centres in particle physics and has phased out the operation of its own large-scale facilities in this programme. In the coming programme period, DESY will focus on the following projects, thereby securing the institute's and Germany's leading role in particle physics:

- Substantial participation in two LHC experiments (ATLAS and CMS). At the same time, the precision analyses of the HERA experiments will be completed. Its results are also of great importance for the LHC analyses.
- Further expansion of the Grid Computing Centre Karlsruhe (GridKa) at KIT as well as the Tier2-Centres and the analysis centre at DESY.
- Theoretical studies in close connection with the experimental activities as well as research at the interface between particle/astroparticle physics and string theory. The lattice gauge theory, including research and development for novel processors, will be continued at the DESY site in Zeuthen in close collaboration with the John von Neumann Institute of the Forschungszentrum Jülich.
- Collaboration in the continuing development of superconducting accelerator technology for the International Linear Collider (ILC), in which DESY plays a world-leading role. Use of the synergy between XFEL and the ILC.
- Detector development for the luminosity increase of the LHC and for precision experiments at the ILC, contributions to the development of detectors for XFEL.
- The Helmholtz Alliance "Physics at the Terascale" is to be consolidated as a result of the review.

Astroparticle Physics

- The measurements taken with the Pierre Auger Observatory are to be continued. Furthermore, there are plans to extend the measurements to include the whole sky. Concomitant research activities relate to the radiodetection of air showers and multi-messenger analysis.
- The neutron telescope IceCube will be upgraded and so guarantees a wealth of results in the next programme period. In connection with this, DESY plans to contribute to the preparatory work on the Cerenkov Telescope Array (CTA).
- The search for dark matter is becoming ever more important as a result of new astronomical studies and is to be expanded through KIT taking a leading role in the European project EURECA.
- The KATRIN experiment will carry out its measurements in the next programme period. The experiment will facilitate the world's most sensitive measurement of neutrino mass.
- Programme-own theoretical work in astroparticle physics will be carried out in close cooperation with the Universities of Potsdam and Karlsruhe.

Core-financed Costs of the Research Field Structure of Matter
(Plan 2010*, including non-programme-bound research)



*First year of the new Programme Funding Period 2010–2014

Please note: Due to the Helmholtz Association's High Data Rate Processing and Analysis Initiative, the costs for the Research Field Structure of Matter only represent provisional figures. The final figures are expected at the start of 2010.

Hadrons and Nuclear Physics

- Lead participation in the international FAIR project (Facility for Antiproton and Ion Research) at the GSI. This worldwide unique accelerator complex is being jointly built by the GSI and the FZJ, together with national and international partners and will run as from 2012.
- Intensity upgrade of existing accelerator facility at GSI for its role as FAIR injector.
- Carrying out a specifically targeted experimental programme at the GSI and COSY. Completion of the research programme at COSY to further strengthen the FAIR activities. Preparations at COSY on phase space cooling and polarisation of antiprotons at FAIR.
- Central role of GSI together with the German universities in building and using the ALICE detector within the scope of the heavy ion programme at the LHC, CERN. Assembly and operation of a high performance Tier2-Centre for ALICE at the GSI.
- Intensifying the programme's theory activities with respect to ALICE and FAIR physics as well as future hadron physics.
- The multidisciplinary and interdisciplinary topic of "Extreme Densities and Temperature: Cosmic Matter in the Laboratory" has been pursued with the Helmholtz Alliance EMMI since 2008 and will be further advanced in the coming period.

Research with Photons, Neutrons and Ions (PNI)

The centres participating in this programme are pursuing their own research projects with the strategic goal of using and optimising the full potential of the large-scale facilities and supporting external users as efficiently as possible. At the Helmholtz-Zentrum Berlin für Materialien und Energie, opportunities for the complementary use of photons and neutrons are particularly highly promising, for example, for studying magnetic materials.

Photons:

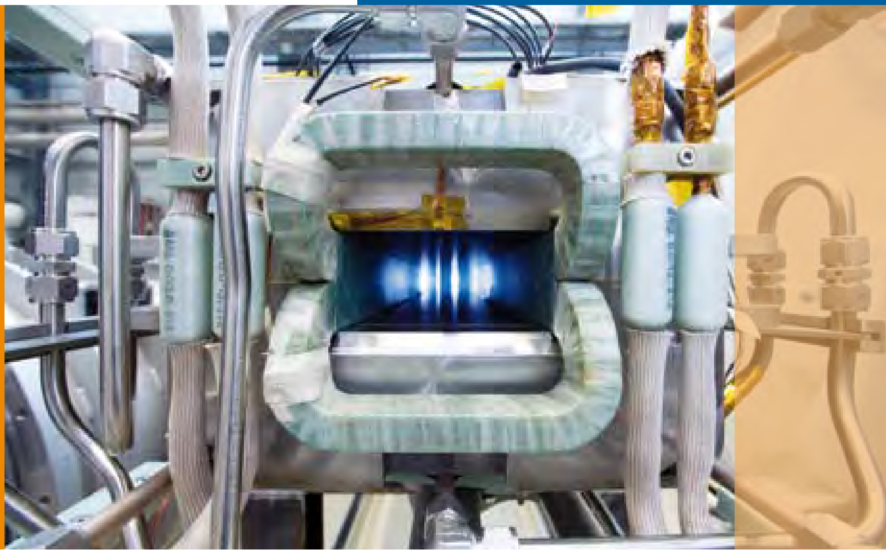
- Lead participation in the European X-ray laser XFEL at DESY as well as the expansion of the "Centre for Free Electron Laser Studies" in collaboration with the Max Planck Society and the University of Hamburg as a basis for German use of XFEL.
- Operation of PETRA III as the world's best source for hard X-ray radiation. Establishment of a "Centre for the Structure and Dynamics of Condensed Matter on the Nanoscale" as well as the creation of the Engineering Materials Science Centre at DESY by the GKSS.
- Further expansion of the user programme at the FLASH laser.
- Expansion programme for BESSY II "2007 Plus", in particular for the microscopy of the terahertz range through to X-ray radiation and the generation and application of short X-ray pulses with a free choice of polarisation.
- Expansion of ANKA to create a user facility in combination with the existing research priorities at KIT and the infrastructure, using superconducting undulator technology.
- Creation of a Centre for Structural Biology at DESY, together with the Research Field Health.

Neutrons:

- Strengthening the Helmholtz commitment to the FRM II, construction of further instruments, including, inter alia, by the Jülich Center for Neutron Science (JCNS), the GKSS and the HZB.
- Operation of BER II with the available extreme probe environments available there, as well as the commissioning of the first expansion stage (25T) of the high-field magnet, upgrade of a selection of instruments and neutron units at BER II and the cold source.
- Consolidation of the branch of the Jülich Centre for Neutron Science (JCNS) at the Spallation Neutron Source (SNS) in Oak Ridge, creation of a flight-time instrument with polarisation analysis. Assembly of a Short Pulse Engineering Spectrometer SPES at the Institut Laue-Langevin (ILL).
- Contribution to concepts for new neutron sources (ESS) and their instrumentation.

Ions:

- Extension of the opportunities for materials research, plasma and nuclear physics with ions at the GSI, especially also for FAIR.



PROJECTS

GSI Helmholtz Centre for Heavy Ion Research

THE INSIDES OF STARS IN THE LAB

What did the universe look like just after birth? What conditions prevailed inside the stars and planets? And how could super heavy elements form, such as uranium, for example? A globally unique accelerator complex at the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt is to answer these questions in several years: FAIR is a collaborative European project in which 16 countries are participating. The core components for the plant – strong, superconducting magnets – recently passed their first acid test.

> "Among other aspects, we aim to find out how matter behaves under extreme densities, such as those found inside stars or giant gas planets."

FAIR stands for "Facility for Antiproton and Ion Research". At the heart of this facility lies a double ring accelerator with a circumference of 1100 metres. It supplies a complex system of storage rings and experiment stations with quick, energy-rich ions. Just to get these charged particles moving at all, they have to be held in an orbit inside the accelerator by strong magnetic fields. This is exactly what the 108 special magnets that GSI experts are currently working on are there for. Each magnet is three metres long, looks like a tube and weighs more than three tonnes. "What's so special about the magnets is that they are superconducting and can be switched on and off extremely quickly," explains GSI physicist Dr. Pierre Schnizer. "They can be run up to a field strength of two teslas and back down within a second." This is important because it means that several experiments can be run at the same time. The quicker the magnets are, all the more shots can be fired by the accelerator, which in turn enables the experts to collect all the more measuring data. In technical terms, however, the construction of such fast magnets is an enormous challenge. Because an energy of 50 kilojoules is pumped into them within half a second – about as much power as is needed for 40 hotplates. This inevitably leads to thermal losses that have to be cooled with a clever fluid helium cycle. What's critical about this is that the magnets always have to remain superconducting, which means they have to function without any electrical resistance. This is why the temperature must never exceed four Kelvin (minus 269° Celsius). "Together with colleagues from the Russian Research Centre in Dubna, we have built and successfully tested an initial prototype," says Schnizer. "Now we're working on the next, improved version." With the help of fast, energy rich ions from the accelerator, the physicists want to crack some of the most exciting puzzles of astrophysics. "Among other aspects, we aim to find out how matter behaves under extreme densities, such as those found inside stars or giant gas planets," explains Dr. Horst Wenninger, Head of the FAIR Joint Core Team. Furthermore, the experts would like to find out where the heavy atomic nuclei in our universe come from – elements like platinum or uranium. The Big Bang only produced light chemical elements, essentially hydrogen and helium. Most of the other chemical elements, like oxygen, sulphur and iron were subsequently formed inside stars in the course of billions of years.

> "What's so special about the magnets is that they are superconducting and can be switched on and off extremely quickly."

However, the super heavy elements like uranium can only have been formed through cosmic events, such as exploding supernovas. The scientists hope that FAIR could help to replicate these processes on a small, experimental scale. And they also want to find out how exactly quarks, the smallest building blocks of matter, act and want to study exactly which characteristics actually differentiate matter from antimatter. And last but not least, FAIR will also test spacecraft and satellite components for ESA, for example, to see how to protect future astronauts flying to Mars from dangerous cosmic radiation. "Scientists from all kinds of different research institutions will

108 SUCH DIPOLE MAGNETS ARE NEEDED FOR THE LARGE CIRCULAR ACCELERATOR AT THE FAIR FACILITY. PHOTO: C. GRAU, GSI

come to Darmstadt," says Wenninger. "For them, FAIR will become the world's most powerful facility – a kind of CERN of nuclear physics."

Preparations for the some 1.2 billion euro large-scale facility are progressing full steam ahead. Germany is financing three quarters of the sum. The remainder comes from the 15 partner countries. After founding a joint limited company, the official groundbreaking ceremony for the FAIR testing hall took place in autumn 2009. The first experiments are to begin around four to five years later. The world's most ambitious accelerator project in nuclear physics is expected to be fully completed in 2017 or 2018. FRANK GROTELÜSCHEN

Karlsruhe Institute of Technology

THE WORLD'S LARGEST HELMHOLTZ COIL SYSTEM

Neutrinos are regarded as ghostly particles. Produced in the Big Bang in great numbers, they permeate the universe and play an essential role in its development. Nevertheless, we only know very little about their properties, and we don't even know their mass yet. Working in collaboration with colleagues from Germany, Europe and the United States, astroparticle physicists at the Karlsruhe Institute of Technology have built an enormous spectrometer called Karlsruhe Tritium Neutrino Experiment – KATRIN in short – to determine the neutrino mass. They aim to do this by using the decay of tritium (hydrogen-3) into helium-3, in which both electrons and neutrinos are emitted.

"We are building the world's largest Helmholtz Coil System to determine the neutrinos' mass."

By precision-determining the electron energies, the scientists can identify the neutrino mass. However, a suitable magnetic guide field has to be generated at the spectrometer and, furthermore, the Earth's magnetic field has to be compensated as well as possible. "This is why we are building the world's largest Helmholtz Coil System capable of generating a magnetic field along the whole length of the KATRIN spectrometer," says Professor Dr. Guido Drexlin, who is in charge of the KATRIN experiment. This involves a frame of 15 rings made of aluminium profiles with diameters of 12.6 metres bearing the twists and turns of the coil which generate the magnetic guiding field.

The magnetic field can be set at between three and six Gauss. To fine-tune the magnetic guide field, each ring can be operated at different power rates. A maximum of up to 70 amperes is planned. To shield the Earth's magnetic field, which has a strength of roughly 0.5 Gauss, two further coil systems are integrated vertically and horizontally relative to the axis of the spectrometer making use of the ring structure of the Helmholtz Coil. After commissioning of the coil systems, the first experiments with KATRIN are planned for summer 2010. ARÖ

THE KATRIN SPECTROMETER IS SURROUNDED BY 15 LARGE RINGS WHICH BEAR THE COILS FOR GENERATING THE MAGNETIC GUIDE FIELD. Photo: KIT

THE HIGGS PARTICLE THOUGHT TO PROVIDE OTHER PARTICLES WITH MASS COULD BE DETECTED WITH THE LHC'S ATLAS DETECTOR. PHOTO: CERN

Deutsches Elektronen-Synchrotron DESY

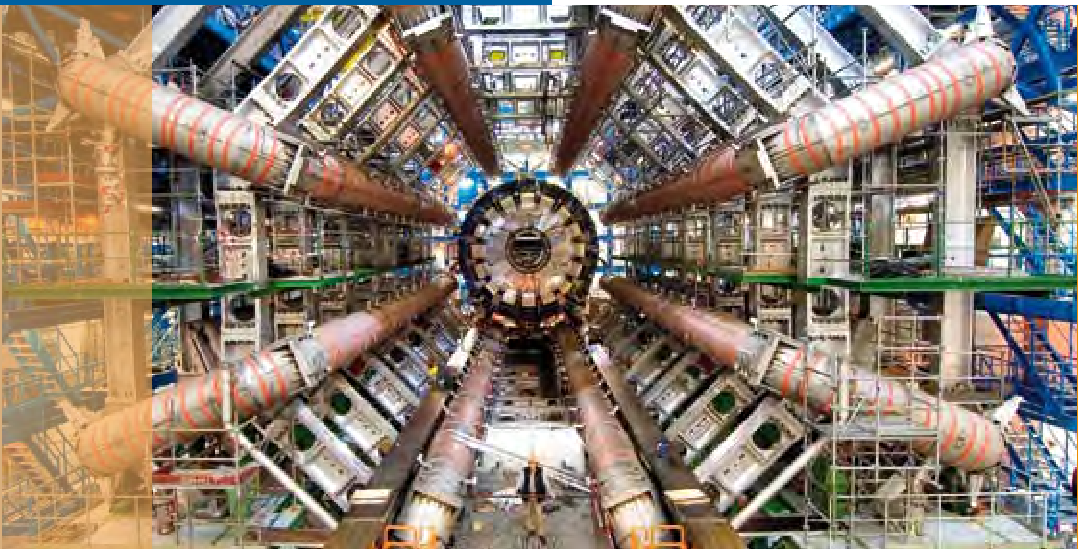
SIGHTS SET ON HIGGS AND SUSY

"This is a decisive step forward. We expect to gain completely new insights into particle physics!" Prof. Dr. Joachim Mnich is visibly expectant of the results which the strongest accelerator of all times will deliver – the Large Hadron Collider (LHC) in Geneva. Almost ten thousand physicists from around the world are contributing to the mega experiment – including several hundred from Germany. Since summer 2007, the German particle hunters have been concentrating their activities in the Helmholtz Alliance "Physics at the Terascale".
The LHC was installed in a 27 kilometre long ring tunnel at CERN and fires protons to collide head-on with each other. Giant particle cameras, detectors called ATLAS and CMS, watch whether these collisions lead to new and unknown particles. What makes this so special? "The LHC will be the first accelerator to achieve collision energies in the range of teraelectronvolts," says Mnich, Research Director for Particle and Astroparticle Physics at DESY in Hamburg. In numbers: The LHC aims to accelerate protons up to seven teraelectronvolts (trillions of electron volts) – almost ten times more than the previous record holder, an accelerator in Chicago.

"The LHC will find Higgs, if it actually exists".

By doing so, the LHC will answer some of the most exciting questions of physics. What exactly is the mysterious dark matter? And where do elementary particles like quarks and electrons actually get their mass from?
An idea of how this question could be answered was already put forward in the 1960s by the Scottish physicist Peter Higgs. He postulated a field that lies beneath the universe, like a carpet. Figuratively speaking, the Higgs Field allows the particles to soak up mass. If the theory is correct, there must be a special particle, the Higgs particle. "The LHC will find Higgs," believes Mnich, "if it actually exists."

The discovery of the so-called SUSY particles, as predicted by the theory of supersymmetry (SUSY), would be even more spectacular. This extends well beyond the standard model of particle physics. The latter assumes that quarks and electrons form the basic building blocks of matter together with some other kinds of particles. They are held together by four natural forces, including electromagnetic force and strong interaction. These forces are transmitted by messenger particles. For example, strong interaction uses the "gluons" to stick quarks to protons and neutrons, the building blocks of atomic nuclei. The problem is that in the standard model, matter and messenger particles stand next to each other, but are unrelated. In SUSY, however, the forces and particles are abstractly symmetrical – as long as a previously undiscovered "super partner" exists for each and every known particle. Indeed, it is this very SUSY particle that the LHC might find – a discovery that would also fascinate cosmologists. For certain, SUSY particles could lie behind the dark matter – a form of matter that seems to dominate the universe, but whose consistence remains a puzzle.
The experiments on the LHC that aim to answer these questions are highly complex, however. Enormous volumes of data would be delivered alone by the two detectors ATLAS and CMS, their analysis would be a never-ending task. "In order to make this work easier for the German institutes and universities involved, we initiated the Helmholtz Alliance," explains Mnich. The particle research centre DESY in Hamburg acts as the central hub. Furthermore, experts from 19 universities, a Max Planck Institute and the Karlsruhe Institute of Technology are also contributing. An analysis centre at DESY offers direct access to the LHC data and provides computing resources. A virtual theory institute is running joint seminars and organises video conferences. And the "Virtual Detector Lab" is continuing to advance detector technology. At the same time, the accelerator experts are already working on plans for an even stronger accelerator, the Linear Accelerator ILC. Over a period of five and a half years, the Alliance has a budget of 75 million euros available to it – 25 million euros from the Helmholtz Association, plus almost 50 million euros from the 22 partners.



"So far, our concept has proven very successful," says Mnich. "The continuation of the Alliance beyond 2012 would certainly make good sense. Then we could continue to maintain the structures that we are currently creating."

FRANK GROTELÜSCHEN

Deutsches Elektronen-Synchrotron DESY

FROM ACCELERATOR TO SUPERLAMP

Ever since the particle accelerator HERA came to its scheduled end at DESY, the pre-accelerator PETRA has been available again for other tasks and assignments. To this end, the facility has been completely re-equipped to become the world's brightest storage ring X-ray source.

The new light source enables biologists to understand the atomic structure of tiny protein crystals.

So, it ideally complements the experimental options and choices at the European X-ray Laser XFEL, which is still being built. To refit PETRA, the 2.3 kilometre long storage ring was completely modernised and a new experiment hall equipped with 30 measuring stations was built over 300 metres in length. "This involved the world's longest, continuous concrete slab being poured beneath the hall to guarantee the very best conditions for the experiments," says Dr. Hermann Franz, who co-ordinated the redevelopment project.
PETRA III delivers X-rays of a particular high brilliance. Very many photons are precision packaged to create a highly intensive light beam. This means that the atomic structure of extremely small material probes can also be examined. That is important for biologists who study complex molecules that do not form larger crystals. With the new light source, the biologists can already explain on the basis of tiny protein crystals how atoms arrange themselves spatially. And so they can, for example, develop new drugs that are applied exactly where pathogens attack. The brilliant X-ray source also opens up new opportunities for materials scientists. Particularly energy rich photons with a strong penetration capacity are needed to examine welding seams or to study material fatigue on tools. The PETRA storage ring can generate radiation of up to 100 kilo electron volts with a high brightness and hence is a lamp that provides a greater insight. "Now that all the dry runs have been successfully completed, the colleagues are looking forward expectantly to the first real experiments in order to throw an even sharper insight into the nanocosm," says Franz.

ARÖ

THE AERIAL PICTURE SHOWS THE PETRA III EXPERIMENT HALL THAT IS 300 METRES LONG AND HAS ROOM FOR 30 NEW EXPERIMENTS. Photo: DESY

Helmholtz-Zentrum Berlin für Materialien und Energie

MAGNETIC STRUCTURES DISPLAY NEW QUANTUM EFFECT

Using neutrons and synchrotron light, scientists at the Helmholtz-Zentrum Berlin für Materialien und Energie are currently addressing a magnetic phenomenon previously known only in the field of electronics. It is a kind of magnetic Quantum-Hall Effect. In the future, this might make it possible to build much higher performance computers. The complex reflection patterns that Dr. Konrad Siemensmeyer obtained in his scattering experiments with neutrons on the crystal lattice of the chemical compound thulium boride (TmB4) initially took his breath away. “At first, I thought it’s impossible to understand this,” admits the physicist. On closer observation, however, Siemensmeyer and his team were able to identify characteristic stripes. “If the effect had appeared at room temperature and not only at an icy ten Kelvin, we would probably even have written a patent rather than a scientific paper.” And he even has to laugh a little at his words.

> “If the effect had appeared at room temperature and not only at an icy ten Kelvin, we would probably even have written a patent rather than a scientific paper.”

Some of the magnetic structures discovered by Siemensmeyer and his team are less than ten nanometres (a millionth of a millimetre) in size. Such dimensions would be perfectly suitable as bits and bytes for computers. However, the materials scientists had not intended to invent particularly compact storage media. Siemensmeyer and his colleague, Dr. Ralf Feyerherm, who impressively confirmed the measurements with the help of synchrotron radiation at Berlin’s Electron Storage Ring BESSY II, were actually more interested in the fundamental interaction of the magnetic moments in the crystal lattice of this chemical compound made of thulium – a rare earth metal – and the metalloid boron. In so doing, however, they found something that could bring the materials sciences a significant step forward. At very low temperatures, the compound exhibits extensive plateaus in the magnetisation, and namely at values that can be depicted as fractions such as 1/7, 1/9, 1/11. This strongly resembles the well-known Quantum-Hall Effect, believes Siemensmeyer. “Only that these are magnetic phenomena.”

For his discovery of the Quantum-Hall Effect, the German physicist Klaus von Klitzing won the Nobel Prize for Physics in 1985. He was able to show that the electrical resistance in deep-cooled systems in which electrons only move at the surface increases step by step when a strong magnetic field affects the charge carrier. These plateaus can be set so exactly that they today form a basis for the international standard of electrical resistance. In addition, this provides a simple way of determining natural (physical) constants like the elementary charge or the Planck constant, which mark the starting point of modern physics. Just a few years later, the German Horst Ludwig Störmer and an American colleague discovered that Hall Resistivity can even manage fractional values. Together with the American Robert B. Laughlin, who was able to explain this phenomenon from a physical perspective, they also received the distinguished Swedish medal for their work in 1998. Laughlin believed that specific fluctuations in the solid bodies were responsible for this so-called fractional Quantum-Hall Effect. These excitations act in much the same way as the magnetic monopoles that had been predicted by theoreticians. These excitations act in much the same way as the magnetic monopoles that had been predicted by theoreticians. Siemensmeyer also believes that such explanations are possible. “However, it is still too early to state this with certainty,” supposes the materials scientist. “We need further experiments.”

Other experts presume that one day so-called quantum computers could be built with such stimuli. They not only compute with ones and zeros, like conventional computers, but also allow intermediate values. This is why they can compute many calculations much faster – for example, for sorting large volumes of data or splitting larger numbers into prime factors, which is important for encryption techniques. One advan-

USING NEUTRON SCATTERING EXPERIMENTS, DR. KONRAD SIEMENSMEYER HAS DISCOVERED AN INTERESTING EFFECT IN COMPLEX MATERIALS. PHOTO: HZB

tage would be that the quantum information could be robustly secured in a solid body. Furthermore, it would be possible to draw on the whole scenario of solid-state physics in the production phase. However, Siemensmeyer does not want to think that far ahead yet. "It's all still basic physics," he emphasises. Basic research that certainly offers access to a completely new and exciting form of physics. Quite a few surprises could well arise. GERHARD SAMULAT

GSI Helmholtz Centre for Heavy Ion Research

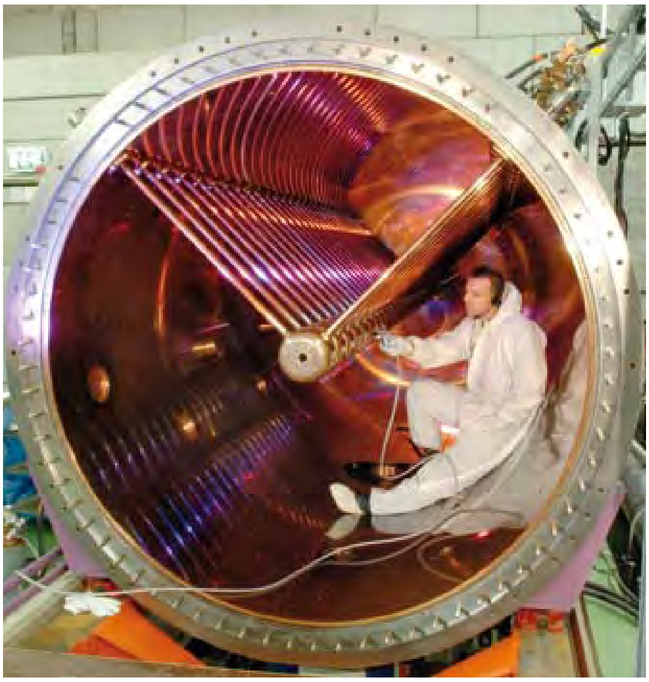
ELEMENT 112 TO BE NAMED „COPERNICIUM"

On Earth, super heavy elements no longer exist, they are unstable and can only be generated in accelerators for a very short time. The GSI Helmholtz Centre for Heavy Ion Research is a world leader in this field. This is where the elements 107, 108, 109, 110, and 111 were discovered and named.

"We agreed to propose the name 'Copernicium' for element 112, in honour of the astronomer Nicolaus Copernicus, who permanently changed our view of the world."

In early summer 2009, the relevant commission at the International Union of Pure and Applied Chemistry (IUPAC) also recognised the discovery of Element 112 at the GSI. Prof. Dr. Sigurd Hofmann and an international team of 21 scientists at the UNILAC accelerator of GSI were already able to detect an atom of Element 112 as early as in 1996. In further experiments using the accelerator lab RIKEN in Japan, super heavy 112 atoms have since been generated which confirm the GSI discovery. As the discoverers, Hofmann and his colleagues were able to propose what the new element's name should be. "We agreed to propose the name 'Copernicium' for element 112, in honour of the astronomer Nicolaus Copernicus, who permanently changed our view of the world," says Hofmann.

To produce element 112, the scientists fire zinc ions through the 120 metre long GSI particle accelerator onto a lead foil. Through nuclear fusion, the two atomic nuclei of the elements zinc and lead fuse to form the new element. It possesses the so-called atomic number 112, hence the provisional name "Element 112". The atomic number stands for the number of protons in the atomic nucleus. The atomic nucleus is circled by 112 electrons, which determine the chemical characteristics of the new element. GSI



A GLANCE INTO THE 120 METRE LONG LINEAR ACCELERATOR AT GSI.
Photo: G. Otto, GSI

RESEARCH FIELD AERONAUTICS, SPACE AND TRANSPORT

PROF. DR. JOHANN-DIETRICH WÖRNER
Vice-President of the Helmholtz Association, Coordinator of the Research Field Aeronautics, Space and Transport, German Aerospace Center (DLR)

GOALS AND ROLES

Mobility, communication and information are indispensable for modern national economies, but also involve risks such as environmental impacts and pollutants, risks of accidents, safety and security problems as well as ever more transport and traffic bottlenecks. Scientists at the Research Field Aeronautics, Space and Transport address these challenges. They draw up new concepts and technical solutions to problems and advise political decision-makers. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) is the only centre in the Helmholtz Research Field Aeronautics, Space and Transport. It is Germany's national research centre for aeronautics and space. Working on behalf of the Federal Government, the DLR is, in its capacity as the German Space Agency, additionally responsible for the conception and implementation of research within the national space programme and contributions made to the European Space Agency (ESA). The 13 DLR sites in total in the various federal states are closely networked with universities and non-university research institutions. The DLR also collaborates closely with other Helmholtz Centres, in particular with the two Research Fields Energy, on the one hand, and Earth and Environment, on the other. In the Research Field Aeronautics, Space and Transport new collaborative projects have been agreed and existing ones strengthened and consolidated, while new large-scale facilities have also been taken into commission. Atmosphere research has been given an excellent research platform in the form of HALO – the High Altitude and Range Research Aircraft. The German radar-eye in space, the satellite TerraSAR-X, entered its second successful mission year, and spring 2010 will see its partner TanDEM-X follow in its "footpaths".

At the DLR site in Braunschweig, a high-performance computer, the centrepiece of the Center for Computer Applications in AeroSpace Science and Engineering (C2A2S2E) went online. In the Helmholtz Alliance "Planetary Evolution and Life" six DLR institutes are working together with twelve partners largely from the university sector to study the conditions for the evolution of living organisms on other planets. Furthermore, the Institute of Air Transport Concepts and Technology Valuation was founded.

The Research Field Transport and Space was evaluated at the beginning of 2008 within the scope of the Helmholtz Association's programme-oriented funding and was renamed Aeronautics, Space and Transport as from 1 January 2009. The Helmholtz Annual Report at hand provides an overview of the structure and tasks of the Research Field in the period under report up to the end of 2008 and presents the three research programmes that form the strategic focus of the Research Field in the coming years. The previous and the new structure are explained by means of an overview of the distribution of funds in 2008 as well as the distribution of funds as from 2010. With effect of 2010, all six research fields will be in the second funding period.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2003–2008*

DLR scientists collaborate in three programmes.

- Aeronautics
- Space
- Transport

The work done in these programmes is characterised by their thematic and organisational integration under the DLR umbrella. Researchers in all three programmes have direct access to the shared core competencies they need in aerodynamics, structures and materials, communications, navigation, mechatronics and other fields. Synergies arise at the interface of aeronautics, space and transport, for example in the area of air and space-supported remote sensing.

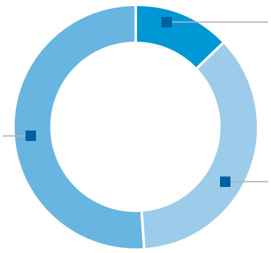
„The world's largest and most environmentally friendly passenger plane, the Airbus A 380, was developed in international collaboration based also on research work performed by the German Aerospace Center, a member of the Helmholtz Association. Impressive proof of the successful interlinking of basic and applied research of social and economic benefit."

DR. DETLEF MÜLLER-WIESNER
Senator of the Helmholtz Association, Senior Vice-President, Chief Operating Officer, Innovation and CTO Deputy Corporate Technical Office, EADS, Suresnes, France

*The first funding period in the Research Field Aeronautics, Space and Transport began in 2003 and was extended by one year to 2008.

Structure of the Research Field Aeronautics, Space and Transport*
Core-financed Costs 2008: 215m euros

The Research Field Aeronautics, Space and Transport additionally received 196m euros of external funds, providing it with a total budget of 411m euros.



*up to 31 December 2008 Transport and Space

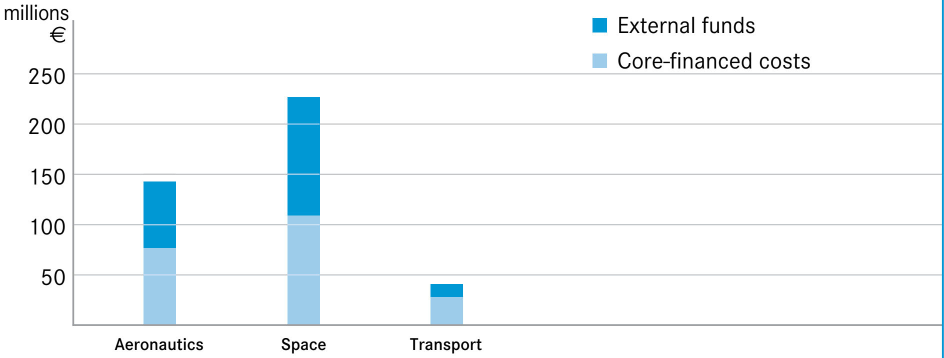
THE PROGRAMMES
IN THE FUNDING PERIOD 2003–2008*

Aeronautics
The aviation industry is shaped by European integration. This is why the programme is driving forward its networking with European partners, and especially with its French and Dutch partner organisations ONERA and NLR. The programme currently focuses on the continuing development of transport aircraft in collaboration with ONERA, on improving the flight guidance technology in collaboration with the NLR, and on expanding the DLR-NLR wind tunnel network by integrating the wind tunnels operated by ONERA. In terms of content, this research has set its sights on the following objectives: raising safety standards, reducing aircraft noise and emissions, and improving the cost-effectiveness and efficiency of the air transport system. The work on fixed-wing aircraft has been pooled under the umbrella of DLR/ONERA Aircraft Research. While the helicopter research conducted under the heading of DLR/ONERA Rotorcraft Research focuses particularly on expanding the flight envelope by ensuring flight safety, even under difficult weather conditions, and, at the same time, aims to improve the environmental compatibility of this air transport system. Another topic addresses efficient and environmentally-friendly propulsion systems. The programme topic Safe and Efficient Air Traffic Management concentrates research on air traffic control, above all in the vicinity of airports. Aviation and environment research is a cross-cutting, interdisciplinary topic. Scientists concentrate on air traffic with low pollutant and noise emissions, and wake vortice research, as well as the use of fuel cells in aircraft. Under the auspices of the ELBASYS project funded by the Federal Ministry of Economics and Technology (BMWi), a fuel cell has been integrated into the DLR research aircraft Airbus A320 ATRA. The research project on “Noise Optimised Approach and Departure Procedures” (LAnAb) has been completed. As a partner in the EU project VITAL, DLR aeronautics research was able to reduce carbon dioxide emissions from the engines by around seven per cent and noise emissions by six decibels. The company Snecma developed the concept for a counter-rotating, slow-turning blade wheel fan for engines with a high bypass ratio.

Space
Space research in Germany means R&D to provide direct benefits to the public and, simultaneously, inspiration for the future. In the long term, the fundamentals of human life can only be secured in a changing world when suitable data and information about Earth and what is happening there are available. Space flight plays a vital role here. At the same time, space flight also changes the image of Earth and the world beyond our planet. How did the universe come into existence? Is there life beyond Earth? How do space conditions influence biological and physical processes?
Germany’s strategic and political space objectives are implemented in an integrated space programme. A highlight in Earth observation was provided by developing and taking into commission TerraSAR-X along with the decision to build a further, practically identical satellite TanDEM-X in a public-private partnership. TanDEM-X will orbit Earth in close formation with TerraSAR-X. While TerraSAR-X has already delivered outstanding images for numerous applications in environmental research and landscape planning since 2007, TanDEM-X is to be launched into orbit in spring 2010.

*The first funding period in the Research Field Aeronautics, Space and Transport began in 2003 and was extended by one year to 2008.

Total Costs of the Research Field Aeronautics, Space and Transport* (2008)



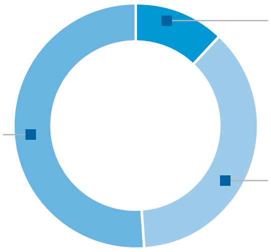
*up to 31 December 2008 Transport and Space

The DLR also heads the European "Network of Excellence in Satellite Communication". Furthermore, progress has been made with preparations for the Satellite Navigation System Galileo and its applications.
In recent years, the DLR contributed to international missions like Cassini (Saturn System), Venus Express, CoRoT (search for extra solar planets), DAWN (mission to two asteroids), Bepicolombo to Mercury as well as Mars Express and Rosetta. The programme topic Research under Space Conditions was examined both in terms of material sciences questions as well as life sciences questions of weightlessness in parabolic flights, sounding rockets and on the International Space Station.
In order to maintain the international competitiveness of the European carrier, key technologies are essential for carrier systems. This is why recent years have seen intensive research done on space propulsion systems, robust structures, innovative cooling concepts, and also for propulsion systems, numerical simulation as well as modelling and flight guidance.
The programme topic Technology for Space Flight Systems creates the basis for future space flight systems and missions by developing and providing innovative technologies. To this end, the DLR provides a number of technological components. These include robotics research for servicing robots in space, innovative operating technologies, development and qualification of new satellite components and the contribution to the "on-orbit verifications" test programme in the National Space Programme.

Transport

Even today, the transport system is already struggling to cope with the present volume of traffic and the amount of traffic is continuing to increase. This chronic overload increasingly jeopardises the competitiveness of the German and European economy. High traffic volumes also affect the environment, reduce people's quality of life, and clearly bear substantial risks of hazards and accidents. Hence, the Transport programme targets three overriding goals: maintaining mobility, protecting the environment and conserving resources, and improving safety levels. To achieve these goals, the DLR develops problem-solving approaches on terrestrial vehicles, traffic management and the traffic system, interlinking specific transport expertise with existing competencies from the fields of aeronautics, space and energy research.
Core topics in the development of road and rail vehicles of the next generation aim to optimise vehicle structures and energy systems, to minimise driving resistance and wear, and to enhance comfort levels while simultaneously reducing environmental impact Individualised (personal) assistance systems aim to further increase safety levels and to provide traffic users with situation-dependent assistance. Novel road, rail and airport management solutions contribute to improving the effectiveness and efficiency of infrastructure usage. Special traffic management information systems and tailor-made decision-making aids provide key support for the emergency services in the event of major incidents or disasters.

Structure of the Research Field Aeronautics, Space and Transport Core-financed Costs Plan 2010*: 255m euros
(including non-programme-bound research)



*Second year of the new Programme Funding Period 2009–2013

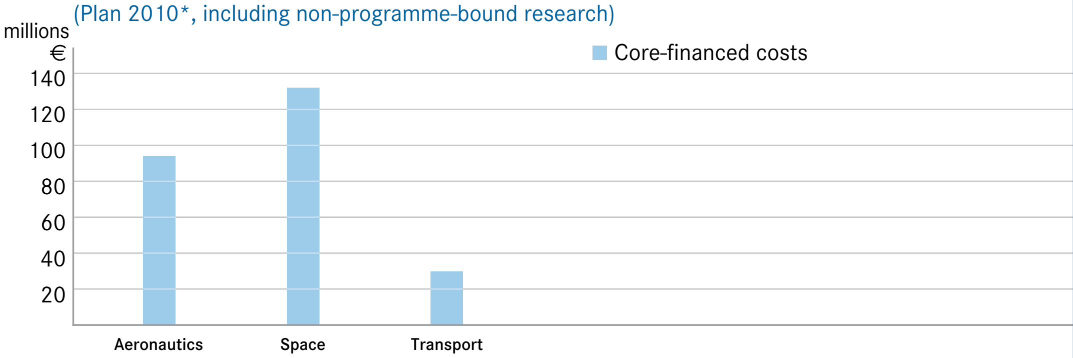
THE PROGRAMMES
IN THE FUNDING PERIOD 2009–2013

The combination of Aeronautics, Space and Transport programmes in a single research centre is unique in the European scientific landscape. This position will be further expanded and extended in the coming years. The German Aerospace Center (DLR) is integrated into the national, European and international research landscape and is excellently networked. This includes collaboration with other centres of the Helmholtz Association in the Research Fields Energy, Earth and Environment, Health, and Key Technologies. After being reviewed by an international panel of experts in 2008, the current period of programme-oriented funding from 2009 to 2013 will see further advances being achieved in the fields of aeronautics, space and transport which together contribute to solving current and future challenges.

Aeronautics
DLR aeronautics research is responsible for strengthening the competitiveness of the national and European aeronautics industry and air transport economy, thereby meeting the requirements of policy-makers and society. The key goals build on a foundation of research from the first round of programme-oriented funding which for the most part will be continued in the second round: research to raise the competitiveness, efficiency and performance of the air transport system, reducing aircraft noise pollution and harmful emissions, and guaranteeing air safety. These goals are targeted within the scope of European collaboration in the EREA Network. Research in these five research areas is conducted with the help of particularly equipped research aircraft, with the research aircraft HALO and ATRA deserving particular mention.

Space
In the Helmholtz Programme “Space”, scientists and researchers not only explore the solar system and the universe, but also develop and advance space flight, draw up technical solutions for transport and landing craft, and prepare concrete missions. All this includes collaboration with partners from industry, research institutions, universities, authorities and agencies, as well as public institutions.

Core-financed Costs of the Research Field Aeronautics, Space and Transport
(Plan 2010*, including non-programme-bound research)



*Second year of the new Programme Funding Period 2009–2013

Hence, the Helmholtz Space Programme is a central link between all the stakeholders and players contributing to space research. The goals for the next five years build on the results and challenges that came with the first funding period. In the field of Earth Observation, the national missions TerraSAR-X, TanDEM-X and EnMAP, the missions of ESA and EUMETSAT and the European GMES Initiative represent a priority focus. For the field of satellite communication, the deployment and use of optical connections through to the creation of a satellite-based terabits/s transport and distribution network is being researched and developed. In the field of satellite navigation, the focus is on creating Galileo and developing applications for it. The research on weightlessness, in particular on the ISS, which is just about to enter its full usage phase, will produce new insights into the material and life sciences. The future use of space for scientific, applied, tourist and technology missions calls for new key technologies in order to facilitate economic and safe space transport. Such key technologies are being studied and researched at the DLR.

Transport

The mobility of people and goods is a cornerstone of our national economy. Making it efficient, safe and environmentally friendly is a key challenge. In view of the constantly growing demand, singular ad-hoc solutions fall short of the requirement. Rather, it is necessary to pursue long-term viable approaches both for individual traffic modes as well as for multimodal transport systems which take the economic, social and ecological requirements into account. This is exactly where the DLR sets out its research contributions on the topics of road and rail vehicles, traffic management and traffic systems. This is made possible by explicitly interlinking the innovative ideas and specific expertise and competencies of researchers and scientists at more than 20 DLR institutes.

PROJECTS

German Aerospace Center (DLR)

WISDOM: KNOWLEDGE À LA CARTE

The Mekong is of the world's largest rivers. Its delta extends across 40,000 square kilometres in South West Vietnam. Tourists experience the Mekong Delta as a fruitful region through which uncountable waterways flow and on which the people in their boats engage in everyday life and business. The markets overflow with tropical fruits, three rice harvests per year and aquacultures for prawn and pangasius secure a modest level of prosperity. However, this idyll is threatened. Strong floods are experienced each year. The mangroves are disappearing. Biological diversity is declining quickly. And the soils are salinating and drinking water is in ever shorter supply. The information system WISDOM (Water-related Information System for the Sustainable Development of the Mekong Delta Vietnam) aims to enable the Vietnamese authorities to gain a better overview so that they can develop sustainable solutions for managing the short availability and supply of resources. Dr. Claudia Künzer from the German Remote Sensing Data Center (DFD) at the German Aerospace Center (DLR) is coordinating the major project in which 60 scientists and researchers and 15 doctoral students from 18 German and Vietnamese research centres and universities are working together.

The reasons for the increasing problems are complex. The population is growing, but climate change, too, as well as dam building in neighbouring countries, all play a role in this development. Time series at the Helmholtz Centre GFZ taken over the past 70 years show that extreme events such as particularly extensive floods and strong droughts are following each other in ever quicker succession. And because the delta has land heights of just a few metres above sea level, a small increase in the sea level already has a clear effect. The inflowing saltwater leads to the salination of the soil, the more intensive farming pollutes the water with residual pesticides and fertilisers.

"Our goal is to create a user friendly information system in Vietnamese that not only benefits the authorities in the capital, but also the decision-makers in the delta provinces, without requiring any special training," says Künzer. "For example, we explain this by taking the example of a restaurant. The ingredients are delivered in the cellar, i.e. the data, which are fed into the databases. The kitchen is on the ground floor, where the raw data are turned into maps and statistics through hidden database queries and algorithms to create added value. On the first floor, the guest gets the menu à la carte, namely the information that was ordered." For example, what areas in a specific region are particularly strongly affected by flooding? How densely populated are these areas, and what is grown there? Behind all this lies the knowledge of ten different subjects, ranging from hydrology via sociology through to remote sensing with satellites, Künzer's own special field. The scientists measure water levels and water quality, record how the land is used and ask locally about education levels, lifestyles and living conditions. "All the doctoral students and many scientists are working in the delta to carry out measuring campaigns and to ask the people, for example, whether they collect rainwater or how they purify their drinking water," reports Künzer. These surveys are jointly carried out by German and Vietnamese doctoral students.

> "Our goal is to create a user friendly information system in Vietnamese that decision-makers in the delta provinces can use without requiring any special training."

An important data basis is provided by Earth observation satellites, such as the radar satellite TerraSAR-X, which is managed by the DLR. TerraSAR-X records the extent of the flooding, the settlement density and the road network. Further data are then added from satellites such as MODIS, LANDSAT, SPOT, Quickbird, ALOS and ENVISAT. GFZ scientists have created a new network of sensors that transmit information on the local water level plus sediment and salt content to a field station. This is then complemented by the results of local, on-site studies that are also entered into the databases. "The project also improves the collaboration between the Vietnamese decision-makers and stakeholders who previously did not know about

WATER SHAPES THE LANDSCAPE AND INDUSTRY IN THE MEKONG DELTA IN VIETNAM. THIS IS DECISIVE FOR THE PLANNING. PHOTO: DLR

each other. Many only realise through our workshops how important it is not to keep the information to oneself, but rather to share it," says Künzer.
For the end users, the System currently still in a prototype stage will one day be as intuitive to us as Google Earth. Simple mouse clicks enable the overlay of various kinds of information like maps, satellite images, statistics, reports and photos – knowledge à la carte. In a possible follow-up phase (2010 to 2013) the WISDOM Information System will be led to maturity and finally transferred to the Vietnamese partners. Other countries are showing a strong interest in the technology, which can be transferred easily. ANTONIA RÖTGER
www.wisdom.caf.dlr.de

German Aerospace Center (DLR)

SPECIAL AIRCRAFT FOR ATMOSPHERIC RESEARCH

"The specially developed measurement instruments and devices plus the enormous performance capacity of the research aircraft HALO make it unique in the world," says Dr. Helmut Ziereis, who coordinates the work on HALO at the German Aerospace Center (DLR). HALO stands for "High Altitude and Long Range Research Aircraft". With an altitude of more than 15 kilometres and a range of over 20,000 kilometres, HALO can carry out measurements in the upper troposphere and lower stratosphere, even in extremely remote regions. These regions could previously only be reached selectively by means of measuring probes. Over many years, DLR experts at the site in Oberpfaffenhofen prepared the first missions, in close cooperation with partners from the Helmholtz Research Centres in Karlsruhe, Jülich and Potsdam, Max Planck Institutes, universities and the Leibniz Association.
The atmospheric researchers want to record and analyse the chemical reactions, transport processes and cloud formation in the troposphere. These not only influence global air pollution and ozone degeneration, but are also entered into the climate simulation models.
Using HALO they now want to study the large-area convection currents that determine regional weather events and are strongly influenced by climate change. The impact of aircraft flying in high altitudes has hardly been studied at all yet, for example, the question of whether and how the vapour trails in the upper troposphere increase the formation of ice clouds.
"However, before HALO can take off for science, complex external devices which carry important measurement instruments have to be installed on the plane, tested in flight and then approved," says Ziereis. These tests will take place from autumn 2009, so that HALO can fly for research as from 2010. ARÖ
www.halo.dlr.de

THE MEASUREMENT INSTRUMENTS ARE CURRENTLY BEING THOROUGHLY CHECKED AND TESTED. Photo: DLR

THIS IMAGE OF THE GOLDEN GATE BRIDGE AT THE ENTRY TO THE BAY OF SAN FRANCISCO DEMONSTRATES THE EXCEPTIONAL PRECISION OF THE TERRASAR-X IMAGES. PHOTO: DLR

German Aerospace Center (DLR)

RADAR SATELLITE LOOKS THROUGH THE CLOUDS

The satellite TerraSAR-X has been observing Earth for more than two years now. Terra, from the Latin, stands for Earth, SAR for the radar technology – Synthetic Aperture Radar – and X for the frequency range in the X-band. Using the radar technology, the satellite can also collect data from the Earth's surface in cloudy or dark conditions. The images are in great demand among scientists and commercial users. "TerraSAR-X is Germany's first radar satellite and simultaneously serves as the first national remote sensing satellite implemented in public-private partnership between the German Aerospace Center (DLR) and the company Astrium GmbH from Friedrichshafen," explains DLR Chairman of the Board, Professor Dr. Johann-Dietrich Wörner. "Germany is now a pioneer in collaborative space missions involving the public sector and industry," he emphasises. The DLR is responsible for the mission's planning and realisation, for operating the satellite and radar instrument as well as for the scientific use of the TerraSAR-X data.

> "Germany is now a pioneer in collaborative space missions involving the public sector and industry."

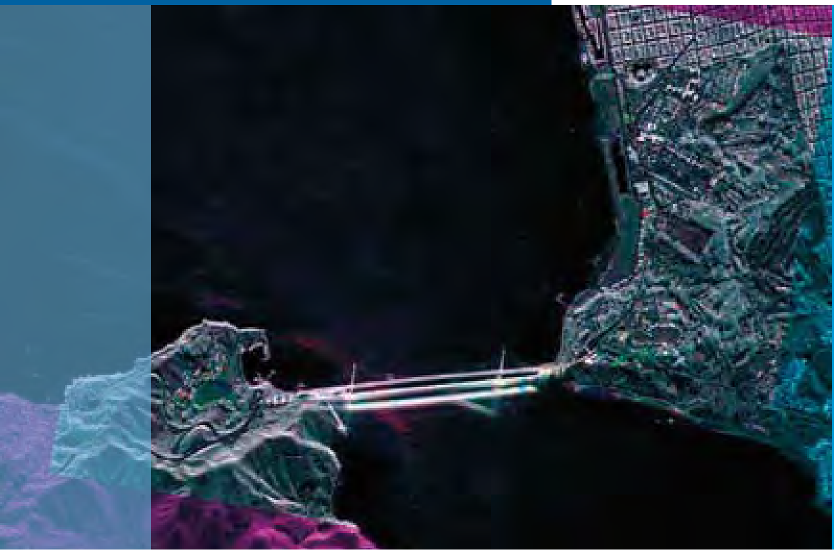
Since TerraSAR-X was launched, the DLR Mission Control Center has produced more than 35,000 radar images of the Earth's surface and processed these into some 50,000 high-quality products. Due to the high spatial resolution and a geometric accuracy which is well below one metre, it is also possible to fully automatically overlay two time-delayed images of a scene down to the last pixel. And this produces exciting pictures in which changes become visible. The radar instrument's radiometric precision and excellent stability continues to inspire the users, whether their applications are in the field of agriculture or forestry, or are needed for land use or vegetation assessments, or involve the observation of urban areas or are used in the field of cartography. Ice research or maritime applications also profit from these data.

In fact, the information gained so far has already been used on several occasions to provide crisis management support for international authorities following natural disasters. Flooded areas have been mapped or post earthquake damage assessed. When disastrous floods led to a million people being left homeless after weeks of rainfall at the beginning of November 2007 in the Mexican federal states of Tabasco and Chiaps, the DLR Center for Satellite Based Crisis Information (ZKI) supported the Mexican civil protection agency with satellite image maps of the flooded areas. Users can also draw on the TerraSAR-X data for traffic observation tasks. The DLR has already taken images of selected motorway sections in Germany, Austria, Switzerland, and of highways in California.

> "We can also measure the mean speed along motorways and so calculate the current travelling time between traffic intersections."

In contrast to stationary measurement methods, satellites gain traffic information without needing any ground-based installations, and what's more, regardless of the weather conditions and even across borders. Applications are not only limited to recognising traffic jams. "We can also measure the mean speed along motorways and so calculate the current travel time between traffic intersections," explains Hartmut Runge from the DLR's Remote Sensing Technology Institute (IMF). These data help traffic information service providers to verify the data collected with conventional methods and so they can close any gaps in their information network.

The example of a spectacular image taken of the Golden Gate Bridge at the entry to the Bay of San Francisco clearly highlights the exceptionally high localisation precision of the TerraSAR-X images. It even shows the bridge mirrored on the water surface as a result of the radar signal reflecting between bridge and water surface. Even the two primary cables with a diameter of 0.92 metres and the suspender at a distance of 15 metres can be recognised. By overlaying three



different colour coded images taken at different times, the changes produced between these images appear in colour. All the unchanged areas are grey.
Spring 2010 will see a second almost identical German radar satellite, TanDEM-X, launched into space from the Russian launch pad at Baikonur. The German double will then fly in close formation with distances of between several kilometres and 200 metres. This will involve the new satellite, TanDEM-X, practically dancing around TerraSAR-X. Together the two satellites will deliver three-dimensional data products that lead to a global, digital altitude model of all the land masses of the Earth's surface with a previously unattained level of precision. CORDULA TEGEN

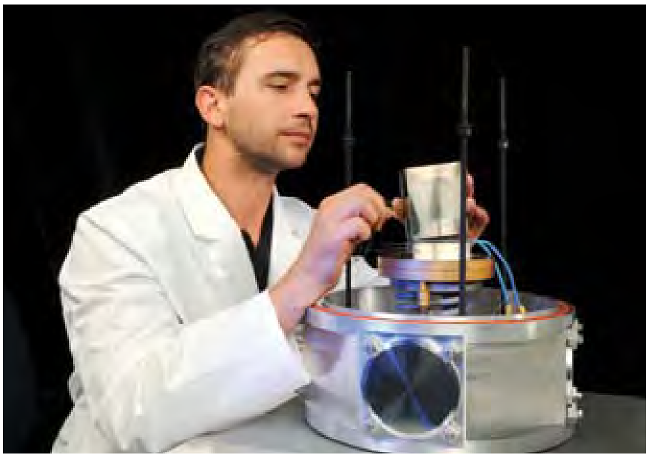
German Aerospace Center (DLR)

200 WATTS OF POWER OUTPUT THROUGH EXHAUST HEAT

The waste heat from car exhausts currently escapes alternator car battery. "Hidden reserves lie here. We could use the waste heat and convert it into electrical power," explains Dr. Wolf Eckhard Müller, Head of Department at the Institute of Materials Research at the German Aerospace Center. Because a temperature difference between two different metals or semiconductor materials can generate a voltage via the so-called Seebeck effect. Such thermoelectric generators, called TEGs in short, generate power in space probes, for example, from the decay heat of a radioactive isotope. However, the technology used there is expensive and unsuitable for road traffic. "Rather, we are interested in taking this technology out of space and bringing it back to Earth. To achieve this, we are working on affordable and safe thermoelectric generators that use the waste heat that is produced anyway," says Müller. The first step has already been completed. Working in cooperation with DLR experts, car maker BMW Group has already equipped a test vehicle with a TEG that can withstand up to around 200 watts of power for the on-board electrics from the waste heat. This TEG, which was directly integrated into the exhaust gas system, contains the compound bismuth telluride, which can generate temperatures of around 250° Celsius.

"We expect to achieve fuel savings of up to 5 per cent."

However, most of the waste heat from engines and energy plants – whether in traffic or in industry – arrives at much higher temperatures of 400° to 500° Celsius. This is why the DLR materials experts are already researching completely new material classes, such as chalcogenides, skutterides, silicides and clathrates, mostly in the form of solid solutions and nanomaterials. In the lab, they have already set their sights on later mass production and are also working on new manufacturing and bonding methods. "We expect to achieve fuel savings of up to 5 per cent with such improved thermoelectric generators," explains Müller. ARÖ



USING A TEST STAND TO MEASURE THE EFFICIENCY OF A THERMOELECTRICAL GENERATOR. Photo: DLR

THE SCIENCE PRIZE OF THE STIFTERVERBAND – ERWIN SCHRÖDINGER PRIZE 2009

TITANIUM FROM JÜLICH: POROUS YET STRONG

This year's honours go to a materials scientist from Jülich and an expert from the Swiss medical technology company Synthes. They share the Science Prize of the Stifterverband – Erwin Schrödinger Prize. The prize is worth 50,000 euros and was presented to the winners at the Helmholtz Annual General Assembly held in Berlin on 17 September 2009.

The Helmholtz Association and the Stifterverband have been awarding the prize to scientific and technical projects that extend across the borders of subject areas for ten years now. "The scientists were chosen for the award because they optimised a method from the field of fuel cell development to create a completely different application. The implant they developed together with industrial partners can enable patients with seriously damaged intervertebral discs to live a practically pain-free life," explained Prof. Dr. Jürgen Mlynek, President of the Helmholtz Association.

This year's prize is shared by Dr. Martin Bram, Dr. Hans-Peter Buchkremer and Prof. Dr. Detlev Stöver from the Institute of Energy Research at the Forschungszentrum Jülich and Dr. Thomas Imwinkelried from the Swiss company Synthes. The experts from Jülich developed a patented manufacturing method for producing tailor-made pores in high-tech materials. Working in close collaboration with Dr. Thomas Imwinkelried from the Swiss company Synthes, the scientists optimised the method for titanium until they were able to produce pores exactly the right size to facilitate the colonisation with bone cells and enhance bone ingrowth. In this way it is possible to firmly anchor the implant quickly and so ensure stability and freedom from pain. Despite its high porosity, the implant meets all the requirements needed to be able to resist the strong, permanent and repeated loads that arise when humans move. The company Synthes, the world market leader in osteosynthesis as well as dental and spinal surgery, performed the necessary tests for the market launch, beginning with cell culture experiments through to pre-clinical studies. Synthes markets the implants with know-how from Jülich under the trade name "PlivioPore".

Originally, the researchers from Jülich had developed porous materials like these for fuel cells. When they presented their "metal foams" at a specialist congress in 2001, the company Synthes approached the research group. "It all went pretty quickly then from initial idea through to the finished product, 'PlivioPore'," says project coordinator Dr. Martin Bram. The implant has already successfully passed the clinical test phases and is being used to enable people with seriously damaged discs to live a practically pain-free life again. The physicians do this by placing two rectangular implants horizontally in place of the defective disc. Over the course of time, they bond with the neighbouring dorsal vertebrae and stabilise them. The Jülich team is already working on the next generation. "We want to use injection moulding to directly manufacture porous metal parts," reveals Bram. This method does without the mechanical processing of the implants, which simplifies the production process and makes it more cost effective.

THE PRIZE WAS PRESENTED BY THE SECRETARY-GENERAL OF THE STIFTERVERBAND, PROF. DR. ANDREAS SCHLÜTER AT THE ANNUAL GENERAL ASSEMBLY OF THE HELMHOLTZ ASSOCIATION (FROM LEFT TO RIGHT: PROF. DR. JÜRGEN MLYNEK, PRESIDENT OF THE HELMHOLTZ ASSOCIATION, THE PRIZEWINNERS PROF. DR. DETLEV STÖVER, DR. THOMAS IMWINKELRIED, DR. HANS-PETER BUCHKREMER, AND DR. MARTIN BRAM, DR. ANDREAS SCHLÜTER). Photo: Helmholtz/D. Ausserhofer

10TH ANNIVERSARY OF THE SCIENCE PRIZE OF THE STIFTERVERBAND FÜR DIE DEUTSCHE WISSENSCHAFT – ERWIN SCHRÖDINGER PRIZE

2008 **Network of Protein-Protein Interactions in the Human Body**
The Prizewinners
Prof. Dr. Erich E. Wanker, Max Delbrueck Center, Berlin-Buch
Dr. Ulrich Stelzl, MPI for Molecular Genetics
Dipl.-Ing. Christian Hänig, Max Delbrueck Center, Berlin-Buch
Gautam Chaurasia, M.Sc., Humboldt-Universität zu Berlin
Dr. Matthias Futschik, Humboldt-Universität zu Berlin

2007 **Analysis of the Strategies of Bacteria in Complex, Natural Surroundings**
The Prizewinners
Dr. Burkhard A. Hense, GSF – National Research Center for Environment and Health[1)]
Dr. Christina Kuttler, GSF – National Research Center for Environment and Health[1)]
Prof. Dr. Johannes Müller, GSF – National Research Center for Environment and Health[1)] and TU München
Dr. Michael Rothballer, GSF – National Research Center for Environment and Health[1)]
Prof. Dr. Anton Hartmann, GSF – National Research Center for Environment and Health[1)]
Dr. Jan-Ulrich Kreft, University of Bonn

2006 **Innovative Heating for the ITER Fusion Test Reactor**
The Prizewinners
Dr. Hans-Dieter Falter, Max Planck Institute for Plasma Physics
Dr. Werner Kraus, Max Planck Institute for Plasma Physics
Dr. Ursel Fantz, Max Planck Institute for Plasma Physics
Dr. Peter Franzen, Max Planck Institute for Plasma Physics
Dr. Eckehart Speth, Max Planck Institute for Plasma Physics

2005 **Deep Brain Pacemaker for Parkinson's Sufferers based on Mathematical Models**
The Prizewinners
Prof. Dr. Dr. Peter A. Tass, Forschungszentrum Jülich
Prof. Dr. Volker Sturm, University of Cologne

2004 **Separating Metallic and Semiconducting Carbon-Nanotubes**
The Prizewinners
Marcel Mayor, Forschungszentrum Karlsruhe[2)]
Frank Hennrich, Forschungszentrum Karlsruhe[2)]
Ralph Krupke, Forschungszentrum Karlsruhe[2)]
Heiko Weber, Forschungszentrum Karlsruhe [2)]

2003 **The Dynamics of Ca2 in Living Cells**
The Prizewinners
Dr. Martin Falke, Hahn-Meitner-Institut Berlin[3)]
Prof. Dr. Patricia Camacho, University of Texas, San Antonio
Prof. Dr. James Lechleitner, University of Texas, San Antonio

2002 **Improving the Efficiency in the Production of Oil-in-Water Emulsions**
The Prizewinners
Dr. Jürgen Allgaier, Forschungszentrum Jülich
Prof. Dr. Gerhard Gompper, Forschungszentrum Jülich
Prof. Dr. Dieter Richter, Forschungszentrum Jülich
Dr. Thomas Sottmann, University of Cologne
Prof. Dr. Reinhard Strey, University of Cologne

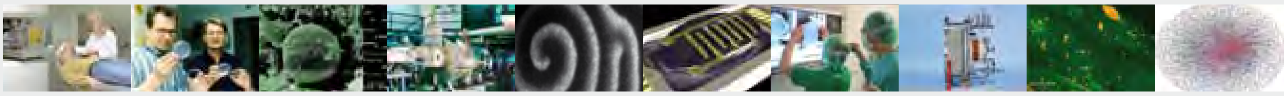
2001 **Filtering Microbial Mercury from Waste Water**
The Prizewinners
Dr. Irene Wagner-Döbler, German Research Centre for Biotechnology[4)]
Prof. Dr. Wolf-Dieter Deckwer, German Research Centre for Biotechnology[4)]
Prof. Dr. Kenneth Nigel Timmis, German Research Centre for Biotechnology[4)]

2000 **Guides for Immune Defence**
The Prizewinners
Prof. Dr. Reinhold Förster, Max Delbrueck Center, Berlin-Buch
Dr. Elisabeth Kremmer, GSF – National Research Center for Environment and Health[1)]
Dr. Dr. Martin Lipp, Max Delbrueck Center, Berlin-Buch
Prof. Dr. Eckhard Wilhelm Wolf, LMU Munich

1999 **Preparation, Development and Clinical Introduction of Cancer Therapy with Ion Beams**
The Prizewinners
Prof. Dr. Gerhard Kraft, Gesellschaft für Schwerionenforschung[5)]
Dr. Wolfgang Enghardt, Forschungszentrum Rossendorf
Dr. Dr. Jürgen Debus, German Cancer Research Center

The Erwin Schrödinger Prize is worth 50,000 euros and is awarded alternately by the Helmholtz Association and the Stifterverband für die Deutsche Wissenschaft for outstanding interdisciplinary work.

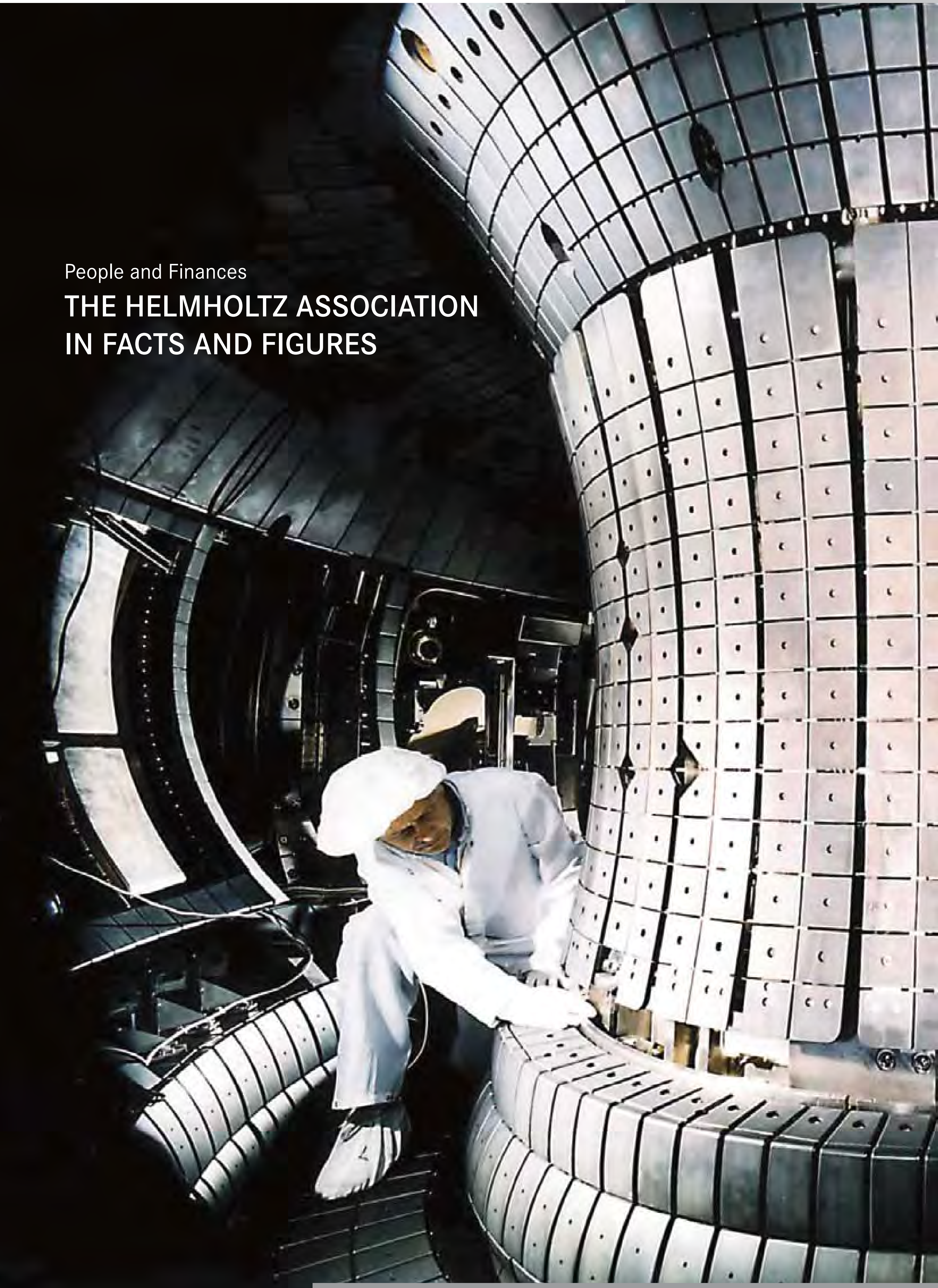
1999 2008



[1)] Now Helmholtz Zentrum München – German Research Center for Environmental Health. [2)] Now Karlsruhe Institute of Technology. [3)] Now Helmholtz-Zentrum Berlin für Materialien und Energie. [4)] Now Helmholtz Centre for Infection Research. [5)] Now GSI Helmholtz Centre for Heavy Ion Research.

People and Finances

THE HELMHOLTZ ASSOCIATION IN FACTS AND FIGURES

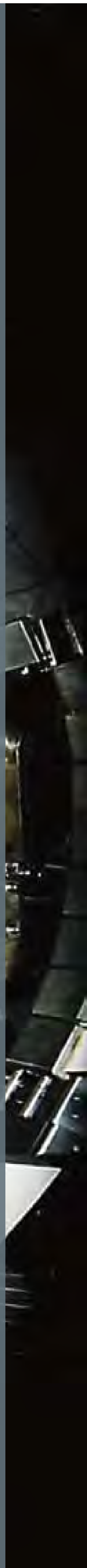


"In a 'flat Earth' environment, it is those nations that have laid the basis for the technologies of the future that will be in the driver's seat – especially in those areas of manufacturing that are centrally dependent upon 'high tech'. For this reason, the work of the Helmholtz Association – its Centres and Institutes – in the various areas of 'structure of matter', the fundamental sciences and technologies underlying virtually all areas of modern 'high technologies', provides the long-term basis for building Germany's capabilities as a major international competitor in forefront technologies – from electronics and IT to aeronautics, robotics, and green energy technologies, and to medical sciences and health care. The translation of such fundamental research to the practicum of industry takes time – sometimes decades – and therefore requires foresight and patience: And it is a core function of the Helmholtz to look into the future, to provide this foresight, and through its successes to calm German society's apprehensions, to secure its patience, and to allow Germany to face the future with confidence."

PROF. DR. ROBERT ROSNER, Senator of the Helmholtz Association, University of Chicago, USA

"Comprehensive system competence is called for. Maintaining and improving the range of mobility options for people and goods is one of the central tasks for the future. Numerous factors coincide, such as people, driver assistance systems, efficiency and traffic safety, energy costs and availability, environmental protection (in particular, CO_2, NOX, HC, CO and airborne particulate matter). The energy categories ranging from hydrogen, bio energy, petrol and diesel fuel, mineral oil-based resources through to electricity alone show how complex the combinations can be. Engines and drives depend on fuel, while the use of alternatives always has to consider the overall process – from source through to wheel. The Helmholtz Association has the expert institutions that can and must contribute to producing the necessary solutions."

PROF. DR. ULRICH SEIFFERT, Senator of the Helmholtz Association, Managing Director of WiTech Engineering GmbH, Braunschweig



TALENT MANAGEMENT IS A KEY ELEMENT IN THE HELMHOLTZ CULTURE

Comprehensive talent management is a key element in the Helmholtz Culture. We promote young scientists and investigators, and also offer our staff a wide range of opportunities to enable them to develop and unfold their talents. In addition to this, we are also strongly committed to the education of children and youngsters. The Helmholtz Association is proud of the intensive support that it provides for young postdocs to enable them to enter a career in science.

The Helmholtz Association supports the early independence of young scientists and researchers with its Helmholtz Young Investigators Groups and offers them reliable career prospects. This makes the centres attractive for creative talents from all around the world. The funding targets scientists and researchers who have gained a doctorate in the last two to six years, minus child raising periods. They can establish and head their own research group – and what is more under the excellent working conditions of a major research centre. The young scientists and researchers selected in a multi-stage process are initially given a five-year employment contract and, during this period, receive an annual budget of 250,000 euros with which they can set up their group and push ahead with their research. At the same time, they are given the prospect that their research work could continue to be financed by the centres, if they are positively reviewed in an evaluation process (tenure track option). This offer has already succeeded in bringing scientists and researchers from distinguished foreign institutes to Germany. In addition to the 116 Helmholtz Young Investigators Groups funded so far, the Helmholtz Centres have established further independent Young Investigators Groups that are led by young and early-stage researchers. This programme attaches particular importance to close cooperation with universities and higher education institutions. The Young Investigators Group Leaders collaborate with the universities, gain teaching experience and acquire the qualifications needed for an academic career. Some of them have already been jointly appointed to a junior or assistant professorship by the Helmholtz centre and the university. The Helmholtz Association aims to introduce this joint appointment procedure for all Young Investigators Group Leaders who have excelled in their successful research work.

Structured path to a doctorate

Two further instruments make the Helmholtz Centres attractive for the best young scientists and researchers from around the world: the Helmholtz Graduate Schools and Helmholtz Research Schools. These support and promote young scientists and researchers who have just completed their studies and offer a structured path to a doctorate together with reliable frameworks for their academic supervision as well as a personal qualification programme. The Graduate Schools provide a roof for doctoral students from various subject areas. These graduates work on their doctorate, while simultaneously engaging in the training given in joint seminars, lectures and internships. This concurrent training extends far beyond the field of the doctorate itself and additionally delivers the key qualifications needed for a career in science and business and industry.

The Helmholtz Association has additionally established so-called Helmholtz Research Schools at some centres that focus on individual research topics. Up to 25 highly talented doctoral students can engage in collaborative research in these research schools. In addition, they are supported with courses to advance their professional qualifications and their personal development. The Helmholtz Association has concluded agreements with part-

MAY 2009: GRADUATION OF THE FIRST HELMHOLTZ MANAGEMENT ACADEMY COHORT.
Photo: Helmholtz/D. Ausserhofer

ners to achieve this, such as with the Graduate School at Imperial College London. The English-speaking Helmholtz Research Schools raise the centres' appeal for foreign doctoral students.

The Helmholtz Management Academy

The Helmholtz Management Academy prepares excellent young scientists and researchers as well as the coming generation of managers in infrastructural and administrative fields for their future management responsibilities. An external partner, the Malik Management Zentrum St. Gallen, is responsible for the content and methodology of the training programme. The participants spend 18 months attending on-site seminars coupled with independent learning, into which topics from their current work are integrated. Between the workshops, work on the topics is continued via an e-learning platform in order to create an end-to-end learning environment. A specially developed mentoring programme additionally supports the expansion of a management network within the Helmholtz Association. The Academy started its activities in autumn 2007 with 30 young managers from the Helmholtz Centres. In summer 2009, the first academy cohort celebrated their graduation. In the meantime, the third year cohort has just begun with 62 participants, including some from universities as well as from other science and research organisations.

Creating more equal opportunity

Experiential knowledge and an efficient network are prerequisites for a successful career and excellent research management. The mentoring programme "In Führung gehen" (Leading the Way) supports young women in acquiring these prerequisites so that they can actively plan their career and take on management positions. On the one hand, the programme targets postdoctoral women scientists who have already gained some initial experience as group or project leaders. On the other hand, young women from the administrative and management sphere who are aspiring to a leading management position are fostered. The mentees come from various centres of the Association. Individuals from the executive level of the Helmholtz Centres as well as from other science and research organisations take on an active role as mentors. This "cross-mentoring" specifically strengthens the networking among the participants within the Association and also within the science community in general.

Promoting talent before university

To awaken an early interest in the natural sciences, technology and engineering, the Helmholtz Association and the Helmholtz Research Centres have created a network of school labs that are intensively used by school classes and for the professional development and in-service training of teachers. This is where children and youngsters do hands-on experiments and gain an insight into research, where teachers can get to know new ideas and enter into exchange with others. More than 50,000 pupils and students meanwhile visit the Helmholtz School Labs every year, which are now based at 24 sites. The diversity of topics and methods is as broad as the breadth of research priorities of the individual Helmholtz Centres.
The initiative "Haus der Kleinen Forscher" (Tiny Tots' Science Corner) aims to strengthen early child education by giving children in all of Germany's day-care centres and kindergartens the chance to experience technology and the natural sciences for themselves. This rapidly expanding, nationwide initiative is financed by the Helmholtz Association, management consultants McKinsey & Company, Siemens AG, the Dietmar Hopp Foundation and the Federal Ministry of Education and Research. Local networks ensure that educators and kindergarten staff can profit from professional development and in-service training courses offered locally on site, which have been developed by the initiative. To achieve this, the networks send out trainers, provide extensive working material and award participating day centres the title "Haus der Kleinen Forscher". Some 8,000 day nurseries and day-care centres in Germany are already taking part in the scheme.
By engaging in all these activities, we want to make a contribution to ensuring that young people can be inspired for natural sciences and technology, that many of them later decide to study these subjects and that the best apply to the Helmholtz Centres, because we offer particularly attractive working conditions and opportunities for our staff and scientists to continue their personal and professional development.

PARTNER IN THE JOINT INITIATIVE FOR RESEARCH AND INNOVATION

As a partner in the Joint Initiative for Research and Innovation, the Helmholtz Association has committed itself to making its contribution to growth and prosperity: through scientific excellence, by improving collaboration and networking in Germany itself as a centre of science as well as on the international stage, by promoting young scientists and researchers, fostering equal opportunity, engaging in knowledge transfer, and encouraging innovation through new approaches.

Last year, the Helmholtz Association took a number of important steps towards fulfilling these tasks. These activities are financed, on the one hand, by programme-oriented funding, and, on the other, by the President's Initiative and Networking Fund. The Joint Initiative for Research and Innovation strengthens both sources of funding by guaranteeing an annual increase of three per cent to the total budget of the Helmholtz Association and has made it possible to top up the Initiative and Networking Fund from 58.5 million euros in 2009 to 60 million euros in 2010.

Assuring excellence through competition

All funds in the Helmholtz Association are awarded on the basis of competitive science-based processes. The scientific quality of the research programmes developed by the Helmholtz Centres is assessed by international review panels every five years. A total of 1.621 billion euros are being spent in the programme-oriented funding system in 2009.

All funds in the Helmholtz Association are awarded on the basis of competitive science-based processes.

In 2008, the three Research Fields Aeronautics, Space and Transport*, Health, and Earth and Environment were evaluated. Their high quality was confirmed in this process. Within the scope of the reviews, a number of measures were identified that open up new fields for German Research or complement existing ones.
Outstanding examples include a cross-programme Climate Research Initiative, the expansion of translational research, and

*Up to 31.12.2008 Transport and Space.

PROVIDING INSPIRATION AND NETWORKING

The Initiative and Networking Fund

- Helmholtz Alliances
- Helmholtz Virtual Institutes
- Promoting young scientists and researchers
- Creating frameworks and conditions for top-rate research
- Assuring excellence

the creation of a Helmholtz Cohort Study with 200,000 subjects to identify the risk factors that play a role in the development of common diseases such as cancer, diabetes, dementia, and cardiovascular diseases. The Research Fields Energy, Structure of Matter, and Key Technologies were reviewed from January to April 2009.
Competing at national and international level, the Helmholtz Centres were able to assert themselves in the Excellence Initiative, in the Calls for Proposals for the 7th EU Research Framework Programme (FP7) and in the Starting Grants of the European Research Council. In the period from 2008 to 2009, Helmholtz scientists and researchers also won numerous prizes, including the 2008 Nobel Prize for Medicine received by Professor Dr. Dr. Harald zur Hausen.

By building and running research infrastructures that are unique in the world, the Helmholtz Association creates ideal competitive conditions for top-rate research in Germany and in the European Research Area.

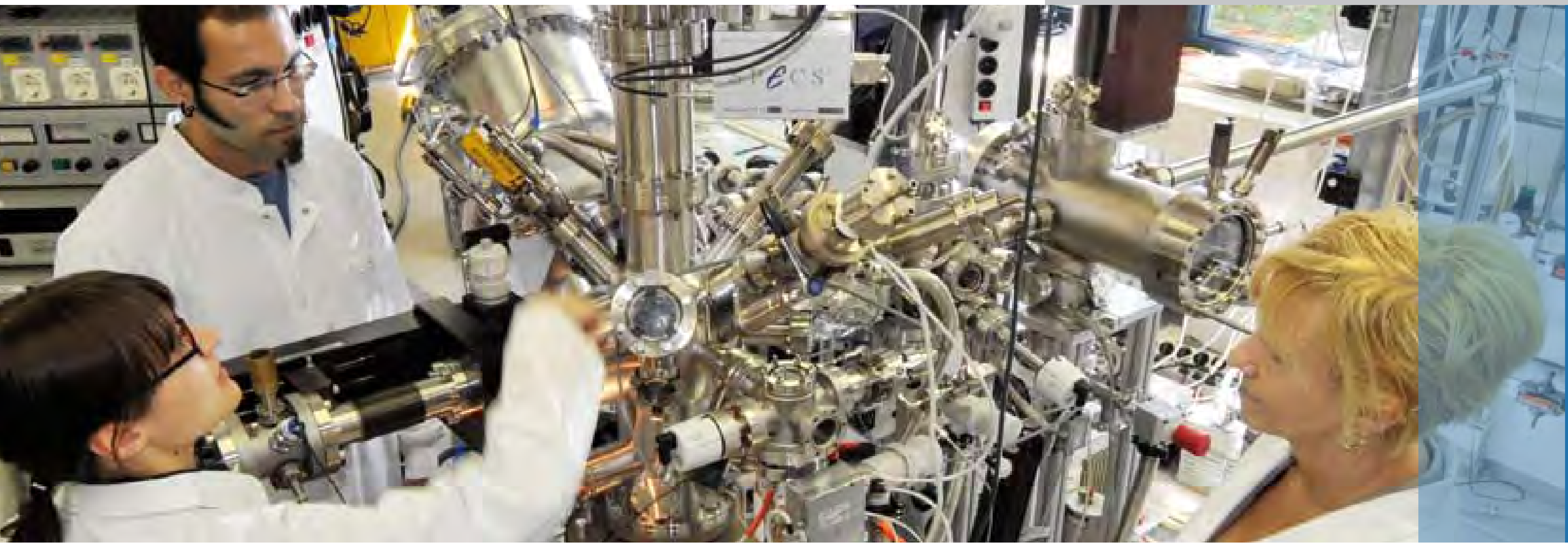
However, the Helmholtz Association not only participates in national and international calls and programmes. By building and running research infrastructures that are unique in the world, the Association creates ideal competitive conditions for top-rate research in Germany and in the European Research Area. For, challenges like climate change with its many different regional impacts, sustainable security of the energy supply, providing a rapidly growing world population with vital resources, or combating widespread diseases can only be managed on a global scale and in long-term collaborations. Hence, the Association's Centres, with their worldwide collaborations and the leading role they play in coordinating major international research projects, such as those pursued by the European Strategy Forum on Research Infrastructures (ESFRI), make an essential contribution to maintaining and expanding Germany's science base. Each year, some 4,500 guest scientists and researchers conduct research at the Helmholtz Centres' scientific infrastructures, of which some are globally unique.

Creating promising partnerships for the future

The Helmholtz Association Centres not only collaborate closely with universities and non-university partners in research and in promoting young and early-stage scientists. These forms of collaboration extend from research networks such as the Helmholtz Alliances through to the three Helmholtz Institutes founded in 2009, which are to be built on the campus of the partner institutions. Over and above this, further important strategic networks are being established, such as in the field of diabetes research. While the merger between the Hahn-Meitner-Institut (HMI) and the Berliner Elektronen-Speicherring Gesellschaft für Synchrotronstrahlung (BESSY) to form the Helmholtz-Zentrum Berlin für Materialien und Energie has been completed.
In 2008, Federal Research Minister Professor Dr. Annette Schavan commissioned the Helmholtz Association with the conception of a new research centre to pool the competence and expertise of dementia research in Germany, to close gaps in the research, to accelerate the progress being made and to improve patient treatment and care. The project provides for a decentralised structure: a primary centre with a broad thematic range working in collaboration with specialised partner institutions at universities, university hospitals and other research institutions. Following the planning phase, the German Centre for Neurodegenerative Diseases was founded on 3 April 2009 under the roof of the Helmholtz Association.

Encouraging knowledge and technology transfer

The Helmholtz Association has been commissioned with combining research and technology development with novel



perspectives for innovative applications and foresighted provisions for tomorrow's world. This includes engaging in regular exchange with industry as well as improving people's living conditions, for example by remediating polluted waters and soils. Given this background, knowledge and technology transfer is a very important aspect in the Helmholtz Association. Last year, the Helmholtz Centres implemented numerous technology transfer measures. These encompassed strategic partnerships with industry and universities, licence agreements

The Helmholtz Association has been commissioned with combining research and technology development with novel perspectives for innovative applications and provisions for tomorrow's world.

with companies and enterprises, as well as spin-offs. Hence, Bayer Schering Pharma AG and the Helmholtz Association's German Cancer Research Center aim to engage in strategic collaboration with the aim of accelerating the use of research findings for the development of new therapies and drugs against cancer. In the next two years, the two partners will each invest 1.75 million euros in collaborative cancer research projects.
A successful licence agreement was signed between Rolls-Royce Deutschland GmbH and the GKSS Research Centre Geesthacht on applications of titanium aluminide alloys. GKSS materials scientists developed an ultra-light and yet extremely stable material made of titanium aluminide which is used in making parts for aircraft engines. The "Helmholtz Enterprise" instrument financed by the President's Initiative and Networking Fund has meanwhile supported 45 spin-offs with funding totalling around 4.1 million euros in the four years since the instrument was established. A particularly successful example is provided by Sulfurcell Solartechnik GmbH, a spin-off from the Helmholtz-Zentrum Berlin für Materialien und Energie.

Building on talent management and equal opportunity

In establishing the Helmholtz Management Academy, the Helmholtz Association has launched a project of great leverage and has consolidated the significance of management in science.
In May 2009, the first year's intake for the Helmholtz Management Academy completed their training, while the second intake had already started its round in October 2008. The third cohort started in 2009 and integrates participants from universities and other non-university organisations for the very first time.
The Helmholtz Association Centres additionally run many doctoral programmes. In 2008, two new Helmholtz Research Schools and three Graduate Schools where approved for funding from the Initiative and Networking Fund. All in all, six Graduate Schools

The Helmholtz Association particularly aims to raise the proportion of women when filling new decision-making and management positions.

and seven Helmholtz Research Schools are being supported. Within the scope of the Helmholtz Research Schools, in particular, young scientists and researchers are being prepared in methodological workshops and seminars for a successful career in science or industry. A further element in the Helmholtz strategy to promote young talent is provided by the establishment of independent Young Investigators Groups. These offer the best young scientists and researchers early scientific independence, good research conditions, as well as reliable career prospects (tenure track) based on proven scientific performance. A total of 96 Helmholtz Young Investigators Groups are currently receiving support from the Initiative and Networking Fund.
Equal opportunity as one of the Helmholtz strategies includes a range of activities and schemes that focus their actions in line with the respective target group's age. Measures such as those meanwhile offered by the Centres' 24 schools labs

serve, on the one hand, to promote an early interest among boys and girls for research and technology. In the career decision stage, special offers for girls aim to make them feel more confident about their own technological skills and competence. The Helmholtz Association also aims particularly to raise the proportion of women when filling new decision-making and management positions. Among other aspects, the meanwhile advanced and upgraded Helmholtz Mentoring Programme for young women “In Führung gehen” (Taking the Lead) is contributing to this. Its goal is to prepare young, career-oriented women from science and administration for more demanding career positions and management responsibilities and to sustainably strengthen their networking within the Helmholtz Association.

Strategically and sensibly shaping the future

The Helmholtz Association has, in dialogue with the Committee of Financing Partners, reached agreement on the commitment which it is prepared to make to an extension of the Joint Initiative for Research and Innovation beyond 2010. At the same time, it has started a discussion process on how it can best continue to develop its role in the national and international science system and so contribute to assuring Germany’s position as a centre of top-rate science and research. In September 2008, the Helmholtz Association additionally completed its work on a strategic agenda. The President and boards of the member institutions drew up a position paper on this – the so-called Liebenberg Paper. It describes the objectives for the continuing development of the Helmholtz Association. The key elements in this position paper are the decisions on developing and opening up new fields of research, and the advancement of quality management as well as ways to optimise decision-making structures in the Association. With these courses of action the Helmholtz Association intends to realise its scientific potential to the full and so, last but not least, to ensure that the implementation of the measures of the Joint Initiative for Research and Innovation is translated into reality.

The decision by the Committee of Financing Partners to continue the Higher Education Pact, the Excellence Initiative and the Joint Initiative for Research and Innovation marked a very positive development for science. In reaching this decision, the policy-makers have, despite the difficult budgetary situation, sent out an important signal for Germany’s future – both nationally and internationally. The additional financial resources – amounting to 18 billion euros in total over the next few years for research and teaching, including a guaranteed five per cent increase to the annual budget for non-university research institutions – allow the Helmholtz Association to offer young people reliable career prospects and create highly qualified jobs. They set the course for research projects of great promise for the future that will be able to answer the grand challenges of our society and will serve to strengthen the essential and indispensable basic research.

In September 2008, the Helmholtz Association additionally completed its work on a strategic agenda.

OVERVIEW OF THE HELMHOLTZ ASSOCIATION

PERFORMANCE RECORD

The Helmholtz Association works continuously on increasing its research capacity to the benefit of society. In the reporting period 2008, the Association, as in previous years, recorded a sound increase in the relevant performance indicators. The published figures for the reporting period 2008 are based on the data from the 15 Research Centres of the Association operating in 2008. As from 2010, the Annual Report will present the development of 16 Centres.

In 2008, the Helmholtz Centres received federal and state government grants to finance the costs amounting to 1,706 million euros in total. In addition to these institutionally funded costs, they raised external funds of 909 million euros in total, which proves the appeal of Helmholtz research for science and industry. The external funds in the applications-oriented research fields come largely from collaboration with industry. In the basic research oriented research fields, these funds are largely raised through competition, for example from funding programmes of the European Union, the German Research Foundation (DFG) or federal or state ministries.

The Helmholtz Association invests its resources in cross-centre research programmes that compete with each other. With this programme-oriented funding, the Helmholtz Centres record the progress made by the programmes, not only on the basis of the activity reports, but also systematically on the basis of quantitative success indicators. In order to make this scientific success – which can be measured by various yardsticks – visible, common assessment criteria have established themselves. One of the foremost responsibilities of the Helmholtz Association – drawing up and developing solutions for socially relevant problems – cannot be adequately recorded in the rigid schema of a performance record. This is why the scientific section of the Annual Report, acting on behalf of our research on the big questions of humanity, presents the latest examples from the Helmholtz Centres (see as from page 14). While the following pages present meaningful figures and information on the depth, range and performance capacity of the research done in the Helmholtz Association.

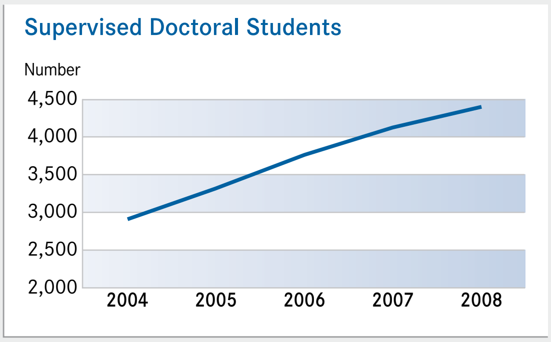
Strong research

Criteria that can be recorded by various indicators play a leading role in the subject area and in scientific excellence. Among experts, the ISI citations bear witness to the relevant disciplinary strength, while the high number of excellent applicants from home and abroad, such as the calls for proposals for Young Investigators Group Leaders, prove how great the appeal of the Helmholtz Association is for young scientists and researchers.

- In 2008, the Helmholtz Association engaged in research in 7,389 scientific collaborations, equal to a 19 per cent increase over the previous year and by 77 per cent over the previous five years.
- Helmholtz participated in 89 DFG Priority Programmes and 78 Collaborative Research Centres in 2008. In 2007, Helmholtz was involved in 100 DFG Priority Programmes and 67 Collaborative Research Centres.
- In 2008, 74 Helmholtz scientists and researchers were appointed to a W2 or W3 professorship at various universities. In 2006, it had been 70 and in 2007 even 107.

Young scientists and researchers

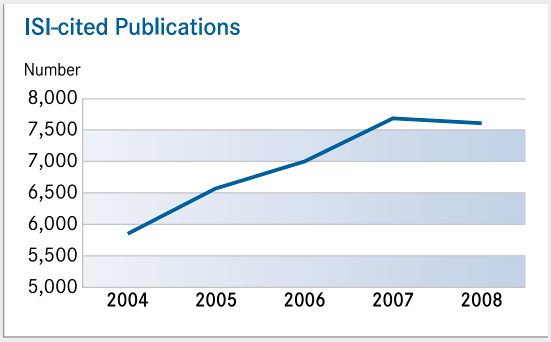
- In 2008, the dissertations of 4,398 doctoral students were scientifically supervised at Helmholtz Centres. Compared with 4,124 doctoral students in 2007, this means that 6.6 per cent more doctoral students were scientifically supervised. The past five years have seen an increase of 11 per cent per year on average.



- 1,640 postdoctoral students worked in the Helmholtz Association in 2008. This amounts to a 10 per cent increase over the previous year.
- In 2008, 34 Helmholtz scientists and researchers gained a habilitation (venia legendi), and seven were appointed to an Assistant Professorship (Juniorprofessor). 276 habilitations have been supervised in the Helmholtz Association since 2003.
- Helmholtz Centres contribute to 33 Research Training Groups of the German Research Foundation (DFG).
- Helmholtz Centres contribute to 43 Marie Curie Funding Measures for Early Stage Research Training Programme of the European Union. No major changes recorded over the previous year.
- The number of Helmholtz Young Investigators Groups amounted to 133 in total in 2008.
- The Helmholtz Association with its initiative “Haus der kleinen Forscher” (Tiny Tots’ Science Corner) is contributing to promoting young researchers long-term with a network of some 8,000 day-care centres and kindergartens.
- In 2008, 1,680 trainees and apprentices were learning their trade or occupation in the Helmholtz Association. This corresponds to a training quota of 7.1 per cent, related to all staff, excluding doctoral students.

Publications

- In 2008 12,104 scientific publications appeared, of which 7,623 were published in ISI-cited scientific journals.
- In contrast to the previous year, the number of publications has fallen slightly, however in the past five years it still rose in sum total by 30 per cent.



- Some 1,200 specialist/scientific books were written in the Helmholtz Association in 2008.

Staff

Scientific Staff

The Helmholtz Association had a total of 27,913 staff in 2008 (previous year: 27,962), of which 9,043 were scientists (previous year: 8,763), 4,398 supervised doctoral students (previous year: 4,124) and 1,680 trainees and apprentices (previous year: 1,620). A total of 12.792 staff (previous year: 13,455) staff were working in the scientific-technical and administrative area.

Women in Science

Much as last year, women accounted for a 22 per cent share of all scientists and researchers, and a 36 per cent share of the young scientists and researchers. The development of women in science management at head of institute and head of department level continues to show a clear upward trend. All in all, the proportion of women currently holding scientific, technical and administrative management positions lies at 17 per cent, while in 2006 it was just 14 per cent.

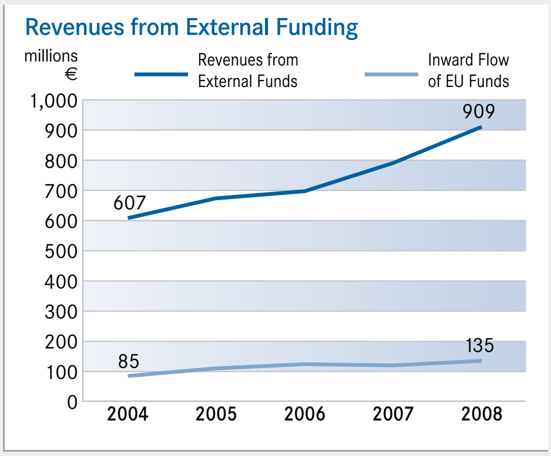
Scientific Guests at the Helmholtz Association

The international scientific appeal that our research centres have for foreign scientists and researchers continues to prevail. This is demonstrated by the large number of guests who came to the centres in 2008 to engage in scientific exchange or to use the research infrastructures. Just under 4,500 scientists and researchers from all around the world used the research opportunities available at the Helmholtz Centres.

Partner of Industry

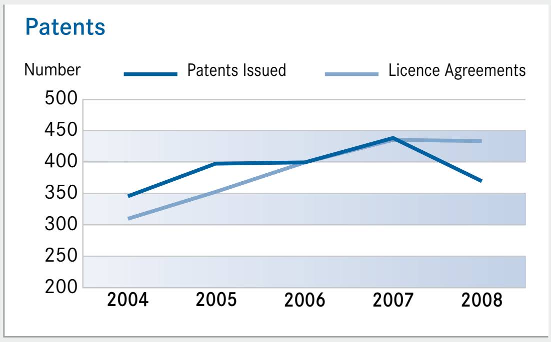
- The inward flow of EU funds from the 7th Framework Programme amounted to 135 million euros in 2008. This means that the Helmholtz Association leads the way among the science and research organisations.
- External funds amounting to 909[1] million euros were raised in 2008, equal to a 15 per cent increase over the previous year 2007. In 2007, 789 million euros were raised.
- This means that the external finds raised in the past five years amounts to a 50 per cent increase, or 11 per cent per year on average.

Revenues from External Funding



- 370 patents were issued in the reporting period 2008. In the past three years, some 400 new patents have been issued annually.
- In terms of licence agreements, the result with 434 agreements concluded in 2008 was just as good as in 2007. The financial volume of the licence agreements amounted to around 11 million euros in 2006, and around 15 million euros in 2007 and 2008, respectively.

Patents



- The last four years have seen 39 companies or enterprises spun-off from the Helmholtz Association. This shows that the Helmholtz Association competes well in the market.

[1] The revenues from external funds shown here also include project grants from Federal Government (for PETRA III, XFEL and FAIR).

PROGRAMME-ORIENTED FUNDING

The Helmholtz Association is committed to competing in science. Programme-oriented funding is the principle by which research is financed in the Helmholtz Association. At the heart of this programme-oriented funding, programmes are financed on the basis of strategic evaluations. Focusing the funding on research programmes enables scientists and researchers to collaborate across and beyond institutional and disciplinary borders. At the same time, programme-oriented funding also fosters competition for funding between the 16 Research Centres as well as between the programmes themselves. The amount of funding provided for the five-year programme term depends on the results of the strategic reviews of the programmes. This approach makes the Helmholtz Association's costs and staffing capacities in the six Research Fields more transparent.

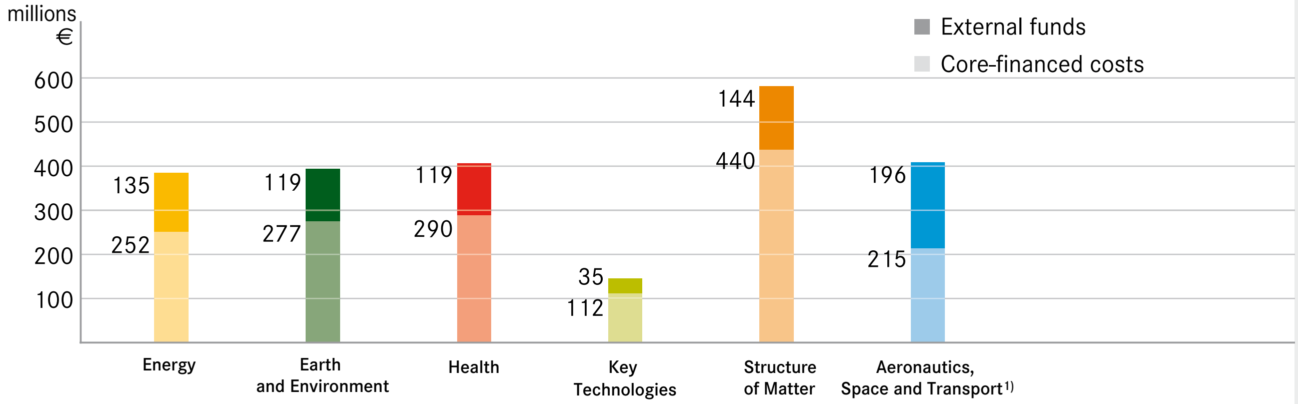
Researching with new approaches

To address new scientific issues and take up innovative approaches, expand and extend the know-how and expertise, and lay the groundwork for strategically important projects, additional means are available to the centres for so-called non-programme-bound research. The level of these resources is dependent on the centres' success in the reviews and amounts to 20 per cent of the total programme funding raised by the individual centres. If centres use these resources to strengthen and advance innovative approaches in the existing research programmes, they are allocated directly to the costs of the respective programme. If new projects are initiated with these resources and new thematic fields developed, they are reported separately under the item non-programme-bound research.

Special tasks

The term "special tasks" covers the tasks that the centres perform independent of their scientific objectives. Typical examples include providing training for young people in technical and administrative professions or performing special scientific-technical or administrative management tasks for federal and state ministries.

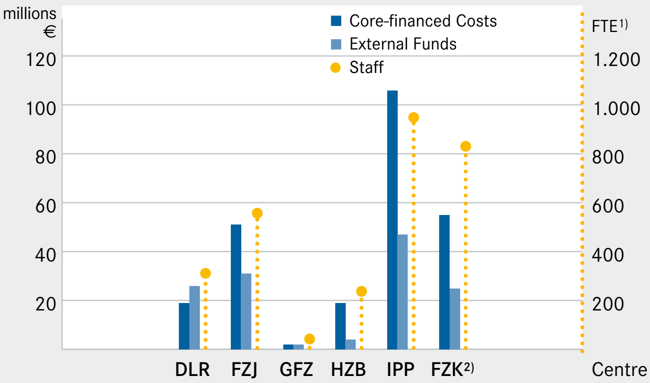
Core-financed and externally funded costs of the Research Fields in 2008
(including resources for non-programme-bound research deployed to strengthen the existing research programmes)



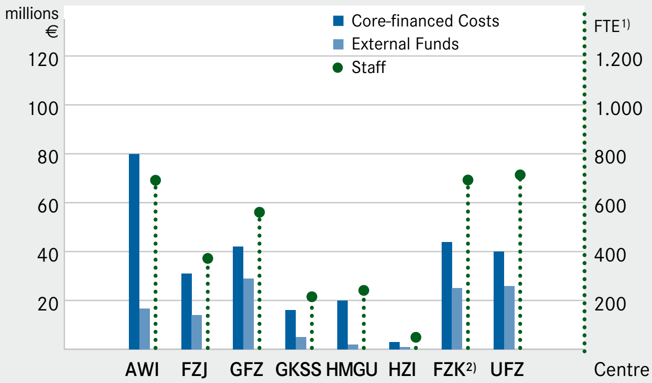
1) Up to 31.12.2008 Transport and Space

COSTS AND STAFF 2008

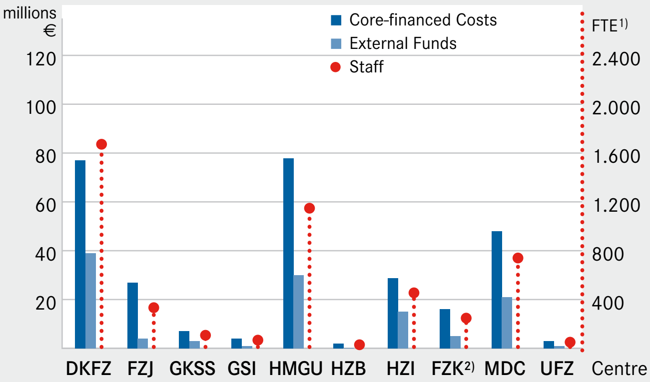
Research Field Energy



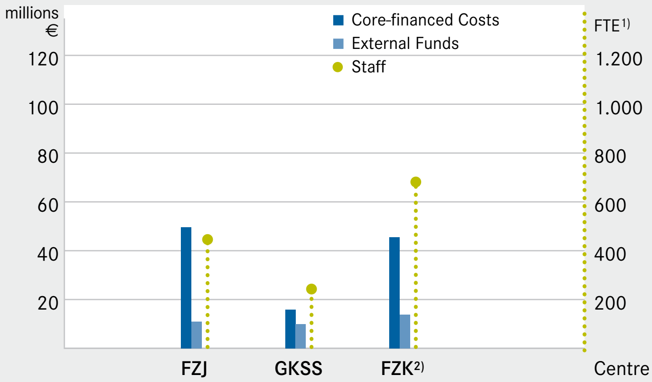
Research Field Earth and Environment



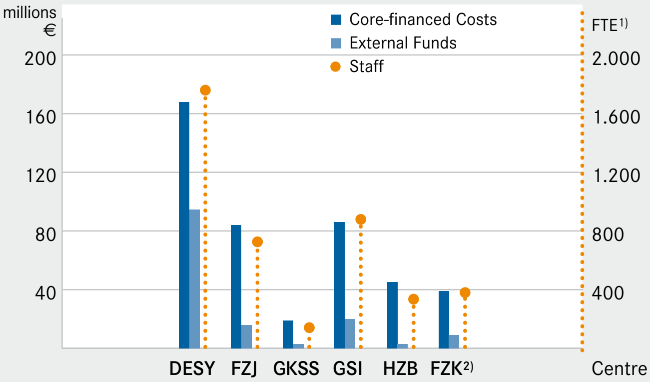
Research Field Health



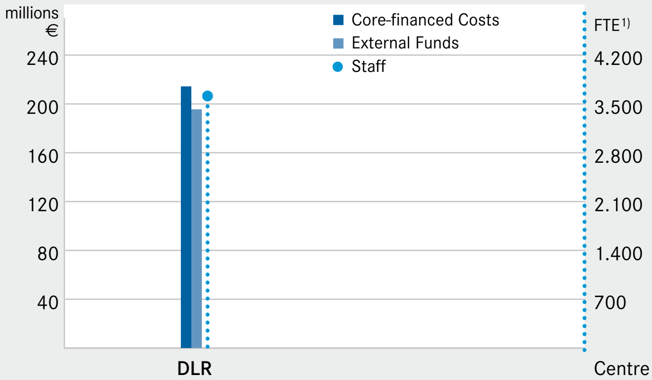
Research Field Key Technologies



Research Field Structure of Matter



Research Field Aeronautics, Space and Transport[3]



[1] Full-time equivalents. [2] From 1.10.2009 Karlsruhe Institute of technology (KIT). [3] Up to 31.12.2008 Transport and Space.

Overview of Helmholtz Association costs and staff	Costs Core-financed costs €'000	Costs Externally funded costs €'000	Costs Total costs €'000	Staff Total staff, FTE[1]
Total, Research Fields	1.584.975	748.940	2.333.915	20.324
Non-programme-bound research[2]	33.029	15.919	48.948	457
Special tasks[3]	88.448	144.474	232.922	2.599
Total, Helmholtz Association	**1.706.452**	**909.333**	**2.615.785**	**23.380[4]**

[1] Full-time equivalents. [2] Funding for non-programme-bound research is calculated as 20% of the total programme funding raised by the individual centres. If centres use these resources to strengthen the existing research programmes, they are allocated directly to the costs of the respective programme. [3] See page 97. [4] In terms of natural persons, the Helmholtz Association employs 27,913 staff.

	Core-financed costs €'000	Externally funded costs €'000	Total costs €'000	Total staff, FTE[1]
Research Field Energy				
Forschungszentrum Jülich (FZJ)	51,022	30,612	81,634	552
Forschungszentrum Karlsruhe (FZK)[5]	55,237	24,993	80,230	826
German Aerospace Center	18,788	25,862	44,650	306
Helmholtz Centre Potsdam (GFZ)	1,583	1,854	3,437	37
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	19,041	4,176	23,217	232
Max Planck Institute for Plasma Physics (IPP)	106,280	47,223	153,503	944
Total, Research Field Energy	**251,951**	**134,720**	**386,671**	**2,897**
Research Field Earth and Environment				
Alfred Wegener Institute for Polar and Marine Research (AWI)	80,253	16,804	97,057	687
Forschungszentrum Jülich (FZJ)	30,992	13,595	44,587	367
Forschungszentrum Karlsruhe (FZK) [5]	44,399	25,011	69,410	688
GKSS Research Centre Geesthacht (GKSS)	15,633	5,147	20,780	210
Helmholtz Centre for Environmental Research - UFZ	40,290	25,855	66,145	709
Helmholtz Centre for Infection Research (HZI)	2,923	1,471	4,394	44
Helmholtz Centre Potsdam (GFZ)	42,312	29,077	71,389	556
Helmholtz Zentrum München (HMGU)	20,081	2,077	22,158	236
Total, Research Field Earth and Environment	**276,883**	**119,037**	**395,920**	**3,497**
Research Field Health				
Forschungszentrum Jülich (FZJ)	27,403	4,199	31,602	324
Forschungszentrum Karlsruhe (FZK)[5]	15,645	4,942	20,587	238
German Cancer Research Center (DKFZ)	76,751	39,209	115,960	1,668
GKSS Research Centre Geesthacht (GKSS)	6,603	2,940	9,543	97
GSI Helmholtz Centre for Heavy Ion Research (GSI)	3,860	658	4,518	57
Helmholtz Centre for Environmental Research - UFZ	2,929	728	3,657	40
Helmholtz Centre for Infection Research (HZI)	29,338	14,982	44,320	446
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	1,756	127	1,883	19
Helmholtz Zentrum München (HMGU)	77,943	30,053	107,996	1,142
Max Delbrueck Center for Molecular Medicine (MDC)	47,629	21,347	68,976	760
Total, Research Field Health	**289,857**	**119,185**	**409,042**	**4,791**
Research Field Key Technologies				
Forschungszentrum Jülich (FZJ)	49,657	11,378	61,035	445
Forschungszentrum Karlsruhe (FZK) [5]	46,208	14,192	60,400	683
GKSS Research Centre Geesthacht (GKSS)	15,775	9,696	25,471	240
Total, Research Field Key Technologies	**111,640**	**35,266**	**146,906**	**1,368**
Research Field Structure of Matter[6]				
Deutsches Elektronen-Synchrotron DESY	167,701	94,675	262,376	1,751
Forschungszentrum Jülich (FZJ)	84,372	15,543	99,915	717
Forschungszentrum Karlsruhe (FZK) [5]	38,528	9,357	47,885	371
GKSS Research Centre Geesthacht (GKSS)	18,670	2,503	21,173	132
GSI Helmholtz Centre for Heavy Ion Research (GSI)	86,028	19,688	105,716	870
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	44,702	2,598	47,300	326
Total, Research Field Structure of Matter	**440,001**	**144,364**	**584,365**	**4,167**
Research Field Aeronautics, Space and Transport [7]				
German Aerospace Center	214,643	196,368	411,011	3,604
Total, Research Field Aeronautics, Space and Transport [7]	**214,643**	**196,368**	**411,011**	**3,604**

[5] From 1.10.2009 Karlsruhe Institute of Technology (KIT).
[6] The revenues from external funds shown here also include project grants from Federal Government (for PETRA III, XFEL and FAIR).
[7] Up to 31.12.2008 Transport and Space.

The Helmholtz Association's annual budget is made up of core financing and external funding. The core financing is provided by federal government and the respective states in which the member centres are registered at a ratio of 90 per cent federal government and 10 per cent federal states. The centres raise some 30 per cent of the total budget themselves in the form of external funds. These core-financed and externally funded costs are presented in the Annual Report, covering the reporting period 2008. The Helmholtz Association's strategic focus on six research fields means that the total costs are listed by Research Fields (see Page 99). For a clearer overview of the financial resources available to the centres, these details are presented analogously at Centre level (see below). This overview is complemented by details on the number of staff, indicated in full-time equivalents, at Research Field level (see Page 99), as well as at Centre level (see below).

Costs and Staff by Centre in 2008	Core-financed costs €'000	Externally funded costs €'000	Total costs €'000s	Total staff FTE[1]
Alfred Wegener Institute for Polar and Marine Research (AWI)	80,253	16,804	97,057	687
Deutsches Elektronen-Synchrotron (DESY)	167,701	94,675	262,376	1,751
Forschungszentrum Jülich (FZJ)	243,446	75,327	318,773	2,405
Forschungszentrum Karlsruhe (FZK)[2]	200,017	78,495	278,512	2,806
German Aerospace Center (DLR)	233,431	222,230	455,661	3,910
German Cancer Research Center (DKFZ)	76,751	39,209	115,960	1,668
GKSS Research Centre Geesthacht (GKSS)	56,681	20,286	76,967	679
GSI Helmholtz Centre for Heavy Ion Research (GSI)	89,888	20,346	110,234	927
Helmholtz Centre for Environmental Research – UFZ	43,219	26,583	69,802	749
Helmholtz Centre for Infection Research (HZI)	32,261	16,453	48,714	490
Helmholtz Centre Potsdam (GFZ)	43,895	30,931	74,826	593
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	65,499	6,901	72,400	577
Helmholtz Zentrum München (HMGU)	98,024	32,130	130,154	1,378
Max Delbrueck Center for Molecular Medicine (MDC)	47,629	21,347	68,976	760
Max Planck Institute for Plasma Physics (IPP)	106,280	47,223	153,503	944
Non-programme-bound research	**33,029**	**15,919**	**48,948**	**457**
Special tasks	**88,448**	**144,474**	**232,922**	**2,599**
Total, Helmholtz Association	**1,706,452**	**909,333**[3]	**2,615,785**	**23,380**

The newly founded German Centre for Neurodegenerative Diseases (DZNE) receives a budget as from 2009.

1) Full-time equivalents.
2) From 1.10.2009 Karlsruhe Institute of Technology (KIT).
3) The revenues from external funds shown here also include project grants from Federal Government (for PETRA III, XFEL and FAIR).

THE SECOND ROUND OF PROGRAMME-ORIENTED FUNDING

The second period of programme-oriented funding began in 2009, initially with the Research Fields Earth and Environment, Health, and Aeronautics, Space and Transport. The second round for the Research Fields Energy, Key Technologies, and Structure of Matter begins in 2010. The centres contributing to these six research fields have reorganised their R&D capacities to form a total of 28 new programmes. This page shows the funding in the second programme period for all 28 programmes as recommended by the Senate following the programmes' evaluation. This sum covers the five-year funding period for the respective research fields and centres. The calculation is based on the core-financed full costs. In contrast to the details for the first programme period, these now also include infrastructure costs. To make the actual changes between the first and the second round more transparent for readers, the infrastructure costs for the reporting period 2008 have also been added to the individual programmes by means of an internal key.

Funding 2009–2013

Research Field Earth and Environment	Core-financed costs €'000s
AWI	448,633
FZJ	148,243
GFZ	198,863
GKSS	100,908
HMGU	92,513
KIT[3]	90,732
UFZ	227,084
SUM TOTAL	**1,306,976**
Research Field Health	
DKFZ	599,137
DZNE	200,000[4]
FZJ	151,424
GKSS	25,269
GSI	19,333
HMGU	403,750
HZI	220,761
MDC	297,781
UFZ	27,431
SUM TOTAL	**1,944,886**
Research Field Aeronautics, Space and Transport	
DLR	1,317,145
SUM TOTAL	**1,317,145**

Funding 2010–2014

Research Field Energy[1]	Core-financed costs €'000s
DLR	99,262
FZJ	292,546
GFZ	10,779
HZB	104,248
IPP	471,370
KIT[3]	498,483
UFZ	21,101
SUM TOTAL	**1,497,789**
Research Field Key Technologies	
FZJ	504,567
GKSS	110,954
KIT[3]	451,855
SUM TOTAL	**1,067,376**
Research Field Structure of Matter[2]	
DESY	981,549
FZJ	265,497
GKSS	47,958
GSI	396,388
HZB	373,182
KIT[3]	206,170
SUM TOTAL	**2,270,744**

The Research Fields Earth and Environment, Health, and Aeronautics, Space and Transport have restructured their research programmes as from 1 January 2009; restructuring of the programmes in the Research Fields Energy, Key Technologies and Structure of Matter takes effect as from 1 January 2010. The charts depicting the distribution of resources at programme level can be found next to the descriptions of the new programmes on the respective pages of the Research Fields (Energy pp. 18/19, Earth and Environment pp. 30/31, Health pp. 42/43, Key Technologies pp. 56/57, Structure of Matter pp. 66/67, Aeronautics, Space and Transport pp. 78/79).

[1] Please note: As a result of the Energy Storage Initiative of the Helmholtz Association, the costs in the field of Energy are only provisional. The final costs are expected at the beginning of 2010. [2] Please note: As a result of the Helmholtz Association's High Data Rate Processing and Analysis Initiative, the costs in the Research Field Structure of Matter are only provisional. The final costs are expected at the beginning of 2010. [3] As from 1.10.2009, Karlsruhe Institute of Technology (KIT). The Annual Report of the Helmholtz Association only lists the Helmholtz share of the costs. [4] On the basis of the start-up budget for the DZNE.

CENTRAL BODIES

Last update: December 2009

President

Prof. Dr. Jürgen Mlynek

Vize-Presidents

Vice-President of the Helmholtz Association, Coordinator of the Research Field Energy
Prof. Dr. Eberhard Umbach, President of the Karlsruhe Institute of Technology

Vice-President of the Helmholtz Association, Coordinator of the Research Field Earth and Environment
Prof. Dr. Karin Lochte, Director, Alfred Wegener Institute for Polar and Marine Research

Vice-President of the Helmholtz Association, Coordinator of the Research Field Health
Prof. Dr. Otmar D. Wiestler, Chairman of the Management Board, German Cancer Research Center

Vice-President of the Helmholtz Association, Coordinator of the Research Field Key Technologies
Prof. Dr. Achim Bachem, Chairman of the Board of Directors, Forschungszentrum Jülich

Vice-President of the Helmholtz Association, Coordinator of the Research Field Structure of Matter
Prof. Dr. Horst Stöcker, Scientific Director, GSI Helmholtz Centre for Heavy Ion Research

Vice-President of the Helmholtz Association, Coordinator of the Research Field Aeronautics, Space and Transport
Prof. Dr. Johann-Dietrich Wörner, Chairman of the Executive Board, German Aerospace Center (DLR)

Administrative Vice-President
Dr. Nikolaus Blum, Administrative Director, Helmholtz Zentrum München – German Research Center for Environmental Health

Administrative Vice-President
Klaus Hamacher, Vice-Chairman of the Executive Board, German Aerospace Center (DLR)

Head Office

Managing Director
Dr. Rolf Zettl

Members of the Senate

ELECTED MEMBERS

Prof. Dr. Dr. Andreas Barner, Chairman of the Board of Managing Directors and Head of Pharma R&D+M, Boehringer Ingelheim GmbH, Ingelheim

Prof. Dr. Ralph Eichler, President of the ETH, Zurich, Switzerland

Prof. Dr. Katharina Kohse-Höinghaus, Bielefeld University, Faculty of Chemistry

Prof. Dr. Gerd Litfin, Chairman of the Supervisory Board, Linos AG, Göttingen

Prof. Dr. Liqiu Meng, Vice-President, Technische Universität München

Dr. Detlef Müller-Wiesner, Senior Vice-President, Chief Operating Officer Innovation and CTO Deputy Corporate Technical Office, EADS, Suresnes, France

Prof. Dr. Mary Osborn, Max Planck Institute for Biophysical Chemistry, Göttingen

Prof. Dr. Hermann Requardt, Member of the Managing Board, Siemens AG, Munich

Prof. Dr. Robert Rosner, University of Chicago, USA

Prof. Dr. Ulrich Seiffert, Managing Director, WiTech Engineering GmbH, Braunschweig

Prof. Dr. Klaus Töpfer, Former Under Secretary General, United Nations, and Founding Director, Institute for Advanced Sustainability Studies, Potsdam

Prof. Dr. Ulrich Wagner, Technische Universität München, Lehrstuhl für Energiewirtschaft und Anwendungstechnik, München

MITGLIEDER DES SENATS EX OFFICIO

Prof. Dr. Hans-Jörg Bullinger, President of the Fraunhofer-Gesellschaft, Munich

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Werner Gatzer, State Secretary, Federal Ministry of Finance, Berlin

Dr. Robert Heller, Councillor of State, Department of Finances of the City of Hamburg

Jochen Homann, Secretary of State, Federal Ministry of Economics and Technology, Berlin

Michael Kretschmer, Member of the German Bundestag, Berlin

Prof. Dr. Jürgen Mlynek, President of the Helmholtz Association

Renate Jürgens-Pieper, Senator for Education and Science of the State of Bremen

Prof. Dr. Annette Schavan, Federal Minister of Education and Research

Prof. Dr. Margret Wintermantel, President of the German Rectors' Conference, Bonn

GUESTS

Prof. Dr. Achim Bachem, Vice-President of the Helmholtz Association, Chairman of the Board of Directors, Forschungszentrum Jülich

Dr. Nikolaus Blum, Vice-President of the Helmholtz Association, Administrative Director, Helmholtz Zentrum München – German Research Center for Environmental Health

Prof. Dr. Peter Gruss, President of the Max Planck Society for the Advancement of Science, Munich

Klaus Hamacher, Vice-President of the Helmholtz Association, Vice-Chairman of the Executive Board, German Aerospace Center (DLR), Cologne

Cornelia Jebsen, Representative of the Staff and Works Councils of the Helmholtz Centres, Forschungszentrum Jülich

Prof. Dr. Matthias Kleiner, President of the German Research Foundation, Bonn

Dr. Martin Lipp, Chair of the Committee of Scientific-technical Councils of the Helmholtz Centres, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

Prof. Dr. Karin Lochte, Vice-President of the Helmholtz Association, Director, Alfred Wegener Institute for Polar and Marine Research

Dr. Simone Richter, Vice-Chair of the Scientific-technical Councils of the Helmholtz Centres, GSI Helmholtz Centre for Heavy Ion Research, Darmstadt

Prof. Dr. Dr. Ernst Rietschel, President of the Leibniz Association (WGL), Berlin

Prof. Dr. Horst Stöcker, Vice-President of the Helmholtz Association, Scientific Director, GSI Helmholtz Centre for Heavy Ion Research

Prof. Dr. Peter Strohschneider, Chairman of the German Science Council, Cologne

Prof. Dr. Eberhard Umbach, Vice-President of the Helmholtz Association, President of the Karlsruhe Institute of Technology

Prof. Dr. Otmar D. Wiestler, Vice-President of the Helmholtz Association, Chairman of the German Cancer Research Center, Heidelberg

Prof. Dr. Johann-Dietrich Wörner, Vice-President of the Helmholtz Association, Chairman of the Executive Board, German Aerospace Center (DLR), Cologne

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Dr. Heike Wolke, Administrative Director

Deutsches Elektronen-Synchrotron DESY
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Chairman of the Board of Directors,
Christian Scherf, Administrative Director

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Chairman of the Board of Directors,
Dr. Ulrich Krafft, Deputy Chairman of the Board of Directors

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Klaus Hamacher, Vice-Chairman of the Executive Board

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Prof. Dr. Wolfgang Kaysser, Scientific Director,
Michael Ganß, Administrative Director

GSI Helmholtz Centre for Heavy Ion Research
Prof. Dr. Horst Stöcker,
Scientific Director,
Christiane Neumann, Administrative Director

Helmholtz Centre for Environmental Research – UFZ
Prof. Dr. Georg Teutsch, Scientific Director,
Dr. Andreas Schmidt, Administrative Director

Helmholtz Centre for Infection Research
Prof. Dr. Jürgen Wehland,
Scientific Director,
N.N., Administrative Director

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Chairman of the Executive Board,
Dr. Bernhard Raiser,
Administrative Executive Board

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Scientific Director,
Dr. Ulrich Breuer, Administrative Director

Helmholtz Zentrum München – German Research Center for Environmental Health
Prof. Dr. Günther Wess,
Scientific and Technical Director,
Dr. Nikolaus Blum, Administrative Director

Karlsruhe Institute of Technology
Prof. Dr. Eberhard Umbach, President,
Dr. Alexander Kurz, Vice-President

Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch
Prof. Dr. Walter Rosenthal,
Chairman of the Foundation Board,
Cornelia Lanz, Administrative Director

Max Planck Institute for Plasma Physics (Associate Member)
Prof. Dr. Günther Hasinger, Scientific Director,
Christina Wenniger-Mrozek, Administrative Director

SENATE COMMISSIONS

Last update: December 2009

The Senate Commissions convene under the chairmanship of the Helmholtz Association President, Prof. Dr. Jürgen Mlynek.

PERMANENT MEMBERS

Research Field Energy
Prof. Dr. Thomas Hartkopf
Department Head Renewable Energies, Technical University Darmstadt

Research Field Earth and Environment
Prof. Dr. Volker Josef Mosbrugger
Director of the Senckenberg Research Institute and Natural History Museum, Frankfurt

Research Field Health
Prof. em. Dr. Heidi Diggelmann
University of Lausanne, Switzerland, and former President of the Research Council of the Swiss National Science Foundation

Research Field Key Technologies
Prof. Dr. Dieter Jahn
Senior Vice-President, Science Relations and Innovation Management, BASF, Ludwigshafen

Research Field Structure of Matter
Prof. Dr. Vera Lüth
Stanford Linear Accelerator Center, Stanford, USA

Research Field Aeronautics, Space and Transport
Jörg Feustel-Büechl
former Director European Space Agency

Representative of the Federal Ministry of Education and Research
Ulrich Schüller
Federal Ministry of Education and Research, Bonn

Representatives appointed by the Länder
Dr. Heribert Knorr
Ministry of Science, Research and the Arts of the State of Baden-Württemberg, Stuttgart

Dr. Beate Wieland
Ministry of Innovation, Science, Research and Technology of the State of North Rhine-Westphalia, Düsseldorf

The permanent members belong to all six Senate Commissions.

SENATE COMMISSION
Research Field Energy

Member of the Senate **Prof. Dr. Hermann Requardt** Member of the Managing Board, Siemens AG, Munich
Member of the Senate **Prof. Dr. Ulrich Wagner** Chair of Institute for Energy Economy and Application Technology Technische Universität München
Representative of the Federal Ministry **Dr. Knut Kübler** Federal Ministry of Economics and Technology, Bonn

Chairpersons of the review panels*

Renewable Energies **Prof. Dr. Louis Schlapbach** ETH Zurich, Switzerland
Efficient Energy Conversion and Use **Prof. Dr. Alexander Wokaun** Paul-Scherrer-Institut, Villigen, Switzerland
Nuclear Fusion **Prof. Dr. Walter F. Henning** Argonne National Laboratory, Illinois, USA
Nuclear Safety Research **Dr. Phillip Finck** Idaho National Laboratory, Idaho Falls, USA
Technology, Innovation and Society **Prof. Dr. Ortwin Renn** University of Stuttgart

SENATE COMMISSION
Research Field Earth and Environmentt

Member of the Senate **Prof. Dr. Klaus Töpfer** Former Under Secretary General, United Nations, Founding Director Institute for Advnced Sustainability Studies, Potsdam
Member of the Senate **Prof. Dr. Liqiu Meng** Vice-President, Technische Universität München
Representative of the Federal Ministry of Education and Research **Wilfried Kraus** Federal Ministry of Education and Research, Bonn

Chairpersons of the review panels*

Geosystem: The Changing Earth **Prof. Dr. Roy H. Gabrielsen** Dept. of Geosciences, University of Oslo, Norway
Marine, Coastal and Polar Systems **Prof. Dr. Guy Brasseur** National Center for Atmospheric Research, Earth and Sun Systems Laboratory, Boulder, USA
Atmosphere and Climate **Prof. Dr. Thomas Stocker** Institute for Climate and Environmental Physics, University of Berne, Switzerland
Terrestrial Environment **Prof. Dr. Johan Bouma** formerly of Wageningen Agricultural University, Netherlands

*The review panels were active during the programme evaluations in 2008 and 2009.

SENATE COMMISSION
RESEARCH FIELD HEALTH

Member of the Senate **Prof. Dr. Dr. Andreas Barner** Chairman of the Board of Managing Directors, Head of Pharma R&D+M, Boehringer Ingelheim GmbH
Member of the Senate **Prof. Dr. Mary Osborn** Max Planck Institute for Biophysical Chemistry, Göttingen
Representative of the Federal Ministry of Education and Research **Dr. Peter Lange** Federal Ministry of Education and Research, Berlin

Chairpersons of the review panels*

Cancer Research **Prof. emer. Dr. Paul Neiman** Member and Director emer. Division of Basic Sciences, Fred Hutchinson Cancer Research Center, Seattle, USA
Cardiovascular and Metabolic Diseases **Prof. Dr. Thomas F. Lüscher** Chairman, Cardiology Clinic, University Hospital Zurich, Switzerland
Function and Dysfunction of the Nervous System **Prof. Dr. Mark Hallett** Chief of Human Motor Control Section, National Institute of Neurological Disorders and Stroke, NINDS, Bethesda, USA
Infection and Immunity **Prof. Dr. Dennis L. Kasper** Channing Laboratory, Department of Medicine, Harvard Medical School, Boston, USA
Environmental Health **Prof. David A. Schwartz** Director, National Institute of Environmental Health Sciences, Research Triangle Park, USA
Systemic Analysis of Multifactorial Diseases **Prof. Dr. Nouria Hernandez** Director, Center for Integrative Genomics, University of Lausanne, Switzerland

SENATE COMMISSION
Research Field Key Technologies

Member of the Senate **Prof. Dr. Gerd Litfin** Chairman of the Supervisory Board, Linos AG, Göttingen
Member of the Senate **Prof. Dr. Katharina Kohse-Höinghaus** Faculty of Chemistry, University of Bielefeld
Representative of the Federal Ministry of Education and Research **Dr. Rainer Jansen** Federal Ministry of Education and Research, Bonn

Chairpersons of the review panels*

Supercomputing **Prof. Dr. Horst Simon** Associate Laboratory Director, Computing Sciences, Lawrence Berkeley National Laboratory, Berkeley, USA
Fundamentals of Future Information Technology **Prof. Dr. Michael M. T. Loy** Chair Professor, Department of Physics, Hong Kong University of Science and Technology, Hong Kong
NANOMICRO: Science, Technology, Systems **Prof. Dr. Erich Gornik** Institute of Semiconductor Electronics, and Center for Micro and Nanostructures, Vienna University of Technology, Austria
Advanced Engineering Materials **Prof. Dr. Berthold Scholtes** Institut für Werkstofftechnik, Metallische Werkstoffe, University of Kassel
BioSoft: Macromolecular Systems and Biological Information Processing **Prof. Dr. Georg Maret** Soft Matter Physics, University of Konstanz
BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces **Prof. Dr. Ernst Hafen** Department of Biology, ETH Zurich, Switzerland

SENATE COMMISSION
Research Field Structure of Matter

Member of the Senate **Prof. Dr. Robert Rosner** University of Chicago, USA
Member of the Senate **Prof. Dr. Ralph Eichler** President, ETH Zurich
Representative of the Federal Ministry of Education and Research **Dr. Beatrix Vierkorn-Rudolph** Federal Ministry of Education and Research, Bonn

Chairpersons of the review panels*

Elementary Particle Physics **Prof. Dr. Michel Davier** Laboratoire de l'Accélérateur Linéaire, Université Paris-Sud 11, France
Astroparticle Physics **Prof. Dr. Roger Blandford** Director, Kavli Institute for Particle Astrophysics and Cosmology, Stanford, USA
Physics of Hadrons and Nuclei **Prof. Dr. Barbara Jacak** State University of New York, USA
Research with Photons, Neutrons and Ions (PNI) **Prof. Dr. Joël F. Mesot** Paul-Scherrer-Institut, Villigen, Switzerland

SENATE COMMISSION
Research Field Aeronautics, Space and Transport

Member of the Senate **Prof. Dr. Ulrich Seiffert** Managing Director, WiTech Engineering GmbH, Braunschweig
Member of the Senate **Dr. Detlef Müller-Wiesner** Senior Vice-President, Chief Operating Officer, Innovation and CTO Deputy Corporate Technical Office, EADS, Suresnes, France
Representative of the Federal Ministry of Economics and Technology **Helge Engelhard** Federal Ministry of Economics and Technology, Bonn

Chairpersons of the review panels*

Aeronautics **Prof. Dr. Jürgen Klenner** Senior Vice-President Flight Physics, Airbus Engineering, Blagnac, France
Space **Dipl.-Ing. Jürgen Breitkopf** Director, Kayser-Threde GmbH, Munich
Transport **Prof. Dr. George A. Giannopoulos** Head of Hellenic Institute of Transport, Thessaloniki, Greece

*The review panels were active during the programme evaluations in 2008 and 2009.

SCIENTIFIC PRIZES AND AWARDS FOR RESEARCHERS IN THE HELMHOLTZ ASSOCIATION

Prizes as from a value of 10,000 euros and particularly selected accolades, period 2008/2009, as per September 2009

Nobel Prize in Medicine (2008)

Prof. Dr. Harald zur Hausen, former Chairman of the Board of the German Cancer Research Center, Heidelberg, together with two other prizewinners

A | Warren Alpert Foundation Prize 2007 (awarded in 2008)
Prof. Dr. Dr. Harald zur Hausen, former Chairman of the Board, and Prof. Lutz Gissmann, German Cancer Research Center

B | Gunther-Bastert-Innovationspreis 2008
Prof. Dr. Otmar D. Wiestler, German Cancer Research Center

2008 Becquerel Medal of the Royal Society of Chemistry
Prof. Dr. em. Syed M. Qaim, Forschungszentrum Jülich

Behnken-Berger-Preis der Berlin-Brandenburgischen Gesellschaft für Nuklearmedizin 2008
Christoph Bert GSI Helmholtz Centre for Heavy Ion Research

C | Award for Excellence in Cancer Control 2009
Prof. Dr. Dr. Harald zur Hausen, former Chairman of the Board of the German Cancer Research Center

Advanced Photon Source Arthur H. Compton Award
Dr. Gerhard Grübel, Deutsches Elektronen-Synchrotron DESY

E | Advanced Investigator Grant of the European Research Council ERC
Prof. Dr. Vasilis Ntziachristos, Helmholtz Zentrum München – German Center for Environmental Health

European Research Council Grant
Dr. Dr. Francesca M. Spagnoli, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch and Charité – Universitätsmedizin Berlin

Investigator Grant des European Research Council ERC
Dr. Björn Rost, Alfred Wegener Institute for Polar and Marine Research

G | Wissenschaftspreis 2009 für “Medizinische Grundlagenforschung” der GlaxoSmithKline Stiftung
Prof. Dr. Norbert Hübner, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

Roland Gutsch Project Management Award 2009
German-Indonesian Tsunami Early Warning System GITEWS
Dr. Jörn Lauterjung, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, and
Dr. Sri Woro Harijono, BMKG, Indonesia

H I **Rahel Hirsch Fellowship of the Charité 2009**
Dr. Racula Niesner, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch and Charité – Universitätsmedizin Berlin

Honda Prize 2008
Prof. Dr. Knut Urban, Forschungszentrum Jülich, together with partners

K I **Sofja Kovalevskaja Award 2008**
Dr. Jan-Erik Siemens, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

N I **Nexans Award 2009, Fonds Culturel de Nexans Suisse SA**
Dr. Gwenaël Imfeld, Helmholtz Centre for Environmental Research – UFZ

O I **Knight Commander's Cross of the Order of Merit of the Federal Republic of Germany**
Prof. Dr. Dr. Harald zur Hausen, former Chairman of the Board of the German Cancer Research Center

Officer's Cross of the Order of Merit of the Federal Republic of Germany
Prof. Dr. Reinhard Hüttl, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

Order of Merit of the Federal State of North Rhine-Westphalia
Prof. Dr. Peter Grünberg, Forschungszentrum Jülich

Order of Merit of the State of Berlin and Grand Cross of the Order of Merit of Niedersachsen
Prof. Dr. Jürgen Mlynek, President of the Helmholtz Association

S I **Chica and Heinz Schaller Research Award 2008**
Dr. Tobias Dick, German Cancer Research Center

Claudia von Schilling Preis 2008
Prof. Dr. Barbara Burwinkel, German Cancer Research Center, together with another prizewinner

The Science Prize of the Stifterverband – Erwin Schrödinger Prize 2009
Dr. Martin Bram, Dr. Hans-Peter Buchkremer, Prof. Dr. Detlev Stöver, Forschungszentrum Jülich;
Dr. Thomas Imwinkelried, Synthes GmbH, Switzerland

Forschungspreis der Walter Schulz-Stiftung München 2008
Prof. Dr. Heike Allgayer, German Cancer Research Center

Ernest-Solvay-Preis 2008
Prof. Dr. em. Christian Wandrey, Forschungszentrum Jülich

State Research Prize Baden-Württemberg in the Field of Applied Research 2009
Prof. Dr. Jürg Leuthold, Karlsruhe Institute of Technology

Stern-Gerlach-Medaille der Deutschen Physikalischen Gesellschaft 2009
Prof. Dr. Friedrich Wagner, Max Planck Institute for Plasma Physics

W I **Carl Friedrich von Weizsäcker Prize**
Prof. Dr. Jens Reich, Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

THE GOVERNANCE STRUCTURE OF THE HELMHOLTZ ASSOCIATION

COMMITTEE OF FINANCING PARTNERS

The Committee of Financing Partners – federal government and host states – defines the research policy requirements, including the research fields, for a term of several years and appoints the members of the Senate.

SENATE

Besides the Assembly of Members, the externally appointed Senate is the central decision-making body of the Helmholtz Association. The members are "ex officio" representatives of federal and state authorities, parliament and science organisations, as well as public figures from science and industry who are elected for three years. The Senate consults on all major decisions, and elects the president and vice-presidents.

SENATE COMMISSIONS

The Senate established Senate Commissions which prepare their deliberations on the funding of the programmes, basing their decisions on the results of the programme evaluations, and their decision on investment prioritization. The Senate Commissions are made up of permanent members – "ex officio" representatives of federal and state authorities – as well as experts covering the spectrum of the six research fields, and also alternating members depending on the research field under discussion.

PRESIDENT

A full-time president heads the Helmholtz Association and represents it externally. He takes on a leading role in the dialogue between science, industry and politics. He is responsible for preparing and implementing the senate's recommendations on programme-oriented funding. He coordinates the development of programmes for the research fields, the cross-centre controlling system, and the development of the association's general strategy.

VICE-PRESIDENTS

Eight vice-presidents support, advise and represent the president in the fulfilment of his duties. The six scientific vice-presidents are also the coordinators of the six research fields. A further two vice-presidents come from the centres' administrative bodies.

HEAD OFFICE

The head office and the offices in Brussels, Moscow and Beijing support the president, vice-presidents and the managing director in the fulfilment of their duties.

- Energy
- Earth and Environment
- Health
- Key Technologies
- Structure of Matter
- Aeronautics, Space and Transport

RESEARCH FIELDS

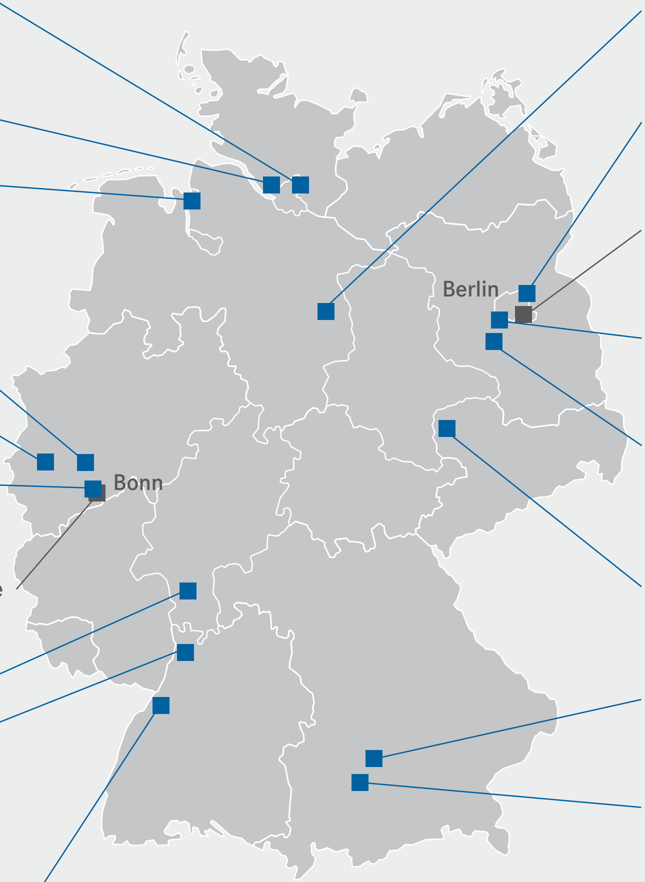
Helmholtz scientists work in six centre-overlapping research fields financed within the framework of programme-oriented funding. Their cross-centre research is performed with external partners in interdisciplinary and international collaborations.

ASSEMBLY OF MEMBERS

The Helmholtz Association is a registered association. Its members are 15 legally independent research centres and one associate member. Besides the Senate, the Assembly of Members is the central decision-making body of the association. The members are the scientific-technical and administrative directors of the member centres. The Assembly of Members is responsible for all of the association's tasks. It defines the framework for the cross-centre development of strategies and programmes, and has the right of proposal for the election of the president and members of the senate.

- Alfred Wegener Institute for Polar and Marine Research
- Deutsches Elektronen-Synchrotron DESY
- Forschungszentrum Jülich
- German Aerospace Center (DLR)
- German Cancer Research Center
- German Centre for Neurodegenerative Diseases
- GKSS Research Centre Geesthacht
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz Centre for Infection Research
- Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
- Helmholtz-Zentrum Berlin für Materialien und Energie
- Helmholtz Zentrum München – German Research Center for Environmental Health
- Karlsruhe Institute of Technology
- Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch
- Max Planck Institute for Plasma Physics (Associate Member)

SITE OF THE HELMHOLTZ RESEARCH CENTRES



GKSS Research Centre Geesthacht
www.gkss.de

Deutsches Elektronen-Synchrotron DESY
www.desy.de

Alfred Wegener Institute for Polar and Marine Research
www.awi.de

German Aerospace Center (DLR)
www.dlr.de

Forschungszentrum Jülich
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www.dzne.de

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www.gsi.de

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www.dkfz.de

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www.kit.edu

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Telephone +49 89 3299-01, Telefax +49 89 3299-2200
E-mail info@ipp.mpg.de, www.ipp.mpg.de

WWW.HELMHOLTZ.DE